References

Commercially Available Biological Control Organisms –

Organization by Associated Pest Groups

Biological control is always only one component of any Integrated Pest Management program. However, the following commercially available organisms may have some application for the following pest groups. The headings used refer to organisms, or groups of organisms, described in the above section.

Pest Group	Potentially Useful Biological Controls
Aphids	Convergent Lady Beetle/Lady beetles, Pink Lady Beetle/12-spotted Lady Beetle, Multi colored Asian LadyBeetle, Green Lacewings, Aphid Predator Midge, Pirate Bugs, Big-eyed Bug, Predatory Plant Bug, Aphid Parasites, *Beauveria bassiana*
Whiteflies	Whitefly Predator, Green Lacewings, Pirate Bugs, Greenhouse Whitefly Parasite, Sweetpotato Whitefly Parasite, *Beauveria bassiana*
Mealybugs	Mealybug Destroyer, Green Lacewings, Mealybug Parasites
Armored Scales	Scale Predator, Green Lacewings, Armored Scale Parasite/Golden Chalcid
Soft Scales	Scale Predator, Green Lacewings, Soft Scale Parasite
Thrips	Thrips Predators/Predatory Mites, Pirate Bugs, Big-eyed Bug, Soil Predator Mite, Parasitic (Predatory) Nematodes/*Steinernema* spp.
Spider Mites	Spider Mite Destroyer, Spider Mite Predator Midge, Sixspotted Thrips, Spider Mite Predators/Predatory Mites, Pirate Bugs, Big-eyed Bug
Leaf Beetles	Pink Lady Beetle/12-spotted Lady Beetle, Green Lacewings, Big-eyed Bug, Predatory Plant Bug, *Bacillus thuringiensis* var. *san diego*, *Beauveria bassiana*
Mexican Bean Beetle	Pink Lady Beetle/12-spotted Lady Beetle, Green Lacewings, Big-eyed Bug, Predatory Plant Bug, Mexican Bean Beetle Parasite
Caterpillars	Green Lacewings, Pirate Bugs, Big-eyed Bug, Predatory Plant Bug, Spined Soldier Bug, Trichogramma Wasps, Caterpillar Parasites, *Bacillus thuringiensis* var. *kurstaki*
Leafminers	Leafminer Parasites
Lygus Bugs	Lygus Bug Egg Parasite
White Grubs	Parasitic (Predatory) Nematodes/*Heterorhabditis* spp.
Grasshoppers	*Nosema locustae*/Grasshopper Spore, Chinese mantid
Fungus Gnats	Soil Predator Mite, *Bacillus thuringiensis* var. *israelensis*, Parasitic (Predatory) Nematodes/*Steinernema* spp.
Mosquitoes	*Bacillus thuringiensis* var. *israelensis*
Flies (Nuisance)	Fly Parasites (Fly Predators)

Biological Control Organisms for Insects and Mites

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Modified from: Suppliers of Beneficial Organisms in North America, a publication of Cal/EPA's Department of Pesticide Regulation.

Online at: www.cdpr.ca.gov/docs/impinov/bensuppl.htm

A wide variety of beneficial organisms are offered for sale by several suppliers to assist in management of insects and mites. The following is a partial listing current as of July 28, 2002.

This is organized in three sections. First is a brief description of organisms with potential applications. At the end of the section is a reference to sources where they may be purchase. This is followed by a brief listing of pest groups and the associated potential biological controls. At the end is a listing of addresses of many suppliers/producers.

Predators of Insects/Mites

Convergent Lady Beetle/Lady Beetles – When sold as "lady beetles" or "ladybugs" the species involved is the convergent lady beetle, *Hippodamia convergens*, a native lady beetle found throughout most of North America. Purchased lady beetles are all field collected insects, captured in high elevation areas of California where they periodically migrate to and mass aggregate, allowing easy collection. Ability of the collected lady beetles to reproduce is suspended (they are in "reproductive diapause") so eggs are not produced for several weeks after release. (Pre-feeding lady beetles prior to release can allow some egg maturation to start and a few companies provide such "pre-conditioned" lady beetles.) Lady beetles tend to readily disperse from the area of release. Since they store well, lady beetles are available most of the year, although supplies often are limited by midsummer.
Sources: 1, 2, 4, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38

Pink Lady Beetle/12-spotted Lady Beetle – The 12 spotted lady beetle, *Coleomegilla maculata* (C-Mac) is a native species to the region and common in agricultural areas, particularly alfalfa fields. In addition to aphids, it commonly feeds on eggs of beetles (e.g., Colorado potato beetle, Mexican bean beetle) egg masses of some caterpillars and pollen.
Sources: 2, 23, 32

Multicolored Asian Lady Beetle – The multicolored Asian lady beetle, *Harmonia axyridis*, is a species that was purposefully introduced into North America and has now become widely distributed, recently colonizing Colorado. It is a fairly large species with highly variable markings and is a voracious predator of aphids, particularly on shade trees. However, it has the somewhat unfortunate habit of often wintering in homes, where it may be a nuisance problem. They go into dormancy (diapause) when day length becomes less than 16 hours.
Sources: 10, 19, 22, 32, 37

Mealybug Destroyer – The mealybug destroyer, *Cryptolaemus montrouzieri*, is a tropical species of lady beetle used to control citrus mealybug. They primarily feed on eggs and some small nymphs. The predatory larvae are covered with wax threads and appear similar to mealybugs.
Sources: 4, 7, 8, 9, 10, 15, 17, 18, 19, 20, 21, 22, 24, 26, 28, 29, 30, 32, 24, 26, 37, 38

Whitefly Predator – Lady beetles in the genus *Delphastus* feed on eggs and small nymphs of whitefly, particularly sweetpotato/silverleaf whitefly. High populations of whiteflies must be present to maintain reproduction of these predators. (**Note**: There has often been confusion as to the specific identity of *Delphastus* sold by suppliers. Although most list the organism as *D. pusillus*, *D. catalinae* probably predominates in most cultures for sale.
Sources: 2, 8, 10, 16, 17, 19, 20, 21, 22, 24, 29, 32, 34, 35, 36, 37, 38

Spider Mite Destroyer – Tiny, dark lady beetles in the genus *Stethorus* develop as predators of spider mites.
Sources: 29, 32, 34, 37

