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Commercially Available Biological Control Agents

By William Olkowski, Everett Dietrick, Helga Olkowski and William Quarles

As environmental effects of chemical pesticides are becoming better understood, there is increasing pressure to replace the more toxic materials. In some cases, biological controls can help reduce, or sometimes replace, these toxic chemicals. Biocontrols are especially useful for crop production in greenhouses, and are well adapted to the needs of organic agriculture. Biocontrols can be released in parks and landscapes to relieve pest pressures in municipal IPM programs. Biocontrols also have a home in the backyard garden.

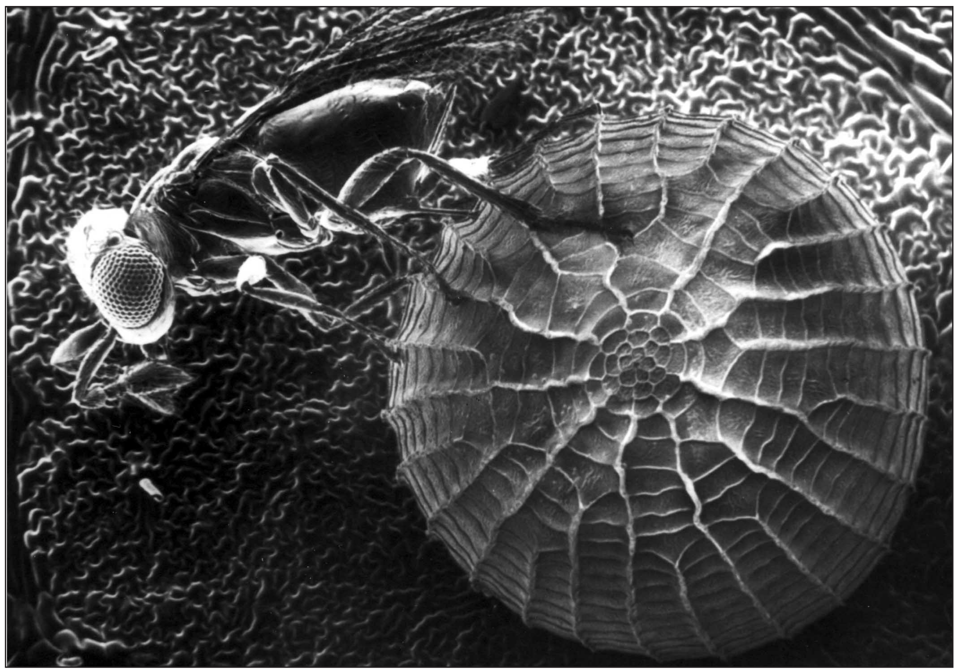

Photo courtesy of USDA

A *Trichogramma* sp. wasp is ovipositing inside the egg of a caterpillar. The developing parasitoid will prevent the pest caterpillar from developing.

The beneficial insects and mites produced by the biological control industry can be divided into two general groups: predators and parasitoids. [Herbivorous weed biocontrol agents that are collected and sold commercially, microbials, and beneficial nematodes will be covered in future articles.] Predators such as the spined soldier bug, *Podisus maculiventris*, minute pirate bug, *Orius tristicolor*, and the convergent lady beetle, *Hippodamia convergens*, directly attack and consume immature and adult pest insects.

Parasitoids—usually tiny wasps—are more indirect, as they lay their eggs on or inside the pest. When the eggs hatch, the pest insect is eaten by the larval parasitoids. Some parasitoids attack only the adult stage of the pest, while others attack either the egg, larval, or pupal stage. Some adult parasitoids also feed directly on the pest organism through wounds made when they insert their eggs, and so have two modes of killing pests.

The most widely produced parasitoids are various *Trichogramma* species, which attack caterpillar eggs. Whitefly parasitoids such as *Encarsia* species attack both the late larval and pupal stages of the pest. Aphid parasitoids will lay eggs in adults, and fly parasitoids attack the pupal stages.

Predators and parasitoids are often further differentiated by their feeding habits. Many predators feed on a broad spectrum of pests. For instance, lacewings eat caterpillars, aphids, and mites. Parasitoids are more selective than predators and generally feed only on one group, and often on only one developmental stage of the pest. For example, *Trichogramma* miniwasps only attack the eggs of moths and butterflies. Because they have a more limited range of prey, and concentrate on a target pest, parasitoids can in some cases be more effective than predators.

In This Issue

The *IPM Practitioner* is published ten times per year by the **Bio-Integral Resource Center (BIRC)**, a non-profit corporation undertaking research and education in integrated pest management.

Update

Target Pests

The biocontrol industry produces predators and parasitoids for suppressing aphids, mites, thrips, beetles, weevils, and caterpillars such as cabbage looper, gypsy moth, diamondback moth, pink bollworm, Oriental fruit moth, and stored product moths. Parasitoids for cockroaches, leafminers, mealybugs, flies, scales, whiteflies, and other pest species are also available.

A complete list of biocontrol organisms and their suppliers can be found in the publication, *Directory of Least-Toxic Pest Control Products*. This Directory is produced each year by the Bio-Integral Resource Center (BIRC). [To order copies, contact BIRC, PO Box 7414, Berkeley, CA 94707; 510/524-2567, birc@igc.org].

Structure of the Industry

In North America, beneficial insects and mites are raised by about 30 relatively small independent companies and a division of the large corporation Syngenta. There is an industry group called the Association of Natural Biocontrol Producers (ANBP) that represents industrial interests and organizes meetings. In Europe, production and distribution is dominated by two large corporations: Koppert and Biobest. These corporations have distributors throughout the world (see the BIRC Directory).

How Beneficials are Reared

In North America, beneficial insects and mites are generally raised on live hosts. Thus, insectaries first grow a culture of the target pest or a suitable substitute, then use this host culture to feed beneficials. In order to rear the host, it is often necessary to grow the plant that the pest attacks. For example, potatoes are used to feed the citrus mealybug, *Pseudococcus citri*, which in turn is used to feed predatory lady beetles, *Cryptolaemus montrouzieri*. Tobacco plants are used to feed the whiteflies that are utilized by *Encarsia formosa* parasitoids.

Laboratory cultures of both pests and natural enemies must periodically be renewed in order to avoid deterioration of the genetic stock. In addition, strict attention must be paid to sanitation to prevent contamination of the various organisms used in mass-rearing cultures. For example, if the mealybug parasitoid, *Pauridia* spp., contaminates the mealybug culture used as food for predatory lady beetles, too few mealybugs will survive to sustain the lady beetles.

Distribution of Beneficials

Natural enemies are generally shipped directly from the insectary for overnight delivery to the customer or to a distributor who resells them to clients. Live beneficial insects are often packaged with an alternate food source to insure the beneficials do not starve should there be a delay in delivery or release. The packaging also usually includes a cooling medium to protect the beneficials against excessive heat and to retard their development until released.

Some kinds of parasitoids are sold as pupae glued on cards, which are hung on the foliage of the crop. Other parasitoids are released as pupae mixed with sawdust that is sprinkled into greenhouse pots. Still others are released as adults.

Mites are either released mixed with bran, which is sprinkled into greenhouse pots or the mites are distributed on infested leaves that are placed in the crop canopy. Most larger predators such as predatory bugs are sold and released as larvae or adults that are dispersed by hand over the crop canopy (van Driesche et al. 2003). Lacewings are applied as larvae or as eggs, and a mechanical applicator has been developed to apply lacewing eggs (see *IPMP* 22(4):1-5)

Trichogramma for Caterpillars

Tiny parasitic wasps in the genus *Trichogramma* are the most widely studied biological control agents in the world. These parasitoids attack the eggs of caterpillar

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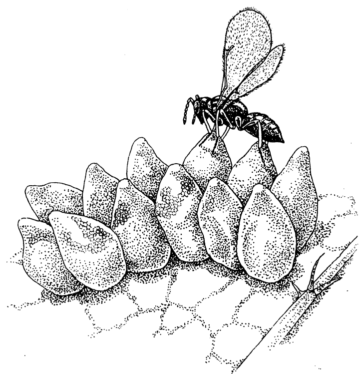


***Tetrastichus galerucae* attacks eggs of the elm leaf beetle.**

pests such as corn earworms, corn borers, spruce budworms, fruitworms, hornworms, riceworms, armyworms, and many others.

On a worldwide basis, species in the genus *Trichogramma* attack more than 400 pest species in 203 genera, 44 families and 7 orders (Bao and Chen 1989). The genus *Trichogramma* is only one of 75 genera in the hymenopteran family Trichogrammatidae with a total of about 500 species. Given the worldwide occurrence of this genus and its potential for development of additional commercial species, it is surprising how little research attention it has received.

The most important work with *Trichogramma* has occurred in the USSR and China, with Canada, Mexico, Europe, and the U.S. lagging behind. Taxonomic classification of the North American species is badly in need of revision. This effort is now underway under the direction of Dr. John Pinto at the University of California at Riverside (Pinto 1998).

Three Common Species

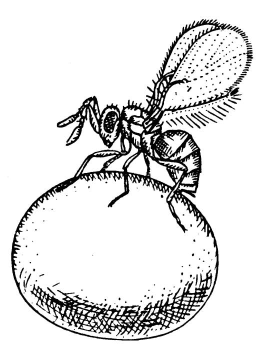
The three common species are *T. pretiosum*, *T. minutum*, and *T. platneri*, and these are the major mass-produced species in North America. The latter two species may eventually be redescribed as a single species. According to Pinto, *T. minutum* and *T. platneri* are morphologically identical, and mating crosses are not all fertile, thus reducing their effectiveness as biological control agents. This suggests that *T. minutum* should not be released in areas where *T. platneri* occurs naturally, and vice-versa.

In general, *Trichogramma* designated for use in mass rearing systems should be collected in the field from their ultimate hosts. In North America and Europe, parasitoids are reared on eggs of the Angoumois grain moth, *Sitotroga cerealella.* A single *Trichogramma* wasp emerges from each host egg. The moth itself is raised on wheat kernels. This mass production system using an "unnatural" (factitious) host was developed by Flanders in 1926 (Essig 1931). Improvements on this system are reviewed by Morrison and King (1977).

Today, ovipositing (egg-laying) *Trichogramma* females are placed into a dimly-lit enclosure containing host eggs for a short time, and then removed. Parasitized eggs are then collected and distributed for release in crops, orchards, gardens, and ornamental landscapes. Some producers recommend that adult wasps be allowed to emerge in the container and feed on a solution of honey water before they are released into a crop or garden.

Trichogramma in China

In China, three other hosts are used on a much larger scale to rear *Trichogramma.* The major hosts there are the oak silkworm, *Antheraea pernyi*, and the eri silkworm, *Philosamia cynthia ricini*. The rice moth, *Corcyra cephalonica*, is used to a lesser degree. Eggs of the oak and eri silkworms are much larger than the grain moth eggs used in North America and Europe.



A *Trichogramma* wasp probes a caterpillar egg.

Moth cocoons are collected from field sites, and adult moths are allowed to emerge after a period in cold storage. Large sterile moth eggs are taken from the unmated females, dried, parasitized and placed in cold storage for later use. These rearing systems are briefly reviewed in Olkowski and Zhang (1990). The large moth eggs used in China can produce 250 or more parasitoids from a single egg, but 60 to 80 *Trichogramma* per egg are more typical. *Trichogramma* reared in large eggs from which multiple parasitoids emerge are thought to be more robust and to have greater host searching capabilities than those raised in the smaller grain moth eggs that produce a single parasitoid. However, there is not yet a definitive study to verify any differences. Chinese researchers report high levels of parasitism by *Trichogramma* released in agricultural crops. For example, up to 100% parasitization of first and second generation Oriental corn borer *Ostrinia furnacalis* have been reported (Zhang et al. 1978).