Scale Predator – A beetle, *Rhyzobius* (=*Lindorus*) *lopanthae*, develops as a predator of scales, particularly various armored scales (Diaspididae). Some soft scales (Coccidae) may be eaten, although effectiveness of the beetle is inhibited by the presence of honeydew.
Sources: 2, 18, 19, 20, 21, 24, 26, 32, 37, 38

Green Lacewings – Green lacewings (*Chrysoperla* spp.) are general predators of a wide variety of insects, including aphids, and soft-bodied insect larvae. The most common species sold are *Chrysoperla rufilabris*, a native of southeastern U.S. mostly associated with trees/shrubs, and *C. carnea*, a native western species found most commonly in agricultural

settings. *C. comanche* is also sold. They are one of the most widely available insects used in biological control, functioning as a sort of general predators. They are usually sold as eggs, most often mixed with a carrier such as rice hulls to be sprinkled around plants. Some suppliers apply the eggs to cards that can be hung on plants. Less commonly adults, or pupae shipped in cells, may also be purchased. Shipped insects should be released soon after receipt as the larvae are cannibalistic and eggs should not be chilled. Ants are an important predator of the eggs and may disrupt the effectiveness of a release if abundant. Adults are not predatory but feed on nectar and pollen.
Sources (*C. rufilabris*): 1, 7, 18, 21, 24, 25, 26, 29, 30, 31, 32, 34, 35, 36, 38
Sources (*C. carnea*): 1, 7, 8, 9, 18, 21, 22, 25, 30, 32, 38
Sources (*C. comanche*): 18, 21
Sources (unspecified *Chrysoperla* species): 2, 3, 4, 10, 11, 12, 13, 14, 15, 16, 17, 27, 28

Chinese Mantid – The Chinese mantid, *Tenodera aridofolia sinensis*, is the only species of commercial trade. The are sold as egg cases (oothecae) each containing about 200 eggs. Adult Chinese mantids reach a size of about 4 inches and are the largest mantids found in North America. They are poorly adapted to surviving winter conditions in Colorado, almost invariably dying out. (Other species of mantids, notably the common European mantid, *Mantis religiosus*, do overwinter successfully in parts of Colorado, particularly if winters are mild.) Mantid egg cases are usually available only during spring through early summer. They are generalist predators of a wide variety of insects, including some beneficial species. Their effectiveness for control of pests is marginal, but they are striking insects that are an attractive complement to the garden.
Sources: 1, 2, 4, 8, 13, 15, 20, 21, 27, 28, 30, 31, 32, 34, 35, 36, 37, 38

Aphid Predator Midge – Larva of a tiny fly, *Aphidoletes aphidimyza* develops as predator of aphids. It is a native insect of the region, found most commonly in late summer within aphid colonies. *A. aphidimyza* is sold for use in greenhouses, supplied as pupae that disperse after they transform to the adult stage. When used during winter supplemental lighting must be provided to maintain a minimum of 16 hours of daylight or the predators become dormant.
Sources: 2, 9, 10, 14, 15, 17, 18, 20, 21, 22, 24, 26, 29, 30, 32, 36, 37, 38

Spider Mite Predator Midge – Larvae of another gall midge, *Feltiella acarisuga*, are sometimes sold for control of twospotted spider mite. *Therodiplos persicae*, also a gall midge, also will feed on spider mites.
Sources (*Feltiella acarisuga*): 32
Sources (*Therodiplos persicae*): 22

Sixspotted Thrips – The sixspotted thrips, *Scolothrips sexmaculatus*, is a predator of spider mites, reported adapted to hot and dry conditions.
Sources: 2, 7, 32

Spider Mite Predators/Predatory Mites – About five species of commercially available predatory mites (Phytoseiidae family) appear to have some potential application under Colorado conditions, particularly for greenhouse and interiorscape use. Each has a range of temperature and humidity under which they are most efficient, and some require humidity conditions rarely reached in Colorado. The more experienced suppliers/producers can provide consultation as to appropriate species to consider.
Sources (Western predatory mite, *Galendromus occidentalis*): 2, 6, 8, 17, 21, 24, 28, 30, 32, 36, 37, 38
Sources (*Neosieulus californicus*): 2, 6, 8, 13, 17, 20, 21, 22, 24, 26, 28, 29, 30, 32, 36, 38
Sources (*Amblysieus fallacis*): 6, 13, 17, 26, 32, 37, 38
Sources (*Mesosieulus longipes*): 2, 6, 8, 17, 20, 21, 24, 29, 30, 32, 36, 38
Sources (*Phytoseiulus persimilis*): 2, 4, 6, 7, 8, 9, 13, 16, 17, 20, 21, 22, 24, 26, 28, 29, 30, 32, 34, 36, 37, 38
Sources (Predatory mites, unspecified and/or mixtures): 34

Thrips Predators/Predatory Mites – Two species of commercially available predatory mites (*Amblysieus cucumeris*, *A. degenerans*) feed primarily on thrips, particularly flower thrips. Pollen may be an important part of the diet of these predators.
Sources (*Amblyseius cucumeris*): 8, 9, 13, 15, 17, 18, 20, 21, 22, 24, 26, 28, 29, 30, 32, 34, 36, 37, 38
Sources (*Amblyseius degenerans*): 22, 24, 32, 37, 38

Pirate Bugs – Pirate bugs (*Orius* spp.) are small black and white bugs that are generalist predators of small insects (e.g., thrips, aphids), mites, and insect eggs. Many species are present in the region and they are very important natural controls. At least four species are sold commercially.
Sources (*Orius insidiosus*): 2, 10, 15, 16, 17, 22, 24, 26, 29, 32, 34, 36, 37, 38
Sources (*Orius laevigatus*): 22
Sources (*Orius majusculus*): 22
Sources (Unspecified *Orius* sp.): 4, 8, 17, 20, 21, 30, 31, 35

Big-eyed Bug – Big-eyed bugs, *Geocoris* spp., are predatory seed bugs that feed on a wide variety of insects, including aphids, soft-bodied insect larvae, and insect eggs. Several species are native to the region. *Geocoris punctipes* appears to be the species commercially available.
Sources: 2, 4, 32

Predatory Plant Bug – A predatory plant bug, *Deraeocoris brevis*, is a generalist predator of soft-bodied insects and is native to the region.
Sources: 21, 38

Spined Soldier Bug – The spined soldier bug, *Podisus maculiventris*, is a native species of stink bug that is predatory on many types of caterpillars and leaf beetle larvae. Experimental work with the species is limited, although naturally occurring populations have often been reported as useful biological control agents.
Sources: 2, 32

Soil Predator Mite – The soil dwelling mite, *Hypoaspsis miles*, is a generalist predator of insects that spend part of their life cycle in the soil, including fungus gnat larvae and pupae of thrips. Once introduced, *H. miles* usually can reproduce and establish.
Sources: 2, 8, 16, 17, 20, 21, 22, 24, 26, 29, 32, 34, 37, 38

Parasites/Parasitoids of Insects

Trichogramma Wasps – Several species of Trichogramma species wasps exist, all of which attack and kill various kinds of insect eggs. Insect larvae already hatched are not susceptible to Trichogramma attack. Most of the eggs parasitized by Trichogramma are from insects in the order Lepidoptera (Moths and Butterflies), which includes cutworms, codling moths, cabbageworms and armyworms. Although some Trichogramma wasps are naturally present in the Rocky Mountain region, they are usually found in low numbers. Commercially available Trichogramma wasps are often used as a form of a biological insecticide where they are expected to eliminate most of the developing eggs of pests shortly after release. High levels of control are not often achieved in practice, but the wasps may effectively supplement existing controls. Multiple releases of Trichogramma wasps are recommended, since persistence of the parasites may be short-term. Several different species of trichogramma wasps are produced (e.g., *T. minutum*, *T. platneri*, *T. pretiosum*) and they have different habits. The more sophisticated suppliers will provide advice on which species is most appropriate for the intended crop and pest.
Sources (*Trichogramma minutum*): 1, 2, 7, 8, 10, 14, 17, 18, 21, 30, 31, 32, 36, 38
Sources (*Trichogramma brassicae*): 7, 26, 31, 32
Sources (*Trichogramma platneri*): 2, 8, 14, 18, 21, 26, 313, 32, 38
Sources (*Trichogramma pretiosum*): 1, 2, 8, 14, 17, 18, 21, 26, 30, 31, 32, 36, 38
Sources (*Trichogrammatoidea bactrae*): 8, 18, 21, 32, 38
Sources (Unspecified *Trichogramma* species): 3, 4, 12, 13, 15, 16, 20, 25, 27, 29, 35

Fly Parasites (Fly Predators) – Several species of parasitic wasps develop in the pupae of filth breeding flies species of *Muscidifurax* (*M. raptor*, *M. zaraptor*, *M. raptorellus*), *Spalangia* (*S. cameroni*, *S. endius*, *S. nigroaenea*) and *Nasonia vitripennis*. These are used to suppress nuisance flies in areas of livestock or where manure storage otherwise is stored.
Sources (*Muscidifurax raptor*): 4, 7, 20, 30, 32, 35
Sources (*Muscidifurax zaraptor*): 8, 18, 20, 26, 28, 30, 32, 33, 36, 38
Sources (*Muscidifurax raptorellus*): 26, 32, 33, 36
Sources (*Spalangia cameroni*): 32, 32
Sources (*Spalangia endius*): 18, 28, 30, 38
Sources (*Spalangia nigroaenea*): 30
Sources (*Nasonia vitripennis*): 8, 18, 28
Sources (Unspecified mixtures of fly parasites): 1, 3, 12, 14, 20, 22, 24, 25, 27, 31, 35, 37

Aphid Parasites – Several small parasitic wasp are commercially available, primarily for control of aphids in greenhouses or interiorscapes. Some are generalists, other more specific as to the aphids they will attack. Among the most commonly available (and their hosts) are *Aphelinus abdominalis* (green peach aphid), *Aphidius colemani* (melon/cotton aphid, green peach aphid), *Aphidius ervi* (potato aphid, pea aphid, green peach aphid), and *Aphidius matricariae* (green peach aphid).
Sources (*Aphelinus abdominalis*): 2, 22, 32
Sources (*Aphidius colemani*): 2, 8, 9, 10, 14, 20, 22, 24, 26, 31, 32, 37, 38
Sources (*Aphidius matricariae*): 2, 10, 18, 21, 26, 29, 32, 35, 37, 38
Sources (*Aphidius ervi*): 2, 9, 18, 20, 22, 26, 32, 38

Greenhouse Whitefly Parasite – A small wasp, *Encarsia formosa*, attacks and develops within immature whitefly nymphs. Introduction of this parasitic wasp has proven useful for whitefly management in warm greenhouses (average temperatures above 72°F). The whitefly parasite is supplied on cards, as developing wasps within whitefly nymphs. The latter turn black when hosting this parasite.
Sources: 2, 4, 7, 8, 9, 12, 15, 16, 17, 18, 20, 22, 24, 26, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38

Sweetpotato Whitefly Parasite – Another parasite of whiteflies is *Eretmocerus eremicus* (= nr. *californicus*). Originally developed to help manage sweetpotato whitefly it also is an effective natural enemy of greenhouse whitefly. Adult stages may kill many developing whiteflies by stinging them and blood feeding. Whitefly nymphs parasitized by this insect turn a golden color.
Sources: 2, 9, 17, 20, 21, 24, 26, 32, 36, 37

Mexican Bean Beetle Parasite – *Pediobius foveolatus* is a small, parasitic wasp that develops within immature stages of the Mexican bean beetle. Releases should be made shortly after bean beetle eggs are first detected. This insect does not survive winters in the region.
Sources: 2, 32

Mealybug Parasites – Several species of parasitic wasps are parasites of mealybug nymphs. Most commonly available is *Leptomastix dactylopii*, a parasite of citrus mealybug. *Leptomastidea abnormis* also is specific to citrus mealybug, while *Anagyrus pseudococci* has a somewhat broader host range and develops on Comstock mealybug as well citrus mealybug.
Sources (*Leptomastix dactylopii*): 2, 7, 20, 21, 22, 32, 38
Sources (*Leptomastidea abnormis*): 32
Sources (*Anagyrus pseudococci*): 32

Armored Scale Parasite/Golden Chalcid – A small parasitic wasp, *Aphytis melinus*, develops in many armored scales associated with interiorscape plants. (It is not a parasite of armored scales found on landscape plants in Colorado).
Sources: 2, 7, 14, 17, 18, 20, 21, 24, 26, 30, 32, 37, 38