Field Releases

Field evaluations of the effectiveness of *Trichogramma* in the U.S. and Canada have centered on the following species:

- *T. minutum* against the spruce budworm, *Choristoneura fumiferana*, in the forests of Ontario, Canada;
- *T. platneri* against the avocado leafroller, *Amorbia cuneana*, on avocado in California;
- *T. pretiosum* against the almond moth, *Cadra cautella*, and Indian-meal moth, *Plodia interpunctella*, in stored peanuts;
- *T. pretiosum* on *Heliothis* spp. and *Helicoverpa zea* in Arkansas and North Carolina,
- *T. nubilale* against the European corn borer, *Ostrinia nubilalis*, in Delaware.

Project summaries and cited literature are reviewed in Olkowski and Zhang (1990).

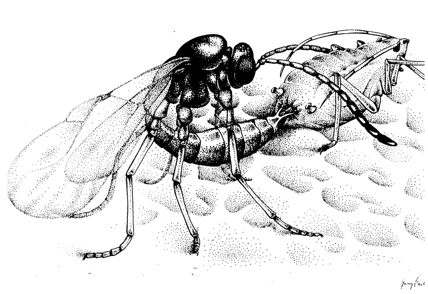
Update

In addition to *Trichogramma*, about 19 other parasitoid species are commercially available for caterpillar control, including *Goniozus legneri* for management of the navel orangeworm (BIRC 2003) (see *IPMP* 24(1):1-4).

Aphid Parasitoids

Aphid parasitoids such as *Aphidius colemani, Aphidius ervi* and *Aphelinus abdominalis* are sold to control aphids in greenhouse crops such as tomatoes, peppers, and cucumbers. The usual targets are the green peach aphid, *Myzus persicae;* the potato aphid, *Macrosyphum euphorbiae;* and the melon aphid, *Aphis gossypii.*

Aphidius parasitoids have also been used to control grain aphids with good success (Pike et al. 1997; 1999). *Aphidius* spp. develop entirely inside host aphids, which eventually become mummies when the larvae pupate. When the adult emerges, it leaves a characteristic exit hole. The parasitoid is a good searcher, and can locate new aphid colonies even when aphid populations are low. The parasitoid is shipped either as aphid mummies (pupae) or as newly emerged adults. If adults are ordered, better results are obtained if some leaves are placed in the wasp container for about 30 minutes prior to introduction. Adults should be released immediately by walking along plant rows, allowing them to fly out of the container (IPM 2003). Nine species of aphid parasitoids are currently available (BIRC 2003).



An aphid parasitoid attacks an aphid.

Filth Fly Parasitoids

Parasitoids of garbage and manure-breeding flies are commercially available. Many of these parasitoids only attack flies in a specific family or genus, so a variety of parasitoids are often needed to solve problems involving several groups of flies. The parasitoids are mass-reared on pupae of houseflies in plexiglass cages. Trays of 33,000 pupae are exposed to egglaying parasitoids, then removed from cages and shipped for release. Directions for mass rearing house fly hosts are described by Morgan (1981). For rearing the parasitoids, consult Morgan (1980).

The mass-production and release of fly parasitoids in poultry houses, dairy farms, cattle feed lots, and other livestock operations for control of the house fly, *Musca domestica*, and related manure-breeding fly species, is an excellent example of an IPM program incorporating biological control tactics. Dietrick (1981) reviews this subject, as does Olkowski (1985a).

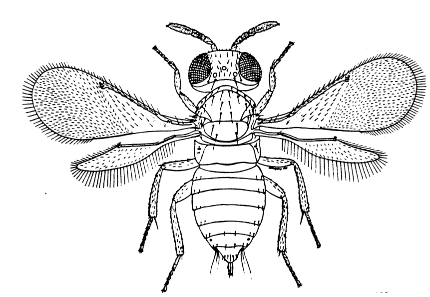
Patterson et al. (1981) describe a number of biocontrol-oriented IPM programs for flies. These programs are based primarily on research by Dr. Fred Legner and associates at the University of California at Riverside, who collected parasitoids from various continents, colonized many species, developed mass-rearing systems, and field tested IPM programs with cooperating farmers. There is also an excellent IPM program for the house fly and the biting fly, *Stomoxys calcitrans*, described by Merritt et al. (1981).

These IPM programs are operated by pest control advisors whose services include regular monitoring of fly numbers and populations of beneficials, injury level assessments, and treatment actions. Treatments emphasize habitat modification to create conditions favorable to indigenous natural enemies, mass trapping adult flies, occasional selective use of insecticides (particularly in bait stations), and releases of parasitoids.

Parasitoids used successfully against pest houseflies have included various species in the genera *Spalangia, Muscidifurax, Pachycrepoideus*, and *Tachinaephagus.* These are all pupal parasitoids, whose adult females lay eggs inside fly pupae or prepupae. The adult female parasitoids obtain nourishment from oviposition wounds, which also results in death of pest flies.

Scale Parasitoids

Two major species of scale parasitoids in the family Aphelinidae are commercially available at present: *Metaphycus helvolus* and *Aphytis melinus. M. helvolus* attacks the black scale, *Saissetia oleae*; citricola scale, *Coccus pseudomagnoliarum* (= citricola); European fruit lecanium scale, *Lecanium tiliae;* hemispherical scale, *S. coffeae*; and nigra scale, *Saissetia nigra. A. melinus* attacks the California red scale, *Aonidiella aurantii.* Importation of these two parasitoids into North America was initiated by researchers in California working on the black and red scale pests in citrus crops. These large, long term importation projects are summarized by Clausen (1978 a,b).



***Aphytis chrysomphali* attacks red scale.**

Efforts to import natural enemies of the black scale started as early as 1891, and continued actively for over 75 years. A major step forward for control of black scale occurred when *M. helvolus* was imported from South Africa and established in California in 1937. After successful colonization, *M. helvolus* was also found to attack the citricola scale. Through the combined action of the native *Metaphycus luteolus*, and the introduced *M. helvolus*, the citricola scale has ceased to reach pestiferous levels.

The red scale parasitoid, *Aphytis melinus*, was imported from India and Pakistan, and has become established in Southern California. It is currently released on many thousands of acres of citrus there, and has substantially reduced pesticide use (Olkowski 1989). Details for mass rearing the scale parasitoids and their hosts can be found both in Rose (1990) and Morrison and King (1977).

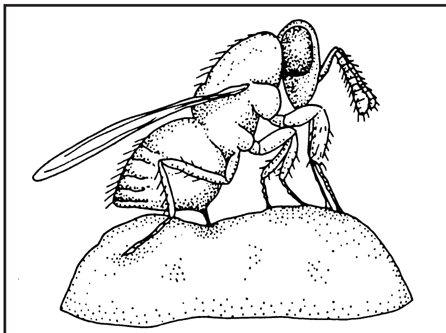
Whitefly Parasitoids

In 1992, only one whitefly parasitoid was widely available commercially. That was *Encarsia formosa*, a highly effective host-feeding parasitoid of late larval and pupal stages of the greenhouse whitefly, *Trialeurodes vaporariorum*, a major pest in greenhouses. This whitefly also attacks a wide range of agricultural and horticultural plants. Additional species have become available to combat the pesticide-resistant sweetpotato whitefly, *Bemisia tabaci*, and the silverleaf whitefly, *Bemisia argentifolii*. Parasitoids available include *Eretmocerus californicus or Eretmocerous eremicus*.

E. formosa was imported from North America into England during the 1930s, where mass production systems were developed. However, the "pesticide era" prevented the technology from being used until the 1960s, when pesticide resistance built up in whiteflies. This resistance stimulated reevaluation of the biocontrol approach and improvements in rearing technology. This history is reviewed up to the 1980s by Hussey (1985a). Research groups in England led by Hussey and Scopes (1985), and in the Netherlands led by van Lenteren (1986) and colleagues, were responsible for this development.

Whiteflies (*Trialeurodes* spp.) are often reared on tobacco plants. *Encarsia* miniwasps are introduced into cages containing the whitefly-infested plants, where they lay eggs in late larval and pupal-stage whiteflies. Parasitized whiteflies turn black and are highly visible. Some insectaries ship the black parasitized whitefly pupae directly on the tobacco leaves, while others deliver the parasitoids on cardboard which can be hung directly on plants infested with whiteflies (Scopes and Pickford 1985).

E. formosa is most effective when released before pest numbers have reached high levels. This parasitoid is now a key component of advanced greenhouse management programs throughout the world. Many examples of their effectiveness are cited in Benuzzi and Guidi, (1989); Bugiani (1988); Lupa (1987); Sell and Kuo-Sell (1989); Yano (1988); and Zabudskaya (1989).



Encarsia formosa

Other Parasitoids

A number of parasitoid species are available for beetle control. Particularly useful is *Pediobius foveolatus* for control of the Mexican bean beetle, *Epilachna varivestis*. Like most parasitoids, it is extremely specific, attacking only the pest beetles and not beneficial ladybugs. It prefers to attack later larval stages, reproduces every 2-3 weeks, and turns yellow bean beetle larvae into brown mummies. Releases of just 4000 wasps divided over 27 sites in Florida killed most of the Mexican bean beetles in an entire county!

The wasp can produce 10 generations a year in warm areas of the South, and pest populations are suppressed for up to two years. Late June releases in urban gardens of Washington, D.C. resulted in nearly complete elimination of beetles on summer and fall beans throughout the area. Only 50 wasps can do the job in an average garden (Quarles 2001).

The parasitoids *Dacnusa sibirica* and *Diglyphus isaea* are useful for controlling leafminers and are available from several producers. Several species of mealybug parasitoids are available, mostly from European suppliers (BIRC 2003).

Predatory Lady Beetles

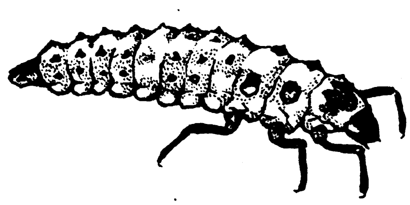
The mealybug destroyer, *Cryptolaemus montrouzieri*, the whitefly predators, *Delphastus pusillus* and *D. catalinae*, and the scale predator, *Lindorus lophanthae*, are three lady beetles available from a number of commercial insectaries. *Stethorus punctillum* is produced for mite control. Lady beetles sold for aphids include *Coleomegilla maculata*, *Harmonia axyridis*, and *Adalia bipunctata*. A new introduction in 2003 is *Pseudoscymnus tsugae* for control of the wooly hemlock adelgid, an aggressive pest in the Eastern US (BIRC 2003).

However, the most widely marketed lady beetle in North America is the convergent lady beetle, *Hippodamia convergens*. This general predator is primarily sold for control of aphids, although this species also attacks other soft-bodied insects such as scales and thrips, as well as pest mites. These beetles are most effective when pest populations are fairly high due to their habit of "knocking the top off" the pest population, then moving on to seek other plants loaded with host insects. It is best to release

Convergent lady beetle,
Hippodamia convergens

them during evening hours because bright sunlight can encourage flight.

The practice of collecting, storing and distributing hibernating *H. convergens* goes back to at least 1908 (Carnes 1912). In fact, California farmers at one time were able to obtain free of charge up to 30,000 lady beetles for every 10 acres of crops by simply writing to the superintendent of the state insectary.