Soft Scale Parasite - A parasitic wasp, *Metaphycus helvolus*, is useful for managing black scale and hemispherical scale on interiorscape plants.
Sources: 2, 7, 18, 20, 21, 24, 26, 30, 32, 36, 38

Caterpillar Parasites – Two species of parasitic wasps attack young stages of caterpillars associated with certain vegetable crops. *Cotesia marginiventris* is a parasite of various loopers, such as cabbage looper. *Cotesia plutellae* is a parasite of diamondback moth larvae.
Sources (*Cotesia marginiventris*): 2, 32
Sources (*Cotesia plutellae*): 2, 4, 14, 32

Leafminer Parasites – Two species of parasitic wasps are used to control leafminers (*Liriomyza* spp.). *Diglyphus isaea* tends to be most efficient in warmer environments; *Dacnusa sibrica* in cooler temperatures.
Sources (*Diglyphus isaea*): 2, 7, 15, 18, 20, 22, 28, 32, 36, 38
Sources (*Dacnusa sibrica*): 7, 9, 15, 17, 20, 22, 28, 32, 37, 38

Lygus Bug Egg Parasite – A minute wasp, *Anaphes iole*, is a parasite of eggs of Lygus bugs, which are occasional pests of fruit crops.
Sources: 17, 32, 38

Pathogens of Insects

Bacillus thuringiensis* var. *kurstaki – The *kurstaki* strain of the bacterium *Bacillus thuringiensis* (Bt) is a bacterial disease organism that has been formulated into a number of microbial insecticides. Trade names include Dipel, Thuricide, Javelin, Deliver, MVP II, and Safer Caterpillar Killer. Applied as a dust or spray to foliage, applications of this strain is effective for control of most leaf-feeding Lepidoptera - webworms, cabbageworms, leafrollers, tussock moths, etc. (Cutworms and armyworms are often less sensitive to Bt.) This product is widely available at Colorado nurseries.
Sources: 9, 12, 20, 21, 22, 30, 31, 34, 36

Bacillus thuringiensis* var. *israelensis – The *israelensis* (or H-14) strain of *Bacillus thuringiensis* is effective for control of certain fly larvae, notably mosquitoes, blackflies, and fungus gnats. (It is not effective against houseflies, blowflies, shore flies and many other fly species.) Formulations sold for use as a soil drench to control fungus gnats include Knock-Out Gnats, Gnatrol. Vectobac, Mosquito Dunks, Mosquito Rings, Aquabac, and Bactimos Briquets are sold for use in water to control mosquitoes and blackflies. Mosquito Dunk is carried by some Colorado nurseries.
Sources: 2, 8, 9, 11, 12, 21, 24, 28, 30, 31, 34, 36

Bacillus thuringiensis* var. *san diego — The *san diego* (= *tenebrionis*) strain of *Bacillus thuringiensis* is effective for control of certain leaf beetle larvae, notably Colorado potato beetle and elm leaf beetle. The formulations sold as Novodor and Colorado Potato Beater is available from some suppliers.
Sources: 11, 12, 21, 31

Milky Spore – Milky spore is a bacterium (*Bacillus popillae*) that is applied to soil to infect larvae of the Japanese beetle. *It is not effective for the white grubs present in Colorado*, although other naturally occurring species of milky spore bacteria naturally occur.
Sources: 2, 29, 31, 35

Parasitic (Predatory) Nematodes/*Heterorhabditis* spp. – Insect-parasitic nematodes in the genus *Heterorhabditis* are applied to soil as a drench to control larvae of various insects. They are capable of penetrating the body of insect larvae and are the most effective from control of soil-dwelling white grubs and root weevils, as well as caterpillars. Several Heterorhabditis species are available, which vary some in pathogenicity to insects and sensitivity to temperature. Among those available are *H. bacteriophora* (=*heliothidis*) (HeteroMask, Grub-Away, BioStrike Hb, GrubStake Hb), *H. indica* (Grub Stake Hi), *H. marelatus*, and *H. megidis.*
Sources (*Heterorhabditis bacteriophora*): 2, 5, 7, 8, 10, 16, 17, 18, 21, 23, 26, 30, 32, 34, 35, 36, 37, 38
Sources (*Heterorhabditis indica*): 23, 32
Sources (*Heterorhabditis marelatus*): 26, 32
Sources (*Heterorhabditis megidis*): 22
Sources (Unspecified *Heterorhabditis* sp.): 9, 11, 12, 14, 20, 29

Parasitic (Predatory) Nematodes/*Steinernema* spp. – Insect-parasitic nematodes in the genus *Steinernema* are similarly applied to soil as a drench to control larvae of various insects. They are somewhat more specific in their host range and do poorly on beetle larvae, but do have a wide range that includes most other insects that have some life stages in soil. Most commonly available is *Steinernema carpocapsae* which is used for control insects such as cutworms, thrips pupae, and fungus gnat larvae. *Steinernema feltiae* (=*bibionis*) (ScanMask, Gnat Not) is thought more effective for control of fly larvae such as fungus gnats and is widely used in greenhouse settings as well as for outdoor use.
Sources (*Steinernema carpocapsae*): 5, 8, 10, 11, 16, 17, 21, 24, 26, 27, 30, 32, 34, 35, 36, 37, 38
Sources (*Steinernema feltiae*): 5, 9, 10, 12, 13, 17, 21, 22, 23, 26, 32
Sources (Unspecified *Steinernema* sp.): 1, 2, 9, 14, 20, 29

***Nosema locustae*/Grasshopper Spore** – A microsporidian parasite of some grasshoppers, *Nosema locustae*, is sold as a bait formulation. It produces a fairly slow developing infection that weakens insects and usually kills them when they are molting. Adult insects are unlikely to be affected. The spores are perishable and should be used fairly soon after manufacture and/or stored with some refrigeration. M&R Durango produces the NoLo bait formulation; Semaspore is produced by Planet Natural.
Sources: 2, 4, 8, 20, 26, 28, 31, 36

Beauveria bassiana – *Beauveria bassiana* is a naturally occurring fungus disease that affects a very wide range of insects - including aphids, whiteflies, psyllids, billbugs and caterpillars. Environmental conditions, particularly humidity, seem critical for the applied spores to successfully germinate and infect insects, a limiting condition often in Colorado. Newly infected insects often are somewhat light brown; when the fungus sporulates it covers the insect with white spores. Available formulations are sold as Mycotrol and Naturalis.
Sources: 11, 20

Sources

1. A-1 Unique Insect Control
5504 Sperry Drive
Citrus Heights, CA 95621
(916) 961-7945
emial: ladybugs@a-1unique.com
Web site (under development): www.a-1unique.com

2. ARBICO
P.O. Box 4247
Tucson, AZ 85738-1247
(800) 827-2847
email: info@arbico.com
Web site: www.arbico.com

3. Beneficial Insectary
9664 Tanqueray Ct.
Redding, CA 96003
(530) 226-6300/(800) 477-3715
email: bi@insectary.com
Web site: www.insectary.com

4. Biofac Crop Care
P.O. Box 87
Mathis, TX 78368
(800) 233-4914
email: info@biofac.com
Web site: www.biofac.com

5. BioLogic Company
P.O. Box 177
Willow Hill, PA 17271
(717) 349-2789
Web site: www.biologicco.com

6. Biotactics, Inc.
20780 Warren Rd.
Perris, CA 92570
(909) 943-2819
email: sales@benemite.com
Web site: www.benemite.com

7. Buena Biosystems
P.O. Box 4008
Ventura, CA 93007
(805) 525-2525
Web site: www.buenabiosystems.com

8. Buglogical Control Systems
P.O. Box 32046
Tucson, AZ 85751-2046
(520) 298-4400
email: info@buglogical.com
Web site: www.buglogical.com

9. Crop King
5050 Greenwich Road
Seville, OH 44273-9413
(800) 321-5656
email: cropking@cropking.com
Web site: www.cropking.com

10. Extremely Green Gardening Company LLC
953 Islington St.
Portsmouth, NH 03801
(603) 427-0299
email: info@extremelygreen.com
Web site: www.extremelygreen.com

11. Gardener's Supply Co.
128 Williston Rd.
Williston, VT
(888) 833-1412
email: info@gardeners.com
Web site: www.gardeners.com

12. Gardens Alive!
5100 Schenley Pl.
Lawrenceburg, IN 47025
(812) 537-8651
email: gardener@gardens-alive.com
Web site: www.gardensalive.com

13. GEMPLER'S Inc.
100 Countryside Dr.
P.O. Box 270
Belleville, WI 53508
(800) 332-6744
email: customerservice@gemplers.com
Web site: www.gemplers.com

14. Great Lakes IPM, Inc.
10220 Church Road
Vestaburg, MI 48891-9746
(989) 268-5693/(989) 268-5911
email: glipm@nethawk.com
Web site: www.greatlakesipm.com

15. Greenfire
2725 A Hwy 32
W. Chico CA 95973
(800) 895-8307
email: info@greenfire.net
Web site: www.greenfire.net

16. Green Home
(415) 282-6400
email: help@greenhome.com
Web site: www.GreenHome.com

17. Heath's Organic Pest Control, Greenhouse, and Nursery
Rte 18 #750
Sugar Hill, NH 03585
(603) 823-8500
email: heaths@ncia.net
Web site: www.EcoBugs.com

18. Harmony Farm Supply & Nursery
3244 Hwy. 116 North
Sebastopol, CA 95472
(707) 823-9125
email: info@harmonyfarm.com
Web site: www.harmonyfarm.com

19. Hummert International
Earth City, MO
(315) 506-4500
email: sales@hummert.com
Web site: www.Hummert.com

20. Hydro-Gardens
P.O. Box 25845
Colorado Springs, CO 80936-5845
(888) 693-0578
email: hgi@hydro-gardens.com
Web site: www/hydro-gardens.com

21. IFM (Integrated Fertility Management)
1422 N. Miller St.
Wenatchee, WA 98801
(800) 332-3179
contactus@agricology.com
www.agricology.com

22. International Technology Services, Inc.
P.O. Box 75
Lafayette, CO 80026
(303) 473-9546
email: its@intertechserv.com
Web site: www.intertechserv.com

23. Integrated BioControl Systems, Inc.
(888) 793-4227 (IBCS)
Web site: www.goodbug-shop.com

24. IPM Labs, Inc.
Main Street
Locke, NY 13092-0300
(315) 497-2063
email: ipmlabs@ipmlabs.com
Web site: www.ipmlabs.com

25. Kunafin Trichogramma Insectaries
Rte. 1Box 39
Quemado, TX 78877
(800) 832-1113
email: office@unafin.com
Web site: www.kunafin.com

26. M & R Durango, Inc. Insectary
P.O. Box 886
Bayfield, CO 81122
(970) 259-3521
email: mail@goodbug.com
Web site: www.goodbug.com

27. Mellinger's Inc.
2310 West South Range Road
North Lima, OH 44452-9731
(800) 321-7444
email: mellgarden@aol.com
Web site: www.mellingers.com

28. Natural Pest Controls
8864 Little Creek Drive
Orangevale, CA 95662
(916) 726-0855
email: info@natpestco.com
Web site: www.natpestco.com

29. Nature's Control
3960 Jacksonville Hwy.
P.O. Box 35
Medford, OR 97501
(541) 245-6033
email: info@NaturesControl.com
Web site: www.naturescontrol.com

30. Peaceful Valley Farm Supply
P.O. 2209
Grass Valley, CA 95945
(530) 272-4769
email: contact@groworganic.com
Web site: www.groworganic.com

31. Planet Natural
1612 Gold Ave.
Bozeman, MT 59715
(800) 289-6656/(406) 587-5891
email: info@plantenatural.com
Web site: www.planetnatural.com

32. Rincon-Vitova Insectaries, Inc.
P.O. Box 1555
Ventura, CA 93022-1555
(800) 248-2847
email: bugnet@rinconvitova.com
Web site: www.rinconvitova.com

33. Spalding Laboratories
760 Printz Road
Arroyo Grande, CA 93420
(888) 562-5696
Web site: www.spalding-labs.com

34. Territorial Seed Company
P.O. Box 1578
Cottage Grove, OR 97424
(541) 942-0510
Web site: www.territorial-seed.com

35. The Beneficial Insect Co.
P.O. Box 119
Glendale Springs, NC 28629
(336) 973-8490
email: Bugfarm336@aol.com
Web site: www.thebeneficialinsectco.com

36. The Bug Store
113 W. Argonne
St. Louis, MO 63122-1104
(800) 455-2847
Web site: www.bugstore.com

37. The Geiger Companies
189 Main Street
Harleysville, PA 19438
(800) 443-4437
service@hortnet.com

38. The Green Spot Ltd
93 Priest Rd.
Nottingham, NH 03290-6204
(603) 942-8925
email: Info@GreenMethods.com
www.GreenMethods.com

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Balduf, W.V. 1937. Bionomic notes on the common bagworm, *Thyridopteryx ephemeraeformis.* Haw., (Lepid., Psychidae) and its insect enemies (Hymen., Lepid.). *Proceedings of the Entomological Society of Washington*, 39: 169-184.