Larva of *Hippodamia convergens*

Collections from Hibernation

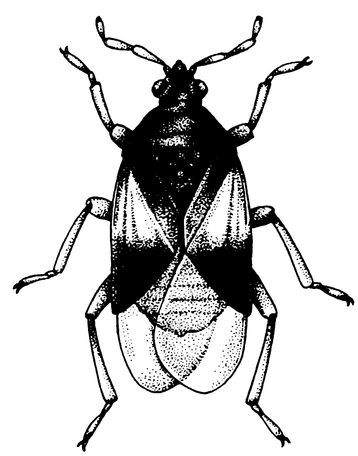
While some contemporary insectaries sell lady beetles reared on the premises, or collected from agricultural fields where they are actively feeding, the primary sources of convergent lady beetles are not insectaries. Most commercially available convergent lady beetles are marketed by entrepreneurs who collect them during winter while the beetles are still in hibernation in mountain areas. After collection, hibernating beetles are stored in refrigerated trailers until the onset of the spring and summer pest season, when they are sold through ads in garden catalogs, or through retail nurseries.

Marketing beetles collected from hibernation has caused controversy because releases may be largely ineffective. DeBach and Hagen (1964) reported that only 10% of lady beetles collected during hibernation remain at release sites, even though ample food is present. This flight is attributed to the fact that beetles collected during hibernation contain stored body fat that must be flown off before post-hibernation appetites can develop. When hungry, the beetles are voracious predators.

Fly Factor

Today, convergent lady beetles are the most commonly sold predators in retail garden outlets. Unfortunately, few of these beetles are either insectary-reared or collected post-hibernation—and thus most fly away when released. On the positive side, people who release lady beetles generally refrain from using pesticides. This restraint in turn, often permits survival of the naturally occurring beneficials necessary to control the pests that originally triggered the lady beetle release. Thus, even if the beetles fly away from the release site, other natural enemies often fill the niche.

On the negative side, purchase and release of lady beetles is often a consumer's first contact with biological control. When they observe the beetles flying away, they may decide biocontrol does not work and be discouraged from trying other, less mobile biocontrol organisms. Other questions concern levels of damage during collection, storage and sale, impacts of removing beetles from their natural habitats, and possible introduction of lady beetle natural enemies.



Minute pirate bug,
Orius tristicolor

Predatory Bugs

In addition to lady beetles, a number of predatory bug (Heteroptera) species are available. A disadvantage of predatory bugs is that they tend to be expensive. The advantage is that they are mobile and effective in seeking pests. Genera available include *Geocoris*, *Orius*, *Podisus*, *Deraeocoris*, *Xylocoris*, *Carcinops*, and *Atheta*. They are released for pest aphids, beetles, mites, thrips, caterpillars, flies, and fungus gnats. *Orius* bugs especially have been successful in controlling western flower thrips, *Frankliniella occidentalis,* in greenhouse crops (Hsu and Quarles 1995).

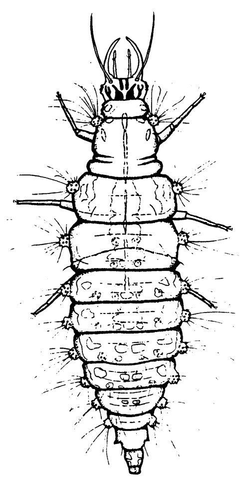
Lacewings

The two most commonly available species of lacewings are *Chrysoperla carnea* and *C. rufilabris*. It is the swift-walking larval stage of these insects that is predacious. The mass production of *Chrysoperla carnea (= Chrysopa californica; = C. plorabunda*) was first developed by Finney (1948; 1950). Lacewing eggs from these cultures were field-tested with promising results against mealybugs, *Pseudococcus maritimus*, on pears in California (Doutt and Hagen 1949). Two releases of 250 lacewing eggs per tree during the first mealybug generation produced lacewing larvae that controlled mealybugs for two seasons (Doutt and Hagen 1950). After releases, indigenous natural enemies, including lacewings, provided long-term suppression.

This success stimulated worldwide research on *C. carnea* and related species, particularly because lacewings have a wide host range. Almost any soft bodied insect, particularly aphids, mealybugs, immature scales, caterpillars, and leafhoppers are attacked, as are pest mites. Lacewings will also consume insect and mite eggs. Lacewings today are sold primarily for aphid control, and few people know that they were originally produced for control of a mealybug.

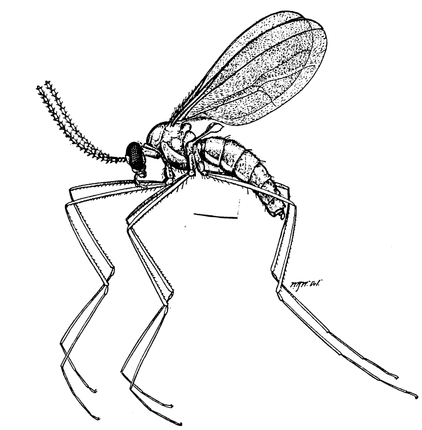
Mass Production

Mass production methods for lacewings are reviewed by Morrison and King (1977). The cannibalistic larvae are raised within individual cells on pre-formed plastic or foam cell packs. The larvae are fed eggs of the Angoumois grain moth, *Sitotroga cerealella*, which can be frozen and stockpiled for later use. In his early work, Finney used larvae of the potato tuber moth, *Phthorimaea operculella,* as the food source. Small experimental cultures can also be started by feeding mealybugs raised on sprouted potatoes to the developing lacewing larvae. After pupation, emerging lacewing adults are fed Food Wheast®, a combination of sugar and the yeast, *Saccharomyces fragilis,* which is cultured on a whey substrate produced as a by-product of the cheese industry (Hagen and Tassan 1970).[Note: Wheast® is no longer available, but similar products, Biodiet or Good Bug are sold. See BIRC's *2003 Directory of Least-Toxic Pest Control Products*.]



A larval lacewing, *Chrysopa* sp.

Lacewing eggs laid on sheets of paper are removed from the oviposition chamber after adult lacewings are temporarily immobilized by carbon dioxide or vacuum suction. A ball of nylon net, or a bleach solution, is used to separate eggs from the silken stalks on which they are laid. The single eggs are then gathered together, measured volumetrically, and sold for distribution by hand on tape or cardboard. Alternately, eggs are distributed by mechanical devices such as blowers. In experimental studies,



Adult aphid midge, *Aphidoletes aphidimyza*

Olkowski and Zeigler (unpublished) developed a mechanized rearing unit which eliminates the need to anesthetize adults in order to remove eggs. Stalked eggs pass through a comb-like edge as the paper on which they are laid is pulled from the rearing chamber. The edge prevents escape of adults. This rearing technique uses eggs and larvae of the flour beetle *Tribolium confusum*, raised on wheat flour, as a food source for lacewing larvae.

Aphid Gall Midge

Orange-colored larvae of the aphid gall midge, *Aphidoletes aphidimyza*, were first produced in mass culture in Finland. Now 27 companies produce or distribute this voracious aphid predator (BIRC 2003). The adults are fragile looking flies which hide beneath the leaves during the day. They are active at night, ovipositing their orange eggs on leaf surfaces within aphid colonies, or on the aphids themselves. The larvae are capable of consuming aphids much larger than themselves. They also paralyze large numbers of aphids, leaving them to die uneaten. In a large public conservatory of plants, the aphid midge was found to be more effective than lacewings for aphid control (Olkowski et al. 1983).

The predatory larvae are raised on living aphids and jump from leaf surfaces to pupate at ground level. Recent refinements in rearing involve use of potted plants in a rack with a water collection system from which the floating larvae and pupae can be removed. After removal, the pupae are shipped by mail.

The Mite Midge

Midges for mite control are also commercially available. Larvae of the mite midge, *Feltiella acarisuga*, prey on pest mites. The predator can consume 80 or more mites per day. It is a useful complementary predator to *Phytoseiulus persimilis* (see below). *P. persimilis* has a low dispersal rate, but the mite midge is highly mobile and seeks areas with high mite densities. Eggs and larval stages of pest mites are the preferred food (Quarles 1997).

Predaceous and Parasitic Mites

There are 29 mite families containing one or more species known to prey on various pest insects and mites (Gerson and Smiley 1990). Most of the commercially available predacious mites are in the family Phytoseiidae. A discussion of *Amblyseius cucumeris*, the predatory mite in the family Phytoseiidae which is being used for control of thrips in greenhouses is found elsewhere (Hussey 1985b).

The two-spotted spider mite, *Tetranychus urticae,* and particularly other members of the family Tetranychidae, are important worldwide pests. Their major predators are other mites, especially members of the family Phytoseiidae. There have been at least 500 papers written about this family. The large text by Helle and Sabelis (1985) is an excellent starting point for information on phytoseiids and other predators of spider mites. Included are numerous reviews showing effectiveness in many different crops.

Phytoseiids

Over 1200 species of phytoseiids have been described. There has been a great deal of confusion regarding the taxonomy of this family, which has made learning about the species difficult for the non-specialist. This confusion may have been largely resolved by Chant (1985). He includes a list of synonyms which should help in searching through earlier literature, and a small key to the four genera of importance for biological control of pest spider mite species: *Phytoseiulus* (contains 4 species), *Amblyseius* (800 species), *Typhlodromus* (275 species) and *Phytoseius* (125 species). The other six genera of phytoseiids which Chant recognizes have no known or potential value in the control of pests.

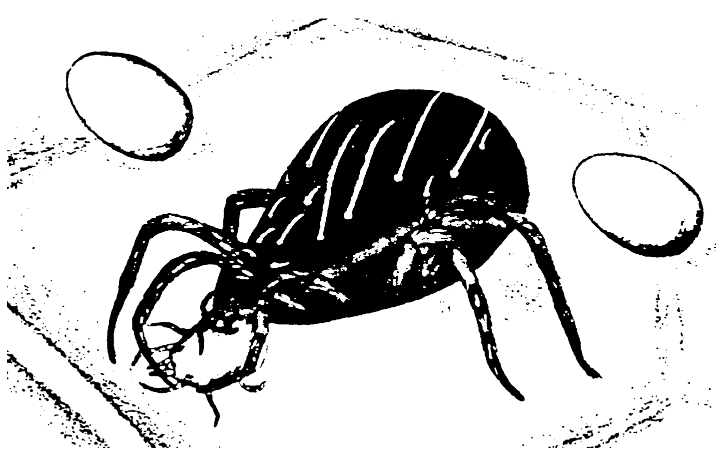
Literature on one of the most important phytoseiids, *Typhlodromus occidentalis,* is particularly rife with confusion because the species has unfortunately also been widely published under the generic name of *Metaseiulus,* and less frequently, *Euseius* and *Neoseiulus* (Chant places the latter two genera in other families). Thus, depending upon the mite specialist, one will still see published literature on *Amblyseius, Euseius, Neoseiulus,* or *Typhlodromus occidentalis* and these names all represent the same mite.

Phytoseiulus persimilis

Mass rearing of *Phytoseiulus persimilis* and *Typhlodromus occidentalis* is reviewed by Morrison and King (1977). *Phytoseiulus persimilis* is one of the most popular biocontrol agents, and it is produced or distributed by more than 100 companies (BIRC 2003). Predatory mites are reared on flat pieces of waxed cardboard painted black for easy visibility. The cardboard squares are placed on a styrofoam platform in a tray containing soapy water used as a moat to prevent mites from leaving the cardboard rearing unit. The prey, generally two-spotted spider mites, *Tetranychus urticae*, are delivered to the cardboard on leaves, where they are consumed by the predatory mites. Predators reproduce on the cardboard. Then they are vacuumed up and placed in containers (usually with wheat bran) for shipment.