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Cheng, H.H., and E.J. Le Roux. 1965. Life history and habitats of the birch leafminer *Fenusa pusillus* (Lepeletier) (Hymenoptera: Tenthredinidae) on blue birch *Betula caerulea grandis* Blanchard, Morgan Arboretum, Quebec. *Annals de la Societe Entomologique du Quebec* 19: 173-188.

Cote, W.A., and D.C. Allen. 1980. Biology of two lined chestnut borer, *Agrilus bilineatus,* in Pennsylvania and New York. *Annals of the Entomological Society of America* 73: 409-413.

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Guevremont and Quednau. 1977. Introduction de parasites ichneumonides pour la lutte biologique contra *Fenusa pusila* (Hymenoptera: Tenthredinidae) au Quebec. *Canadian Entomologist* 109: 1545-1548.

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Hiratsuka, Y., D.W. Langor, and P.E. Crane. 1995. A field guide to the forest insects and diseases of the prairie provinces, 297 pages. ISBN number: 0660159481. Call Vancouver, Canada at 604-822-5959 to order or order at any bookstore.

Houseweart, M.W., and H.M. Kulman. 1976. Lifetables of the yellowheaded spruce sawfly, *Pikonema alaskensis* (Rohwer) (Hymneoptera: Tenthredinidae) in Minnesota. Environmentl Entomology 5:859-867.

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McCullough, D.G., S.A. Katovich, M.E. Ostry, and J. Cummings-Carlson. 1998. Christmas tree pest manual. USDA-FS. 2nd Edition and Michigan State University Extension Bulletin E-2676, 143 pp.

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Taft, W.H., D. Smitley, J.W. Snow. 1991. A guide to the clearwing borers (Sessidae) of the North Central United States, 1991, NCR publication 394, Michigan State University.

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Van Dreische, R. S.. Healy, and R. Reardon. 1996. Biological control of arthropod pests of the Northeastern and North Central forests in the United States: A review and recommendation. USDA:FS, FHTET 96-19, 257 pp.

Suggested readings

Johnson, W.T., and H.H. Lyons. 1991. Insects that feed on trees and shrubs, Comstock Publishing Associates, 560 pages. ISBN 0801426022. Does not contain pesticide recommendations, but excellent coverage of insect identification and damage diagnosis. A great reference book, $50.00.

Cranshaw, W. 1997. Turfgrass insects in Colorado and Northern New Mexico, Colorado State Cooperative Extension, ISBN 1 889143006 Visit their website to order.

Cranshaw, W. et al. 2000. Insects and Diseases of Woody Plants of the Central Rockies. Colorado State University Extension bulletin 506A. Call (877) 692-9358 to order.

Davidson, J.A. and M. Raupp. 1999. Landscape IPM: Guidelines for integrated pest management of insect and mite pests on landscape trees and shrubs, University of Maryland Extension Bulletin 350, 109 pp. Write Ag. Dup. Service, 6200 Sheridan Street, Riverdale, MD 20737

Gill, S., and J. Sanderson. 1998. Ball identification guide to greenhouse pests and beneficials, Ball series, $66.95, ISBN 1-883052-17-3, Item #BO35, see www.ballbookshelf.com

Bradenburg, R., and M. Villani. 1995. Handbook of turfgrass insect pests, Entomological Society of America, 140 pages, $35.00, call 301-731-4538 to order.

Hiratsuka, Y., D. W. Langor, and P.E. Crane. 1995. A field guide to the forest insects and diseases of the prairie provinces, 297 pages. ISBN 0660159481. Call Vancouver, Canada at 604-822-5959 to order or order at any bookstore.

McCullough, D.G., S.A. Katovich, M.E. Ostry, and J. Cummings-Carlson. 1998. Christmas tree pest manual. USDA-FS. 2nd Edition and Michigan State University Extension Bulletin E-2676, call 517-355-0240 to order.

McCullough, D.G., S.A. Katovich, D.L. Mahr, D.D. Neumann, C.S. Sadof, and M.J. Raupp. 1999. Biological control of insect pests in forested ecosystems: A manual for foresters, Christmas tree growers, and landscapers. Michigan State University Extension Bulletin E-2679, 122 pp.

Shetlar, D.J., and D. Herms. 1998. Insect and mite control on woody ornamentals and herbaceous perennials. Ohio State University Extension Bulletin 504, call 614-292-1868 to order.

Plant Health Care for Woody Ornamentals, ISA's Guide to the Plant Health Care Management System, $50.00. ISBN 1883097177.

Vittum, P.J., M.G. Villani, and H. Tashiro. Second edition. 1999. Turfgrass insects of the United States and Canada, Cornell University Press, ISBN 0-8014-3508-0.

Suggested websites

Turf IPM

University of Minnesota, CUES: Center for Urban Ecology and Sustainability.
http://www.entomology.umn.edu/cues

North Carolina State University
http://www.turffiles.ncsu.edu/pubs/

Ohio State University
http://plantfacts.ohio-state.edu/

University of Kentucky
http://www.uky.edu/Agriculture/Entomology/enthp.htm

University of Maryland
http://iaa.umd.edu/umturf/umturf.html

Ornamental IPM

CUES - Center of Urban Ecology and Sustainability
CUES: Center for Urban Ecology and Sustainability: University of Minnesota
http://www.entomology.umn.edu/cues

UC Statewide Integrated Pest Management Project
IPM of greenhouses and landscapes: University of California-Davis
http://www.ipm.ucdavis.edu/

Ohio Factsheet database: Search engine for landscape plant pest information
http://plantfacts.ohio-state.edu

Ohioline: Your Link to Information, News, and Education
http://www.ag.ohio-state.edu/~ohioline

Iowa State University — Internet
Iowa State University web glimpse search site: Iowa State University
http://www.iastate.edu/search/wglimpse.html

National IPM Network North Carolina Component
Urban landscapes including turf, shrubs, and trees: North Carolina State University
http://ipmwww.ncsu.edu/

National Integrated Pest Management Network: Management of the Home, Garden and Yard
Home, garden, and municipal IPM: North Carolina State University
http://ipmwww.ncsu.edu/urban/urban_contents.html

Insects and Plant Diseases: North Carolina State University
North Carolina Cooperative Extension Service; insects, plant diseases, pathology, entomology, and IPM
http://www.ces.ncsu.edu/resources/pests/

Ornamental and Turf Insect Information Notes
Insect fact sheets for landscapes: North Carolina State University
http://www.ces.ncsu.edu/depts/ent/notes/Ornamentals_and_Turf/ort_contents.html

Colorado State Cooperative Extension Insect Publications Menu
Landscape pests: Colorado State University
http://www.colostate.edu/Depts/CoopExt/PUBS/INSECT/pubins.html

University of Kentucky Entomology
Landscape pests: University of Kentucky
http://www.uky.edu/Agriculture/Entomology/enthp.htm
Variety of search topics; Entfacts

Insect Identification Laboratory Home Page
Identification of insects of landscape plants: Virginia Polytechnical Institute
http://www.ento.vt.edu/Facilities/OnCampus/IDInfo.html

Entomology Index: Integrated Pest Management
Integrated Pest Management: Iowa State University
http://www.ent.iastate.edu/List/Integrated_Pest_Management.html

ScaleNet: A Database of the Scale Insects of the World
http://www.sel.barc.usda.gov/scalenet/scalenet.htm

Gypsy Moth in North America
Gypsy moth in North America: Virginia Polytechnical Institute
http://gypsy.fsl.wvnet.edu/gmoth/

St. Paul Field Office - Forest Resources Management and Forest Health Protection, USDA Forest Service, State and Private Forestry, USDA Forest Service St Paul field office
http://willow.ncfes.umn.edu/

National Parks Service IPM Manual
National Park Service IPM manual
http://www.colostate.edu/Depts/IPM/natparks/natpark.html

Pesticide information

National IPM Network North Carolina Component
Pesticide recommendations for turf, ornamentals: North Carolina State University http://ipmwww.ncsu.edu/

US EPA Office of Pesticide Programs Home
Office of Pesticide Programs Pesticide information: EPA
http://www.epa.gov/pesticides

Pest Control Information
National Pesticide Telecommunications Network
http://ace.orst.edu/info/nptn/exten.htm
Pesticide information, use, and safety

Pesticide Information Profiles
EXTOXNET... Pesticide Information Profile (PIPs)
http://ace.ace.orst.edu/info/extoxnet/pips/searchindex.html

Biological control

Biological Control News
University of Wisconsin http://www.entomology.wisc.edu/mbcn/mbcn.html

Guide to Natural Enemies in North America
Biological control: A Guide to Natural Enemies in North America: Cornell University
http://www.nysaes.cornell.edu/ent/biocontrol/

Entomology Index: Biological Control
Biological Control: Iowa State Entomology Index
http://www.ent.iastate.edu/List/Biological_Control.html

Organic and Biological Controls
Insect Identification, Organic and Biological Controls: Virginia Polytechnical Institute http://everest.ento.vt.edu/Facilities/OnCampus/IDLab/altcontrol/altcontrol.html

Animal and Plant Health Inspection Service
Biological Control: USDA APHIS
http://www.aphis.usda.gov

Nematodes as Biological Control Agents of Insects
Nematodes for controlling insects: University of Nebraska-Lincoln
http://ianrwww.unl.edu/ianr/plntpath/nematode/wormepns.htm

Entomopathogenic Nematology at Rutgers
Nematodes for controlling insects: Rutgers University
http://www-rci.rutgers.edu/~wilsonmj/index.html

Suppliers of Beneficial Organisms in North America
Suppliers of Beneficial Insects: California Department of Agriculture
http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm

Association of Natural Biocontrol Producers
http://www.anbp.org

Rincon-vitova.com
www.rincon-vitova.com

Arbico
www.arbico.com

Great Lakes IPM, pheromone traps
www.greatlakesipm.com

Sustainable landscapes

Wild Ones Handbook: A Voice for the Natural Landscaping Movement
http://www.epa.gov/glnpo/greenacres/wildones

U.S. EPA - GLNPO, Visualizing the Great Lakes
http://www.epa.gov/glnpo/image

The Green Thumb Project
http://www.cp.duluth.mn.us/~lakes/grlinks.html

Northern Prairie Wildlife Research Center
http://www.npwrc.usgs.gov/index.htm

USEPA, GREEN ACRES: Green Landscaping with Native Plants
http://www.epa.gov/greenacres/

CUES - Center of Urban Ecology and Sustainability
CUES: Center for Urban Ecology and Sustainability: University of Minnesota
http://www.ent.agri.umn.edu/cues/cues.htm

Sustainable Urban Landscape Information Series
Sustainable landscape design: University of Minnesota
http://www.sustland.umn.edu/

Butterflies of North America
Butterfly web site: USGS
http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/bflyusa.htm

Suggested Diagnostic Clinics in the Midwest

State	Location for soil testing services	Location for diagnostic services
Colorado	**Soil, Water, & Plant Testing Laboratory** Room A-319 NESB Colorado State University Fort Collins, CO 80523-1120 Phone: (970) 491-5061 Fax: (970) 491-2930 Contact: Mary Schumm, Assistant to Lab Manager James R- Self, Ph.D., Lab Manager Email: mcschumm@lamar.colostate.edu jself@ceres.colostate.edu	**Plant Diagnostic Clinic** Jefferson County Extension 15200 W. 6th Avenue, Suite C Golden, CO 80401 Phone: (303) 271-6620 Fax: (303) 271-6644 Email: msmall@co.jefferson.co.us jefferso@coop.ext.colostate.edu **Identification and Diagnostic Service** 342-A General Services Building Department of Bioagriculture Sciences & Pest Management Colorado State University Fort Collins, CO 80523-1177 Phone: (970) 491-6950 Email: idlab@ceres.agsci.colostate.edu
Illinois	No soil testing service is offered by a public agency	(May-Sept) **Plant Clinic** 1401 W. St. Mary's Road University of Illinois Urbana, IL 61802 Phone: (217) 333-0519 Contact: Nancy Pataky Email: npataky@uiuc.edu (Oct-May) N-533 Turner Hall 1102 S. Goodwin Avenue University of IL Urbana, Illinois 61 801 Phone: (217) 333-2478 Fax: (217) 244-1230 Contact: Nancy Pataky Email: npataky@uiuc.edu