One insectary in California produces two-spotted spider mites as prey on bean leaves, which are also the means for delivery of predatory mites. Farmers simply pick up their bags of predator-rich bean leaves, and distribute the leaves among their crops within an hour or two after acquisition.

Reviews citing field evaluations of the impact of predatory mites in different crops can be found in Hoy et al. (1983), Helle and Sabelis (1985), and Scopes (1985). Predatory mites are used widely to control pest mites in commercial strawberry and vegetable crops, fruit and nut orchards, and on ornamental plants. Predatory mites are also increasingly used in greenhouses where pesticide resistance has developed, and on indoor plants in malls, hotels, and office buildings where pesticide use is unpopular.



***Phytoseiulus persimilis* predatory mite**

Conclusion

Biocontrol organisms produced by North American insectaries are beginning to move from a niche industry into the mainstream. Driving this change is the expansion of organic agriculture and the need to find alternatives for the more toxic pesticides. Key to the expansion of the industry is a better understanding by the public of which organisms are available, and how and when to use them. Hopefully, this article has shed some light on this subject.

William Olkowski and Helga Olkowski are BIRC Founders. They can be reached by writing BIRC, PO Box 7414, Berkeley, CA 94707 or by emailing birc@igc.org. Everett Dietrick is the owner of Rincon-Vitova Insectaries, PO Box 1555, Ventura, CA 93002; 800/248-2847, email bugnet@rinconvitova.com. William Quarles, Ph.D. is Managing Editor of the IPM Practitioner, and Executive Director of BIRC.

References

Bao, Jian-zhong and Chen, Xiu-hao. 1989. Research and applications of *Trichogramma* in China. Academic Books and Periodicals Press, Beijing. 220 pp.

Benuzzi, M. and A. Guidi. 1989. Experiments in biological and integrated control in protected and field crops. (Esperienze applicative di lotta integrata e biologica nelle colture protette e di pieno campo. *Informatore-Agrario* 55(Suppl. 35):53-58.

BIRC. 2003. *2003 Directory of Least-Toxic Pest Control Products.* Bio-Integral Resource Center, PO Box 7414, Berkeley, CA 94707; 510/524-2567, birc@igc.org.

Bugiani, A. 1988. Integrated control in the greenhouse (in Italian). *Colture-Protette* 17(8):67-71.

Carnes, E.K. 1912. Collecting ladybirds (Coccinellidae) by the ton. *Calif. State Hort. Comm. Monthly Bull.* 1:71-81.

Chant, D.A. 1985. Systematics and taxonomy. In: Helle and Sabilis, pp. 17-29.

Clausen, C.P., ed. 1978a. *Introduced Parasites* *and Predators of Arthropod Pests and Weeds: a World Review.* Agriculture Handbook No. 480. United States Department of Agriculture, Agricultural Research Service, Washington, D.C. 545 pp.

Clausen, C.P. 1978b. Biological control of citrus insects. In: Reuther et al., pp. 276-320.

DeBach, P. and K.S. Hagen. 1964. Manipulation of entomophagous species. In: DeBach and Schlinger, pp. 429-458.

DeBach, P. and E.I. Schlinger. 1964. *Biological Control of Insect Pests and Weeds.* Chapman and Hall Ltd., London. 844 pp.

Dietrick, E.J. 1981. Commercial production and use of predators and parasites for fly control programs. In: Patterson et al., pp. 192-200.

Doutt, R.L. and K.S. Hagen. 1949. Periodic colonization of *Chrysopa californica* as a possible control of mealybugs. *J. Econ. Entomol.* 42:560.

Doutt, R.L. and K.S. Hagen. 1950. Biological control measures applied against *Pseudococcus maritimus* on pears. *J. Econ. Entomol.* 43:94-96.

Essig, E.O. 1931. *A History of Entomology.* The Macmillan Company, New York. 1029 pp.

Finney, G.L. 1948. Culturing *Chrysopa californica* and obtaining eggs for field distribution. *J. Econ. Entomol.* 41:719-721.

Finney, G.L. 1950. Mass-culturing *Chrysopa californica* to obtain eggs for field distribution. *J. Econ. Entomol.* 43:97-100.

Gerson, U. and R.L. Smiley. 1990. *Acarine Biocontrol Agents, an Illustrated Key and Manual.* Chapman and Hall, London. 174 pp.

Hagen, K.S. and R.L. Tassan. 1970. The influence of Food Wheast® and related *Saccharomyces fragilis* yeast product on the fecundity of *Chrysopa carnea. Can. Entomol.* 102:806-811.

Helle, W. and M.W. Sabelis. 1985. *Spider Mites their Biology, Natural Enemies and Control.* Vol. 1B. Elsevier, Amsterdam. 458 pp.

Hoy, M.A. et al. 1983. *Biological Control of Pests by Mites.* Publication No. 3304. Division of Agriculture and Natural Resources, University of California, Berkeley.

Hsu, C. and W. Quarles. 1995. Greenhouse IPM for western flower thrips. *IPM Practitioner* 17(4):1-11.

Hussey, N.W. 1985a. Whitefly control by parasites. In: Hussey and Scopes, pp. 104-115.

Hussey, N.W. 1985b. Thrips and their natural enemies. In: Hussey and Scopes, pp. 53-57.

Hussey, N.W. and N. Scopes. 1985. *Biological Pest Control, the Glasshouse Experience.* Cornell University Press, Ithaca, New York. 240 pp.

IPM. 2003. IPM of Alaska, Rocco Moschetti, PO Box 875006, Wasilla, AK 99687; www.ipmofalaska.com

Lupa, W. 1987. Possibilities of biological control of the greenhouse whitefly (*Trialeurodes vaporariorum* Westw.) on gerbera freesia and other ornamentals grown in greenhouses (in Polish). *Materialy Sesji Instytutu Ochrony Roslin.* 27(2):33-37.

Merritt, R.W., E.F. Gersabeck and M.K. Kennedy. 1981. The contribution of *Spalangia endius* and *Muscidifurax raptor* to a stable fly management program on Mackinac Island, Michigan: a question of effort. In: Patterson et al., pp. 44-51.

Morgan, P.B. 1980. Mass culturing three species of microhymenopteran pupal parasites, *Spalangia endius* Walker, *Muscidifurax raptor* Girault and Sanders, and *Pachycrepoideus vindemiae* (Rondani) (Hymenoptera: Pteromalidae). VIII. Renunion Nacional de Control Biologico. Tecomon, Colima, Mexico. April 22-25, 1980.

Morgan, P.B. 1981. Mass production of *Musca domestica*. In: Patterson et al., pp. 189-191.

Morrison, R.K. and E.G. King. 1977. Mass production of natural enemies. In: Ridgway and Vinson, pp. 183-217.

Olkowski, W., S. Daar, and H. Olkowski. 1983. IPM for a conservatory and greenhouses. *IPM Practitioner* 5(8):4-6.

Olkowski, W. 1985a. IPM programs for filth flies. *IPM Practitioner* 7(6/7):1-8.

Olkowski, W. 1989. Biological control of pests succeeds in large-scale agriculture. *IPM Practitioner* 11(3):1-8.

Olkowski, W. and A. Zhang. 1990. *Trichogramma* —a modern day frontier in biological control. *IPM Practitioner* 12(5/6):1-15.

Patterson, R.S., P.G. Koehler, P.B. Morgan and R.L. Harris. 1981. *Status of Biological Control of Filth Flies.* Proceedings of a workshop, February 4-5, 1981, University of Florida, Gainesville. USDA, Insects Affecting Man and Animals Research Laboratory, P.O. Box 14565, Gainesville, Fl. 32604. 212 pp.

Pike, K.S., P. Stary, T. Miller, D. Allison, L. Boydston and G. Graf. 1999. Host range and habitats of the aphid-parasitoid *Diaeretiella rapae* (Hymenoptera: Aphidiidae) in Washington State. *Environ. Entomol.* 28:61-71.

Pike, K.S., P. Stary, T. Miller, D. Allison, L. Boydston, G. Graf and R. Gillespie. 1997. Small grain aphid parasitoids (Hymenoptera: Aphelinidae and Aphidiidae) of Washington: distribution, relative abundance, and seasonal occurrence; and key to known North American species. *Environ. Entomol.* 26: 1299-1311.

Pinto, J.D. 1998. The role of taxonomy in inundative release programs utilizing *Trichogramma*. In: Hoddle, M.S., ed. *Innovation in Biological Control Research*, Proceedings of the 1st California Conference on Biological Control, June 10-11, 1998, Berkeley, CA.pp.45-49.

Quarles, W. 1997. Biocontrol of mites with midges. *IPM Practitioner* 19(4):8-9.

Quarles, W. 2001. Beating the Mexican bean beetle. *Kitchen Gardener* 32(5/6):46.

Reuther, W., E.C. Calavan and G.E. Carman. 1978. *The Citrus Industry.* Vol. IV. University of California, Berkeley. 362 pp.

Ridgway, R.L. and S.B. Vinson. 1977. *Biological Control by Augmentation of Natural Enemies, Insect and Mite Control with Parasites and Predators.* Plenum Press, New York. 480 pp.

Rose, M. 1990. Rearing and mass rearing. In: Rosen, pp. 357-366.

Rosen, D. ed. 1990. *Armoured Scale Insects, their Biology, Natural Enemies and Control.* Vol. A. Elsevier, Amsterdam. 383 pp.

Scopes, N.E.A. 1985. Red spider mite and the predator *Phytoseiulus persimilis.* In: Hussey and Scopes, pp. 43-52.

Scopes, N.E.A. and R. Pickford. 1985. Mass production of natural enemies. In: Hussey and Scopes, pp. 197-209.

Sell, P. and H.L. Kuo-Sell. 1989. Well-tried and new beneficial organisms. Practical knowledge obtained in biological pest control in ornamental cultivation under glass and possibilities for its development (in German). *Deutscher-Gartenbau.* 43(42):2548-2553.

van Lenteren, J.C. 1986. Parasitoids in the greenhouse: successes with seasonal inoculative releases. In: Waage and Greathead, pp. 341-376.

Van Driesche, R.G., M. Hoddle, S. Lyon, T. Smith and P. Lopes. 2003. Greenhouse project: natural enemies for suppression of greenhouse pests. III. Buying and using natural enemies in greenhouse floral crops. www.umass.edu/umext/ipm/

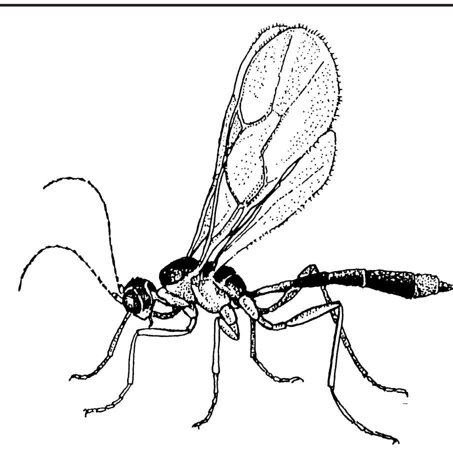
Van Driesche, R.G. and T.S. Bellows, Jr. 1996. *Biological Control.* Chapman and Hall, New York. 539 pp.

Waage, J. and D. Greathead. 1986. *Insect Parasitoids.* Academic Press, New York. 389 pp.

Yano, E. 1988. The population dynamics of the greenhouse whitefly (*Trialeurodes vaporariorum* Westwood) and the parasitoid *Encarsia formosa* Gahan. Bulletin of the National Research Institute of Vegetables, Ornamental Plants and Tea. Part A, No. 2, 143-200.

Zabudskaya, I.A. 1989. Biological control of the greenhouse whitefly, *Trialeurodes vaporariorum* (Homoptera, Aleyrodidae). *Acta-Entomologica-Fennica.* 53:73-76.

Zhang, Zhili et al. 1978. Preliminary study on use of *Trichogramma ostriniae* to control corn borer. *J. of Entomology* 16(5):251-255 (in Chinese).



The parasitoid, *Aphidius* sp.

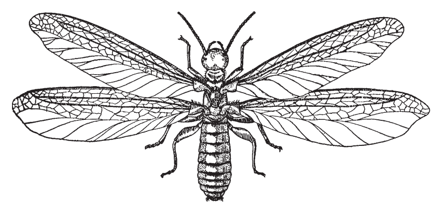
ESA 2002 Annual Meeting Highlights—Part 3

By Joel Grossman

These highlights from the Entomological Society of America's (ESA) annual meeting Nov. 17-20, 2002, in Fort Lauderdale, Florida, were selected from among over 1,800 presentations. ESA's next annual meeting is October 26-30, 2003, in Cincinnati, Ohio. For more information contact program chair Bob Wright (University of Nebraska, South Central Res. & Ext. Center, P.O. Box 66, Clay Center, NE 68933; phone 402/762-4439; rwright2@unl.edu) or the ESA (9301 Annapolis Rd., Lanham, MD 20702; 301/731-4535; http://www.entsoc

Heat treatment is an alternative to fumigation with toxic gases such as methyl bromide and sulfuryl fluoride (Vikane). A whole structure can be treated for drywood termites in a few hours, whereas toxic gases take a day or more, said Brian J. Cabrera (Univ of Florida, 3205 College Ave, Ft. Lauderdale, FL). A heat treatment can be applied after normal business hours or on non-business days, and businesses can avoid closing down and losing customers. Heat can be used to spot treat inaccessible areas and target specific parts of buildings and multiunit dwellings. In addition to drywood termites, heat also kills dust mites, bedbugs, cockroaches, borers, fungi and viruses. Heat, however, does not leave a residual to prevent reinfestation.

The heat feels like a dry sauna, and no breathing apparatus is necessary for pest control operators (PCOs). Short exposures are okay, but workers are advised not to stay too long in the heat. On the downside, there is sometimes heat damage to thin plastics, refrigerator magnets, items with glue, and heat sensitive equipment. The heat output is about 150,000 BTU, and pianos and collections are wrapped in tarps for protection. In Southern California heat fumigation has been adapted to large buildings, and is considered a good choice for those with chemical sensitivities.



A winged termite

South Florida, with its many condos and other compartmentalized buildings, is especially suited for heat treatment, as treatment can be limited to one unit. For attic treatments, mylar can be used to seal the ducts and leave the rest of the house usable. Heat treatment is compatible with current technologies. In fact, it is hard for most people to distinguish Terminex trucks carrying propane cylinders, tarps and burners for heat fumigation from traditional chemical fumigation trucks. Besides heavy equipment, heat fumigation requires labor to monitor temperatures. Also residents must be evacuated for several hours.

Cabrera found that 60 minutes at 115°F (46°C) killed 95-100% of of the drywood termite, *Cryptotermes brevis*; 4 minutes at 120°F (49°C) killed them all. In contrast, Ebeling found that 120°F (49°C) for 33 minutes was needed for 100% mortality of the western drywood termite, *Incisitermes minor*. Terminex provides a margin of error, heating for 60 minutes at 130°F (54°C).

Termite Natural Enemies

According to Guy Mercadier (ECBL, USDA-ARS, CS 90013 Montferrier sur Lez, St Gely du Fesc, France), "the Formosan subterranean termite, *Coptotermes formosanus*, is native to southern China, and is believed to have arrived in the United States on military ships returning from the Pacific theater after World War II." The first colonies were found in New Orleans and later Lake Charles, LA; Galveston and Houston, TX; and Charleston, SC. Its range in the United States is expanding every year, and it has been detected in San Diego, CA. Control and building repair costs are over $1 billion per year. In New Orleans, where 30% of trees are infested, homeowners may spend several thousand dollars per year.

As lead agency in the National Formosan Subterranean Termite Management Program, the USDA-ARS European Biological Control Lab is searching worldwide for natural enemies. About 65,000 termites were collected from 250 localities in China, Malaysia, Australia, and South Africa in 2001. "By sampling as many populations as possible, the chances of finding effective natural enemies are correspondingly high," said Mercadier. Termites have the ability to detect disease in sick or dead individuals. Collecting pathogens from termites themselves might increase the probability of finding an agent that has the ability to evade the detection barrier.

The most virulent fungal pathogens, mainly *Beauveria*, *Metarhizium* and *Paecilomyces*, are being produced and tested. The best will be selected for use in the U.S. Five nematode isolates and parasitic flies attacking termites in China are also being evaluated.

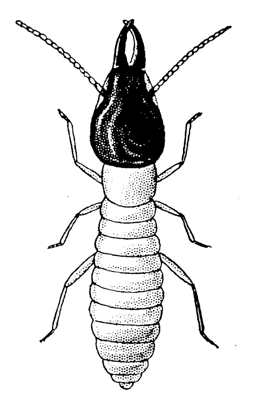
Microbial Termite Control

Termites inhabit a dark, damp habitat favorable to fungi such as *Metarhizium anisopliae*, said Brian

Forschler (Univ of Georgia, Athens, GA), who tested *M. anisopliae* (Bio-Blast™) against *Reticulitermes flavipes* and *R. virginicus.* Though *M. anisopliae* had an impact on termite populations, it did not affect reproductives. Termites stayed away from areas treated with *M. anisopliae* for a few days or a week and did not recolonize the area. Results of monthly termite monitoring with Termatrol™ bait traps were consistent with lab studies. Termites stayed out of areas treated with *M. anisopliae* for a month. Though liquid formulations of *M. anisopliae* did not have a major population impact, Forschler said that it "may be useful if you want to chase termites away from a spot for awhile."

Entomogenous nematodes such as *Steinernema carpocapsae* and *Heterorhabditis indica* can tunnel through soil searching for hosts, making them of interest for termite IPM. Mark Mankowski (Univ of Hawaii at Manoa, 3050 Maile Way room 310, Honolulu, HI) compared the nematode susceptibility of workers and soldiers of *Coptotermes formosanus* and *C. vastator*, a species new to Hawaii. *S. carpocapsae*, produced higher termite mortality in the laboratory than *H. indica.* In mortality experiments (0-320 nematodes/termite), more nematodes were needed to kill workers than soldiers.

When nematodes were confined with *C. formosanus* for four days, there was significantly higher soldier mortality when soldiers were alone, compared to when soldiers were with workers. Exudates covering termite soldiers will be investigated to see if they play a role in nematode attachment. Though he did not observe grooming behavior, Mankowski believes that soldiers cannot groom themselves and that workers groom soldiers to remove nematodes.



Soldier of *Coptotermes formosanus*

Fungi and Termites

In laboratory studies the fungus *Metarhizium anisopliae* kills 100% of healthy termites, but field results are less successful. One possibility is disease-fighting social behaviors within termite colonies. For example, *Zootermopsis augusticollis* infected with fungus bangs its head, producing vibrations that act as an alarm.

Susan Whitney (Univ of Delaware, Townsend Hall room 254, Newark, DE) videotaped various groups of *Reticulitermes flavipes* treated either with *M. anisopliae* (Bio-Blast™) or plain talc, or left untreated. Each 10-minute segment of videotape had 1,200 frames, which meant analyzing tens of thousands of frames with 2-5 termites per frame. Imaging software created by Wayne Rasband of the National Institutes of Health handled the problem of tracking individual termites in the group and tabulating the behavior on each videotape frame.

The analysis showed that termites interact more when the fungus is present. The overall interaction rate increases uniformly when a termite in the group is infected, but the number of interactions with the infected termite does not change. Termites can also recognize the difference between a termite exposed to fungus and one exposed to talc.

Termite Wars

Xing Hu (Auburn Univ, Auburn, AL) talked about interactions between termite species. Workers and soldiers of Formosan subterranean termite, *Coptotermes formosanus*, and eastern subterranean termite, *Reticulitermes flavipes*, collected in Alabama "demonstrated ferocious agonistic behavior" when placed together. Both soldiers and workers of *C. formosanus* were much more aggressive than those of *R. flavipes* in all bioassays. Indeed, *R. flavipes* workers and soldiers suffered more injury and higher mortality than *C. formosanus* workers and soldiers.

When *C. formosanus* workers were tested against *R. flavipes* soldiers, both had a similar degree of injury and mortality. When soldiers were tested without workers, there was 100% *R. flavipes* injury in 144 seconds. When no soldiers were present, workers of both species fought and suffered high injury and mortality rates.

Margaret Schwinghammer (Univ of Missouri, 1-87 Ag Bldg, Columbia, MO) is studying *Reticulitermes* nest evacuation behavior. Typically, when a nest or food source is disturbed, part of the colony abandons the site. This movement could have strong implications on the efficiency of termite baiting systems. The length of time the site remains unoccupied, the factors determining which alternative areas are preferred, and the frequency of return to a disturbed site are unclear.

Colonies with 1% soldiers returned to the disturbed site within 12 hours. Colonies with 3% soldiers returned within two days. Those with a 5% soldier population did not relocate when disturbed. Temperature is also a factor, with a slower response at 16°C (61°F) than at 21 or 27°C (70 or 81°F).

Western Subterranean Termite

According to K. Haagsma (Univ of California, Riverside, CA), 57% of termite service calls in San Diego, CA involve the western subterranean termite, *Reticulitermes hesperus,* a mainly coastal species found from Baja California to British Columbia, Canada. In barrier trials, imidacloprid (Premise) placed between the soil and structures provided greater than expected *R. hesperus* mortality, suggesting an areawide effect. For example, 500 ppm of imidacloprid provided 100% mortality after 14 days, versus an expected 40%; 100 ppm provided 82% mortality, not the expected 5%; 50 ppm caused 38% mortality, instead of no effect.

Haagsma investigated whether *R. hesperus* could pick up imidacloprid from the barrier and transfer it from termite to termite by contact, trophallaxis or other means. Using radioactive imidacloprid to monitor transfer from termite to termite, Haagsma found that 10% of the material picked up was transferred to other termites. Sealing termite mouthparts with superglue had little effect, indicating that trophallaxis was not a major means of spreading imidacloprid, and thus it does not work like a bait. Most likely, imidacloprid is spread among termites by contact. Imidacloprid depresses termite movement; exposed termites are not very ambulatory; and there is probably an attrition effect over time that nullifies the excess mortality observation.

Areawide Baiting in Chile

According to James Smith (Controles Integrados S.A, Venezuela 0675, Recoleta, Santiago, Chile), an areawide baiting approach to management of subterranean termite, *Reticulitermes santonenesis* or *R. flavipes*, is being successfully implemented in a six block area of Santiago, Chile. Some homes in the area have wood in contact with soil, but are very dry and did not have termite problems until recently. Some residents are too poor to afford termite control and have resorted to extreme tactics such as blow torches to stop termites from eating the cardboard or sheetrock parts of their homes.

Government funding is being used to survey for termites with wooden stakes, and within 30 days 22.6% of the stakes were attacked. "It was very difficult to pull wood out of the ground and not find termites," said Smith. Sentricon® baiting and measurement of wood consumption are part of the IPM program. Some areas had such heavy termite levels that even after 1.5 years of baiting with 500 bait tubes in an 0.5 ha area, there are still termites. However, baiting has lowered the number of termites in the whole area, making it harder to find termites and reducing wood consumption.