State	Location for soil testing services	Location for diagnostic services
Indiana	No soil testing service is offered to homeowners by a public agency. Contact the Plant and Pest Diagnostic Laboratory for a partial listing of private soil testing labs	**Plant and Pest Diagnostic Laboratory** Department of Botany and Plant Pathology 1155 Lilly Hall Purdue University West Lafayette, IN 47907 Phone: (765) 494-7071 Fax: (765) 494-3958 or Gail Ruhl - (765) 494-4641 Email: ruhl@btny.purdue.edu or Karen Rane - (765) 494-5821 Email: rane@btny.purdue.edu
Iowa	**ISU Soil Testing Laboratory** G501 Agronomy Iowa State University Ames, IA 50011 Phone: (515) 294-3076 Fax: (515) 294-5567 Email: soiltest@iastate.edu	**Plant Disease Clinic** Department of Plant Pathology 323 Bessey Hall Iowa State University Ames, IA 50011 Phone: (515) 294-0581 Fax: (515) 294-9420 Contact: Paula Flynn Email: pflynn@iastate.edu
Maryland		**Plant Diagnostic Laboratoiy** Department of Entomology University of Maryland 3171 Plant Sciences Building College Park, MD 20742-4454 Phone: (301) 405-1611 (3913) Fax: (301) 314-9290 Contact: Ethel Dutky Email: edl6@umail.umd.edu
Michigan	**MSU Soil and Plant Nutrient Laboratory** A81 Plant & Soil Sciences East Lansing, MI 48824-1325 Phone: (517) 355-0218 Fax: (517) 355-1732 Contact: Hariam Kerr Email: kerrh@msu.edu	**Diagnostic Services** 101 CIPS Michigan State University East Lansing, MI 48824-1311 Contact: Jan Byrne Phone: (517) 353-3504 Fax: (517) 432-0899 Email: byrnejm(@msu.edu
Minnesota	**Research and soil testing laboratory** University of Minnesota Room 135 Crops Research Bldg. 1902 Dudley Avenue St. Paul, MN 55108 Phone: (612) 625-3101 Fax: (612) 624-3420 Contact: Roger Eliason Email: elias004@umn.edu soiltest@soils.umn.edu	

State	Location for soil testing services	Location for diagnostic services
		For commercial growers: **Plant Disease Clinic** Department of Plant Pathology 495 Borlaug Hall 1991 Upper Buford Circle University of Minnesota St. Paul, MN 55108 Phone: (612) 625-1275 Fax: (612) 625-9728 Contact: Sandra Gould Email: gould001@umn.edu
Nebraska	**Soil & Plant Analytical Laboratory** Department of Agronomy & Horticulture. 139 Keim Hall University of Nebraska Lincoln, NE 68583-0916 Phone: (402) 472-1571 Fax: (402) 472-1396 Contact: Anita Jackson Email: aiacksonl@unl.edu	**Plant and Pest Diagnostic Clinic** Department of Plant Pathology 4448 Plant Sciences University of Nebraska Lincoln, NE 68583-0722 Phone: (402) 472-2559 Fax: (402) 472-2853 Contact: Jenifer Chaky Email: jchaky2@unl.edu
North Dakota	**Soil Testing Laboratory** Soil Science Dept. P.O. Box 5575 North Dakota State University Fargo, ND 58105 Phone: (701) 231-8942 Fax: (701) 231-7861 contact: Larry Swenson Email: Larry_Swenson@ndsu.nodak.edu	**Plant Diagnostic Lab** NDSU Plant Diagnostic Lab P.O. Box 5012 North Dakota State University Fargo, ND 58105 Phone: (701)231-7854 Fax: (701) 231-7851 Contact: Cheryl Biller Email: diaglab@ndsuext.nodak.edu
Ohio	Soil testing lab at Wooster has been closed.	**C. Wayne Ellett Plant and Pest Diagnostic Clinic** I110 Kottman Hall 2021 Coffey Road The Ohio State University Columbus, OH 43210-1087 Phone: (614) 292-5006 Fax: (614) 292-4455 Contact: Nancy Taylor Email: taylor.8@osu.edu ppdc2@postoffice.ag:ohio-state.edu
South Dakota	**Soil Testing Laboratory** Plant Science Department Box 2207-A, Ag Hall 06 South Dakota State University Brookings, SD 57007-1096 Phone: (605) 6884766 Fax: (605) 6884667 Contact: Ron Gelderman Email: Ronald Gelderman@sdstate.edu	**Plant Disease Clinic** Department of Plant Science South Dakota State University P.O. Box 2108 PSB 119 Brookings, SD 57007-1090 Phone: (605) 688-5157 Fax: (605) 688-4024 Contact: Marty Draper Email: draper.marty@ces.sdstate.edu

State	Location for soil testing services	Location for diagnostic services
Wisconsin	**Soil & Plant Analysis Laboratory** University of Wisconsin-Madison 5711 Mineral Pt. Rd. Madison, WI 53705 Phone: (608) 262-4364 Fax: (608) 263-3327 Contact: Sherry Combs, Director Email: sherry.combs@wisplan.uwex.edu spal@macc.wisc.edu Soil and Forage Analysis Lab. 8396 Yellowstone Drive Marshfield, WI 54489 Phone: (715) 387-2523 Contact: John Peters Email: jbpeter1@facstaff.wisc.edu **Insect Diagnostic Clinic** University of Wisconsin-Madison Department of Entomology 240 Russell Laboratories 1630 Linden Drive Madison, WI 53706 Phone: (608) 262-6510 FAX: (608) 262-3322 Contact: Phil Pellitteri pellitte@entomology.wisc.edu http://www.entomology.wisc.edu/entodiag.html	**Plant Disease Diagnostic Clinic** University of Wisconsin-Madison Department of Plant Pathology 1630 Linden Drive Madison, WI 53706-1598 Phone: (608) 262-2863 Fax: (608) 263-2626 Contact: Brian Hudleson Email: bdh@plantpath.wisc.edu