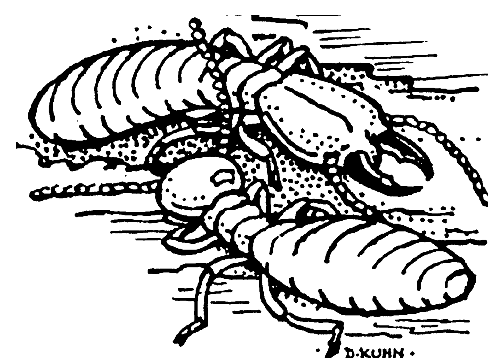
Areawide IPM in U.S.

Areawide termite control is being used in some parts of Mississippi. According to M. Guadalupoe Rojas (USDA-ARS, FSTRU, 1100 Robert E. Lee Blvd, New Orleans, LA), "house by house treatment of subterranean termites is not an efficient control method." The experimental areas in Picayne and Poplarville consisted of blocks of homes where sticky traps had found swarming Formosan subterranean termites during 2000-2001 seasons. Following the areawide concept, 150 Exterra underground stations were installed 15 ft (4.6 m) apart from each other.

Formosan and *Reticulitermes* populations in the test area were exposed to four active ingredients: diflubenzuron; diflubenzuron and the fungus Bio-Blast™; Bio-Blast alone; and the IGR chlorfluazuron. All the tested treatments suppressed the termites. Chlorfluazuron required less active ingredient and took half the time of other actives.

According to Dennis Ring (Louisiana State Univ, PO Box 25100, Baton Rogue, LA), Formosan termites cause $300 million damage each year in New Orleans and $500 million in Louisiana, including collapse and demolition of structures and loan defaults. Even creosote-treated wood and live trees are attacked. An areawide control program began in 1998 in the French Quarter of New Orleans. Fifteen blocks treated with termiticides or baits by licensed PCOs are being compared to untreated blocks as part of the National Formosan Subterranean Termite Management Program.

To monitor for flying reproductives, sticky traps were hung on light poles within 2 m (6.6 ft) of lamps. Termites were counted every two weeks during May and June. In-ground stations were also installed to measure foraging activity. Data from both methods "show that areawide management reduced termite activity in the 15-block area." In 2002, the treated area was expanded to another 15 city blocks.



A termite soldier and worker

Subterranean Termite Baits

Since termites avoid areas containing dead termites, effective baits have to be slow acting and non-repellent (see *IPMP* 25(1/2):1-12). But the effective dose can vary widely among termite species, said Erin Monteagudo (Univ of Florida, Ft. Lauderdale Res & Educ Center, 3205 College Ave, Ft. Lauderdale, FL). Increasing concentrations of the IGR halofenozide can reduce termite consumption of treated wood; over 60% mortality can be achieved in 4-6 weeks.

At 600 ppm, halofenozide starts to become repellent to eastern subterranean termite, *Reticulitermes flavipes*. However, western subterranean termite tolerates 10,000 ppm before there is a great effect. Though not effective against foraging termites, halofenozide shows good potential against Formosan and subterranean termite adult reproductives.

Labyrinth™, a bait matrix impregnated with the chitin synthesis inhibitor, diflubenzuron, is being used in single-family homes and date palm orchards in the United Arab Emirates (UAE) against sand termite, *Psammotermes hypostoma* (Rhinotermitidae), and harvester termite, *Anacanthotermes orchraceus* (Hodotermitidae), said Walid Kaakeh (United Arab Emirates Univ, PO Box 17555, Al-Ain, UAE). Eight termite bait stations were placed around each single-family home; and stations were installed 2 m (6.6 ft) from trees in orchards. The stations were inspected monthly for termites, and 100 g (3.5 oz) of Labyrinth™ bait was added when termite activity was detected.

Complete bait consumption was noticed in most stations one month after placement. The elimination of the termite population at all sites gave complete protection of all single-family houses, as well as date palm trees.

Joe DeMark (Dow AgroSci, 876 Buckeye Lane W., Jacksonville, FL) compared Sentricon® stations baited with either hexaflumuron or noviflumuron for protection of single-family Florida homes and barns. Structures were attacked mostly by *Reticulitermes flavipes,* but some *R. virginicus,* subterranean termite colonies. Pre-baiting foraging territories ranged from 2 to 40 bait stations. An exceptionally large *R. flavipes* colony occupied a former orange orchard containing well-irrigated pines and pine stumps. Noviflumuron (0.25-0.5%) eliminated termite colonies significantly faster than hexaflumuron (0.5%), 113 days versus 191 days. Less than one gram (0.04 oz) of noviflumuron killed an entire colony.

"Pest management professionals in the southeastern United States are most likely to encounter *R. flavipes* and *R. virginicus* when using termite baiting systems," said Idham Harahap (Clemson Univ, Clemson, SC). In the laboratory both native species of termites consume more cellulose at warmer temperatures. However, in the field, native subterranean termites likely avoid soil or monitoring stations that are too hot. Indeed, subterranean termites in South Carolina feed more at monitoring stations in the spring and fall, and survivorship is higher at 18°C (61°F) than at 28°C (82°F).

New Bait Matrix

The idea behind the M-714 bait matrix, marketed as Summon™ is that subterranean termite species will find the bait and produce pheromones to recruit more termites, said James Ballard (FMC Corp, Specialty Products Business, 1735 Market St, Philadelphia, PA). In paired comparison laboratory studies in petri dishes, *Reticulitermes flavipes and Coptotermes formosanus* were given the choice between wet polyester fabric with Summon™ and several wood species commonly used for monitoring. Significantly more termites aggregated on the fabric laced with Summon™, and there was little interest in the wood.

New Jersey Experiment Station field trials in 2001 and 2002 used varied doses of Summon in bait stations against *R. flavipes* and *R. hagenii*. Each four-chambered bait station (Defender™) holds either four FirstLine® GT Plus Termite Bait Stations or wooden monitors. In an October 2001 trial, Defender units with Summon were infested much faster than units without. In a June trial where traps with 5 g (0.18 oz) of Summon dust were checked every 2-3 weeks, significantly more termites were captured in traps with Summon. Within a month, traps with Summon captured 400% to 800% more termites than those with wood attractants.

In September 2002, field trials of Summon were started around homes in seven states. Preliminary results after 2 weeks showed 300% to 700% more termite hits in monitoring stations with Summon.

Borate Avoidance

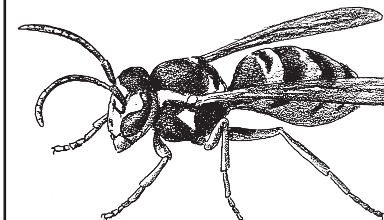
At certain disodium octaborate tetrahydrate (DOT; Timbor®) wood treatment concentrations, termite wood feeding ceases quickly and wood suffers only minor surface damage, said Cory Campora and J. Kenneth Grace (University of Hawaii, 3050 Maile Way, Gilmore Hall Rm 310, Honolulu, HI). Plexiglas™ arenas with damp sand floors and wood wafer foraging sites were established to study the factors causing termites to avoid DOT-treated wood. Untreated and borate pressure-treated Douglas fir wafers were placed in varying arrangements in the arenas. Daily digital imaging quantified termite tunneling in the arenas, and ArcView software visually mapped the data in three dimensions.

Termites usually moved out from the center to forage, and within 10 days populations were randomly distributed. But in arenas with a choice of DOT-treated and untreated wood wafers, termites left the DOT-treated wood and started moving to the untreated wood within 7-9 days.

By day 14, termites had abandoned the DOT-treated wood section of the arena and clustered on the untreated wood. When DOT-treated wood was later replaced with untreated wood, the termite distribution did not change. Future research will help understand whether termites have a learned avoidance of DOT-treated wood.

IPM Takes Sting Out of Schools

"Stinging insects are among the most frequent and persistent pest problems at schools, parks, and similar locations," said Jody Gangloff-Kaufmann (Cornell Univ, 1425 Old Country Rd., Bldg. J, Plainview, NY). Jody is part of a team bringing IPM alternatives to schools and other sensitive sites throughout New York State. Wasp stings often cause mild reactions, but severe allergic reactions to yellowjacket stings kill 40 people in the U.S. every year. Hence, "stinging insects are considered among the most serious of pests in the school environment," and necessi-



Yellowjacket, *Vespula* sp.

tate a high percentage of outdoor pesticide applications.

Semimonthly inspections were sufficient for maintaining control of paper wasps, *Polistes dominulus*, and locating nests of yellowjackets. Yellowjacket nests, particularly in wall voids and in the ground, were harder to locate and remove than paper wasp nests. Often nests were large, and had many adults flying in and out before they were noticed. If a colony had only a single queen, control was obtained without insecticides by knocking down the nest with a pole. Larger nests had a higher likelihood of being rebuilt if not sprayed to kill foragers.

Larger paper wasp colonies or nests in hard to reach places were sprayed with low-toxicity insecticides (particularly dusts) containing mint oil or eugenol, and then removed. When nest destruction was consistently performed early in the season, construction of new nests at managed sites had diminished by mid-summer. During two years, 78 nests at two locations were eliminated with water spray. An attempt to rebuild the nest was made in only 11 (14%) locations. Physically knocking down nests and water sprays worked particularly well against mud daubers.

Several methods were investigated, including vacuuming workers from a void and digging nests out of the ground. Yellowjackets were vacuumed with the hose end at the opening of the nest, capturing workers as they entered and exited the nest. Vacuuming took about an hour. Yellowjacket numbers remained lower, but there was a slow increase over time as workers emerged from pupation. Vacuuming or bagging aerial nests in shrubs and removing nests also worked with baldfaced hornets. Ground removal of nests was less practical, and required workers to wear protective clothing while digging.

Exclusion, Traps, and Sanitation

Exclusion was used extensively to reduce the number of nest sites on the managed properties. The materials used included expanding insulating foam, caulk, steel wool, and insect screening. Exclusion sites consisted of playground equipment, tennis courts, light posts, doorways, signs, and cracks and gaps on the outside of buildings, especially in the eaves. Exclusion was particularly effective in reducing paper wasp activity inside fence pipes and other hollow metal or concrete structures. Exclusion methods were only implemented after IPM techniques or the onset of cold weather killed active nests.

"Food-based attractants in jar traps were used to draw wasps away from sensitive areas," said Gangloff-Kaufmann. Glueboard traps on garbage container lids (underside), over doorways and on playground equipment mainly captured flies, earwigs and other insects; and this line of research was stopped. Pineapple juice, apple juice, fruit punch and beer evaporated rapidly from traps on warm summer days. So new liquid to attract wasps was added and traps were cleaned weekly. At two school sites, 98% of the almost 10,000 insects trapped were yellowjackets, mainly *Vespula* species.

At a prison site, 20 traps alongside six dumpsters by a fence trapped over 1,000 wasps in a month without visibly reducing wasp numbers. In summer, garbage dumpster stench overpowered the attractant in baited traps. In all cases where food wastes attracted wasps, recommendations were made to regularly wash garbage containers, keep them covered, and to place waste into plastic bags, which were then sealed and put into receptacles. Sanitation extended to recycling pails and honeydew-producing aphids on plants. But sanitation alone was not the solution at every school, farm and restaurant site, indicating the need for an IPM approach with multiple control techniques.

A peripheral trap experiment in a hay/grass field involved placing traps 8 ft (2.4 m) high atop metal poles every 20 ft (6.1 m) along plot perimeters, with a trap in the plot center. Yellowjacket container traps were baited every 2-3 days for 2 weeks. The traps were a strong enough attractant that they were deemed "more appropriate in areas that would normally attract yellowjackets, such as garbage disposal areas, or in remote areas away from human activity." In other words, baited traps should not be used in school playgrounds that do not normally have food sources attracting wasps. Information from this ongoing trapping experiment "is needed to help optimize wasp trap placement in areas such as playgrounds, parks and yards."

Commercializing Polymer Film Barriers

In building his own house in Florida, Nan-Yao Su (Univ of Florida - Ft. Lauderdale Res & Educ Cent, 3205 College Ave, Ft. Lauderdale, FL) rejected the conventional solution of treating the soil with large quantities of liquid termiticides in favor of a polymer film barrier containing much less insecticide. The termite species involved were the Formosan subterranean termite, *Coptotermes formosanus*, and eastern subterranean termite, *Reticulitermes flavipes*.

In 1996, a polycarbonate polymer film barrier impregnated with 2% lamda-cyhalothrin was buried in a sand plot, covered with a red clay indicator layer, and topped with concrete. Every year Su drilled sample cores of soil and polymer barrier and analyzed for lamda-cyhalothrin leaching. The first two years termites barely got in, touching the polymer film barrier and then stopping. In subsequent years, termites started penetrating deeper. But even after five years there was still 60%-70% active ingredient in the polymer film barrier, enough to prevent termite penetration.

Steady state soil concentration was a function of the release rate from the polymer and the degradation rate in the soil. Over time, there was less chemical leaching, more degradation, lower soil concentrations and more termite penetration. The commercial product registered with EPA, Impasse™ (Syngenta), uses a stronger yet porous construction-grade plastic that sandwiches lamda-cyhalothrin between two protective polymer layers.

The first Impasse™ product for sale blocks termite entry via utility pipes. Test plots now in their third year should yield a commercial polyethylene film barrier product that can be installed prior to pouring a building's concrete slab.

Soil Treatments

Faith Oi (Univ of Florida, Bldg 970, Natural Area Dr, PO Box 110620, Gainesville, FL) talked about non-repellent termiticides. These are supposed to last for at least five years. However, applications are highly imperfect, leaving the actual concentration applied and barrier thickness variable. It common to have gaps in treatments or treatment depths as thin as 1 mm (0.04 in). When soil was treated to a depth of 1 mm, termites penetrated all concentrations of chlorfenapyr (Phanthom; BASF), fipronil (Termidor; BASF) and imidacloprid (Premise; Bayer). Treatment with 100 ppm at 1 mm depth gave 99% termite mortality with fipronil; 81% with chlorfenapyr; 79% with thiamethoxam; and 28.5% with imidacloprid.

When soil is compacted to different soil densities, the termite tunnel network changes, said Cynthia Linton Tucker (Univ of Florida, Bldg 970, Natural Area Dr, Gainesville, FL). Tucker examined *R. flavipes* tunneling in moistened building sand that was low, moderately, or highly compacted. Subterranean termites do not follow pheromone trails or wood volatiles, but they may follow moisture gradients and be sensitive to soil pore space disturbances. In the first 24 hours there is more tunneling and a higher number of secondary tunnels in soils with low compaction.

Black Pepper for Urban IPM

"Black pepper, *Piper nigrum*, is grown in large quantities in tropical regions of the globe and is one of the most common spice plants traded," said Ian Scott (Univ of Ottawa, 150 Louis Pasteur, Ottawa, ON, Canada). According to Scott, black pepper is worth considering as a botanical pesticide, as it has a long record of safe use and low health risks.

Several wild insect species were bioassayed on plant leaves with a 20% extract of ground peppercorns. In repellent trials, leaves were treated with 100 ml of 0.5% black pepper extract alone or in combination with recommended doses of neem oil, garlic, or lemon grass oil extracts. In field trials, Yukon Gold potato plants with Colorado potato beetle, *Leptinotarsa decemlineata*, were treated with 0.5% black pepper extract.

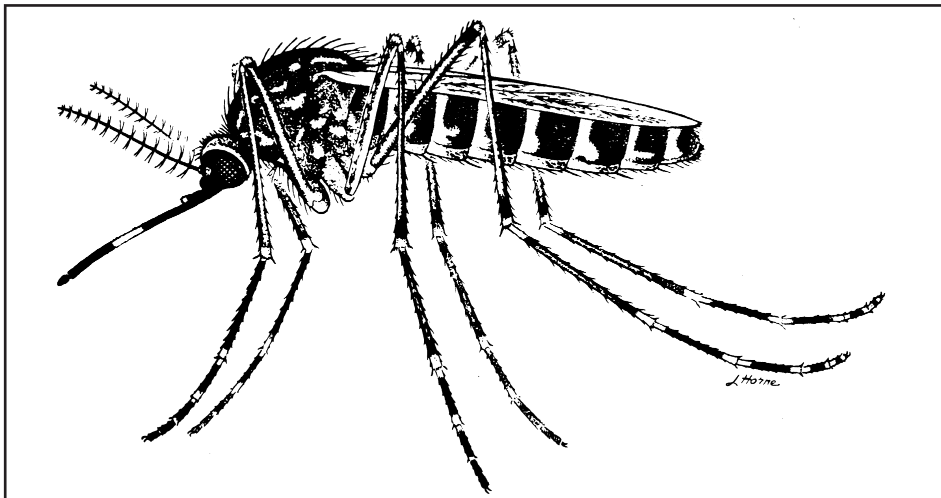
The most practical use of *P. nigrum* extracts may be for control of mosquito larvae in temporary pools, as very low concentrations are needed. Less than 0.1% *P. nigrum* controlled eastern tent caterpillar, *Malacosoma americanum*, European pine sawfly, *Neodiprion sertifer*, and spindle ermine moth, *Yponomeuta cagnagellus*. Between 0.1% and 0.2% *P. nigrum* controlled adult striped cucumber beetles, *Acalymma vittatum*; and larval lily leaf beetles, *Lilioceris lili*; and viburnum leaf beetles, *Pyrrhalta viburni*. Black pepper is also repellent, as 1% *P. nigrum* extract reduced *L. lili* feeding.

"*P. nigrum* extracts can knockdown lepidopterans and hymenopterans at below 0.1% (1,000 ppm), and control adult Colorado potato beetles at 0.5%," said Scott. European chafer, *Rhizotrogus majalis*, 3rd instar larvae were controlled with a concentration of 3% applied to the soil. The downside is that users are advised to wear masks and safety glasses, as pepper extracts are irritants.

Herbal Repellents

"Plants and plant compounds have been used as pest insect repellents for much of human history," said William Irby (Georgia Southern Univ, POB 8042, Statesboro, GA). Pliny (23-79 A.D.) and Dioscorides (60 A.D.) reported that wormwood juice, *Artemisia absinthium*; would repel gnats and flies. Many cultures have traditionally relied upon plant-based preparations for mosquito repellency. Preparations of turmeric, *Curcuma longa*, in vegetable oil are used topically in India. In some regions of Mexico, annato, *Bixa orellana*, is applied in vegetable oil or animal fat for protection against mosquito biting during outdoor activities. However, after the discovery of DEET in 1954, pyrethrum from chrysanthemum flowers was the only major botanical mosquito repellent in use around the world until recently.

Today's main plant-based area repellents are citronella candles and mosquito coils impregnated with



Adult female mosquito, *Culex tarsalis*

pyrethrins. "Unfortunately, effectiveness of these products appears to be limited to areas within the smoke plume produced during burning," said Irby. Most recently, the repellency of certain potted live plants such as basil, *Ocimum americanum*, or *Lantana camara* or *Lippia uckambensis* against *Anopheles gambiae* was demonstrated in experimental hut trials.

Irby tested a granular flying insect repellent and soil additive, Mosquito and Gnat Scat (Dr. T's Nature Products, Pelham, GA), which has attapulgite hormite clay (98.4%) as an inert carrier for lemon grass (1.12%), peppermint (0.08%) and garlic (0.40%) oils.

Dr. T's was applied evenly by hand several hours before dusk at the label rate. CDC light traps baited with live yeast cultures monitored adult mosquitoes at night for 3 weeks. After the initial Dr. T's treatment, mosquito populations were lower for 5 days.

Skin Chemistry & Mosquito IPM

Ulrich Bernier (USDA-ARS, CMAVE, 1600 SW 23rd Drive, PO Box 14565, Gainesville, FL) is renowned for discovering better mosquito attractants. More recently, Bernier discovered from human skin "attractant-antagonists that in blends mask the presence of human odor." By way of loose analogy this means making human appendages invisible to mosquitoes, a kind of stealth protection.

In 1997 a blend of three chemicals from human skin, L-lactic acid, acetone, and dimethyl disulfide, were patented as attractants for yellow fever mosquitoes, *Aedes aegypti*. Glass bead work led to the patent. Approximately 300 different compounds from human skin were deposited on 2.9 mm (0.1 in) glass beads by human handling. A solventless method, thermal desorption, allowed gas chromatography/mass spectrometry identification of the human skin compounds.

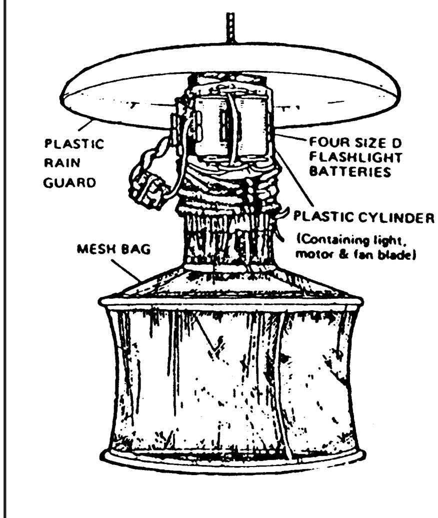
The patented three compound blend proved more attractive to mosquitoes than emanations from human skin, making it a good candidate for traps. Not all human skin compounds are attractive to mosquitoes. Acetone and acetaldehyde are the most attractive individual compounds. Some attractant compounds are repellent at high doses, but this was not the case with acetone. Synergism was noted with binary blends such as methylene chloride and lactic acid, which were more attractive than a real human hand, which also emits carbon dioxide, heat and moisture. However, there is much individual variation among humans, and the best blends are more attractive than some, but not all human hands.

Some blends wiped out mosquito attraction. One inhibitory compound from human skin when added to the patented three compound attractant blend reduced attractancy from 93% to 13%. In theory, if a human hand with a 100% inhibitory compound was placed in a cage full of mosquitoes, all the mosquitoes would be in the back of the cage and not know the hand was there. With DEET, mosquitoes know the hand is there, as they orient around the hand but do not land and feed. In contrast, the best inhibitory compounds from human skin "masked the hand."

Improving CO_2 Traps

According to William Meade (IPM Tech, 4134 N. Vancouver Ave, Suite 105, Portland, OR), the need for dry ice or compressed gas cylinders has limited the use of carbon dioxide (CO_2) traps for tick and mosquito IPM. So, IPM Tech has developed a GasHouse™ that periodically meters environmentally-benign chemicals into a reaction to achieve controlled release of CO_2 for periods of time that are under control of the user.

This system can be added to existing mosquito traps, such as CDC mini-traps or Faye-Prince traps or placed on the ground over a sticky surface to trap terrestrial arthropods such as ticks. In field trials and lab tests GasHouse™ "markedly" increased capture of female Asian tiger mosquitoes, *Aedes albopictus*, a species that does not strongly respond to CO_2. *Culex* mosquitoes were not captured until CO_2 gas generation was turned on.



CDC mosquito trap

Better Traps

CO_2 for trapping mosquitoes dates back to 1922. Using CO_2 from dry ice to capture biting midges, *Culicoides* spp., dates to 1965, said Daniel Kline (USDA-ARS, CMAVE, 1600 SW 23rd Drive, PO Box 14565, Gainesville, FL). *Culicoides furens*, a biting midge, shows little response to octenol (1-octen-3-ol) alone, but there is a "huge synergistic effect" —up to 100-fold more *C. furens* caught— when octenol is added to CO_2 traps in the Everglades (see the Spring 2003 *Common Sense Pest Control Quarterly*). The results vary among biting midge species, and are not the same for *C. melleus*. *C. impunctatus* in Scotland are highly attracted to octenol and acetone.

Adding heat via a heating pad to the semiochemical trapping system tripled the number of *C. furens* caught. In addition to octenol, potential biting midge attractants include butanone, mixed phenol compounds, honey extract and lactic acid. A mixture of octenol and phenols attracted large numbers of *C. furens*, but lac-

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tic acid gave mixed results.

A "4:1:8 mixture of octenol:3-n-propylphenol:4-methylphenol alone or in combination with CO_2" showed good potential for backyard IPM traps, capturing *C. mississippiensis, C. barbosai, C. melleus* and *C. furens* in northwest Florida. There is sometimes geographic variation in the *Culicoides* species trapped, so experimentation with different blends is needed.

Federal and state surveillance and control programs can use baited traps, particularly where pesticide use and physical control measures are not practicable. Backyard IPM programs might use a perimeter of baited traps. Piping CO_2 from tanks to a "barrier" of poisoned targets protected a condo complex where pesticide treatments had previously been ineffective. Traps need to be 20 ft (6 m) apart for *C. furens*, versus 60 ft (18 m) for mosquitoes. Whenever the CO_2 flow into the traps was turned on or off, the biting midge attractant effects were dramatically demonstrated.

A perimeter barrier was also effective around a school in Boyton Beach, FL, where CO_2 was piped through a mangrove swamp. Mineral oil substituted for pesticide on the traps/targets at the school, and the IPM system enabled the kids to finally play safely outside. The school IPM trapping system worked well until a hurricane blew in a new batch of biting midges, at which time the program was repeated. Backyard experiments are underway using compressed CO_2 tanks and the Dragonfly trap, which has an electrocuting grid.

Mosquito Magnet Liberty trap

Mosquito Trap Comparisons

"The number of companies manufacturing mosquito traps has increased dramatically in the last 2-3 years," said John Smith (JAMS Center, Florida A&M University), who compared seven commercial traps and one model under development in terms of numbers and species caught (next year mosquito control will be evaluated) on a northwest Florida peninsula surrounded by a salt marsh. The Mosquito Megacatch and the Mosquito Magnet Liberty captured 2.5X to almost 3X more mosquitoes than the next best trap, the Lentek Mosquito Trap, and 4X to 6X more than the Mosquito Deleto, Mosquito Deleto Prototype, Mosquito PowerTrap and the Dragonfly. The SonicWeb collected considerably fewer mosquitoes than any of the other traps. The Mosquito Magnet Liberty sampled the greatest species diversity with 16 collected. The Mosquito Megacatch and Mosquito PowerTrap tied with 12 species.

Mosquito Monitor

Benedict Pagac (US Army, Bldg 4411 Llewellyn Ave, Fort George G. Meade, MD) talked about monitoring mosquitoes. The U.S. Dept. of Defense monitors mosquitoes using CDC-type black plastic oviposition cups containing aged water and red velour egg deposition strips at 45 mostly Army installations in the northeast and Washington D.C. This surveillance method has proven to be a simple and economical tool in documenting the spread of non-native, container breeding mosquito species over a large geographic area. Cups were checked weekly, and the red valour strips were examined microscopically (6X-30X) for eggs. Strips with eggs were placed into individual mosquito breeders, and adults were identi-

Calendar

September 9-12, 2003. 4th European Vertebrate Pest Management Conference. Contact: L. Nieder, Parma, Italy. nieder@biol.unipr.it

September 12-17, 2003. 14th Intl. Meeting Virus Diseases of Grapevine. Contact: D. Boscia, Bari, Italy. email icvg2003@area.ba.cnr.it; www.agr.uniba.it

September 18-19, 2003. 17th Annual Integrated Roadside Vegetation Management Conference. Iowa City, IA. Contact: Native Roadside Vegetation Center, U. Northern Iowa, Cedar Falls, IA 50614.

September 23, 2003. Benefit for Organic Farming Research Foundation. Larkspur, CA. Contact: www.ofrf.org

September 26-28, 2003. Renewable Energy and Organic Agriculture. Fredericksburg, TX. Contact:K. Houser, 512/326-3391; 877-roundup; www.txses.org

October 4, 2003. Hoes Down Festival at Full Belly Farm. Contact: 800/791-2110; www.hoesdown.org

October 17-18, 2003. Xeriscape Conference. Albuquerque, NM. www.xeriscape.com

October 17-19, 2003. Annual Bioneers Conference. San Rafael, CA. Contact: Bioneers Conf., 901 W. San Mateo Rd., Suite L, Santa Fe, NM 87505; 505/986-0366; www.bioneers.org

October 20-23, 2003. Nonpoint Source Pollution Conference. Chicago, IL. Contact: Bob Kirschner, Chicago Botanic Garden, 1000 Lake Cook Rd., Glencoe, IL 60022; email bkirschn@chicagobotanic.org

October 22-23, 2003. Soil and Soul Sustainable Agriculture. Contact: Bioneers Conf., 901 W. San Mateo Rd., Suite L, Santa Fe, NM 87505; 505/986-0366; www.bioneers.org

November 1, 2003. Deadline for Registration Course in Organic Farming. Contact: UC Santa Cruz, 831/459-4140; www.ucsc.edu/casfs/training

November 2-6, 2003. Organic Agriculture Conference. Denver, CO. Contact: Jane Sooby, jane@orf.org; www.asa-cssa-sssa.org/anmeet/

November 3-6, 2003. 10th Annual Methyl Bromide Alternatives Outreach Conference. San Diego, CA. Contact:MBAO, PMB #345, 7084 N. Cedar Ave., Fresno, CA 93720; www.mbao.org

November 5-7, 2003. California Nonpoint Source Pollution Conf. Ventura, CA. Contact: S. Ziegler, EPA Reg. 9, 75 Hawthorne St., San Francisco, CA 94105; 415/972-3399. email ziegler.sam@epa.gov

November 10-12, 2003. Crop Science and Technology. British Crop Protection Council. Glasgow, Scotland. Contact: www.bcpc.org

November 18-21, 2003. British Crop Protection Conf. Brighton, UK. Contact: www.bcpc.org

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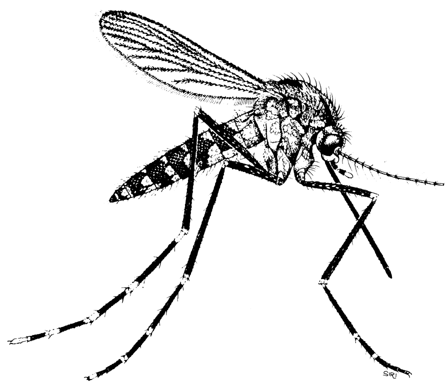

A treehole mosquito, *Aedes* sp.

fied and counted. This monitoring system documented the northward and eastward spread of the Asian tiger mosquito, *Aedes albopictus*, from Houston, TX, in 1984. Similarly, the southward and westward spread of *Ochlerotatus japonicus* from Ocean County, NJ, and Suffolk County, NY, in 1998 was documented.

Light Traps

In late summer, particularly in restaurants, the $407 billion, 878,000 unit U.S. food industry faces problems with nuisance flies, and " as the food industry grows, increasing numbers of flies are produced," said Matthew Aubuchon (Univ of Florida, Bldg 970 Natural Area Drive, Gainesville, FL). Electrocution traps are considered unsanitary, as the insects explode. But traps emitting ultraviolet (UV) light and catching flies on glue boards are acceptable. House flies show sensitivity peaks to 340-350 nm (UV) and 480-510 nm (green-blue) light. Face flies show sensitivity peaks to 360 nm (UV) and 490 nm (blue-green) light. The 330 nm wavelength produces a startle response in flies. Brighter UV light catches more flies than dim UV light.

Eight hour fly-catching assays conducted in enclosed structures with 7-10 day old flies (younger flies are also being assayed) compared cool white, warm white and UV light bulbs with a control. Using B&G matrix traps (B&G Equipment Co, 135 Region South Dr, Jackson GA) with glue boards behind the trap, Aubuchon compared four different bulbs at a time in one trapping device; 1-way ANOVA showed that light provided the main trapping effect. UV light (high UV, low blue-green) attracted more flies (131,695) and a higher percentage of males than cool and warm white fluorescents (high blue-green, low UV). Overall, female flies were more attracted to light than males. But for restaurants the bottom line is the total fly catch. Control was not 100%, because not all the flies flew to the light.

Traps With a Heart Beat

Jerome Hogsette, USDA-ARS, PO Box 14565, Gainesville, FL) talked about fly traps. Visual traps have been used in west Florida to trap stable flies, *Stomoxys calcitrans*, since at least the 1930s. Even on remote ranges, the economic threshold for cattle is 5 flies/leg, and some kind of fly control is needed. Stable flies are attracted to high contrast traps. Box trap research in the 1960s and 1980s revealed this tendency when traps were tested on a beach with lots of sunlight and shadows. However, the same box traps were less effective against stable flies further inland. The original white fiberglass or Williams trap that evolved from this research has been used commercially for two decades. Olson Products (Medina, OH) makes cylindrical, removable Stiky Sleeves that go around the fiberglass and catch house flies as well as biting flies.

Traps using sound are being tried in bakeries and grocery stores, but their efficacy is unknown, said Hogsette. The BugJammer trap, emulates a heart beat. A computer chip can be programmed to produce the heartbeat sound of a dog or human. The trap housing vibrates to recorded dog heart beat sounds; the vibrations can be felt, but only heard very close to the trap.

BugJammer traps can be integrated with heat-producing units, carbon dioxide, or light to increase fly and mosquito catches. When mosquitoes are released into a room and the BugJammer sound button is turned on, mosquitoes are readily collected on the trap surface.

Sound must be carefully integrated with other components, such as visual stimuli. For example, heart beat sounds with white plastic traps capture horse flies. However, no horse flies are trapped if black plastic is used. Factors such as the amount of glue on the sticky part of the trap also need consideration. Indeed, a gooey BugJammer trap caught 281 stable flies, versus 39 for an Olson trap with less glue, although customers find it more convenient to use the less gooey trap.

In an indoor test in a USDA stable fly colony room with 50 male and 50 female house flies released, traps with the sound caught the most house flies.However, in a commercial test, flies buzzed around the trap and few were caught; whereas a light trap did very well.

In a horse paddock experiment with stable flies and a prototype outer sticky glue board, Trap 1 (low fly density) was set in the open and Trap 2 (high fly density) was 100 m (328 ft) away near a feed area where there was large numbers of flies. Sound activation was rotated between the traps, only one trap at a time had sound. BugJammer traps caught three fly species: house flies, horn flies and stable flies. With just the high density trap activated, the catch was 41% house flies. With only the low density trap activated, the catch was 16-24% house flies. The stable fly catch was highest (443) with the low density trap activated. With just the high density trap emitting, the stable fly catch was halved. With horn flies, there was little difference with the sound on or off.

BugJammer traps are available in the SkyMall catalogs found on most airlines; most people do not like to see insect bodies, so a shroud is needed on commercial traps for the general public. Hogsette is toying with the idea of a trap that can be customized for different fly and mosquito hosts with a dial for different heart beats.

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