BIOLOGICAL CONTROL ORGANISMS FOR INSECTS AND MITES

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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 updated April 13, 2007.

This is organized in three sections. First is a brief description of organisms with potential applications followed by reference to sources where they may be purchased. This is followed by a brief summary 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 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, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 29, 30, 31, 32, 34, 35, 37, 41, 42, 44

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. 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Sources: *USDA has asked for this insect to be withdrawn due to a new definition listing it as a pest.*

Sevenspotted Lady Beetle. The sevenspotted lady beetle, *Coccinella septempunctata*, is the lady beetle of nursery rhymes, an introduced species from Europe. It is now widely distributed in North America and a common species. It can be found in many crops, but is particularly common in gardens and field crops, rather than on trees and shrubs. The adults and larvae are voracious eaters of aphids.

Sources: 16, 37, 42, 43

Twospotted Lady Beetle. The twospotted lady beetle, *Adalia bipunctata*, is an aphid predator that most commonly forages on shade trees, shrubs, and fruit trees. It is widely established and common in most of North America.

Sources: 30, 33, 36, 40, 45

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. Effectiveness declines during periods of short day length or in cool conditions.

Sources: 2, 3, 9, 10, 11, 12, 13, 16, 17, 19, 20, 21, 22, 23, 24, 26, 27, 30, 31, 32, 33, 34, 35, 36, 37, 39, 42, 44, 45

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 (*Dephastus pusillus*): 9, 10, 20, 23, 24, 32, 42
Sources (*Dephastus catalinae*): 2, 3, 9, 12, 16, 19, 22, 30, 37, 43
Sources (Unspecified *Delphastus* spp.): 10, 12, 18, 25, 34

Spider Mite Destroyer. Tiny, dark lady beetles in the genus *Stethorus* develop as predators of spider mites.

Sources (*Stethorus punctillum*): 3, 9, 13, 16, 19, 22, 26, 30, 32, 37, 42, 43
Sources (Unspecified *Stethorus* spp.): 9, 25, 26, 39

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: 13, 16, 19, 22, 23, 24, 26, 29, 30, 34, 37, 40, 42, 44

Scale Predator. The scale picnic beetle**,** *Cybocephalus nipponicus*, is a small black (female) to black/orange (male) beetle. It feeds on armored scales, including euonymus scale, San Jose scale, and elongate hemlock scale. It may also be a predator of other scales.

Sources: 16, 17, 19, 26, 37

Fungus Gnat Predator. The rove beetle, *Atheta coriaria*, develops as a predator of shore flies, fungus gnats and small soil dwelling Diptera larvae. It is also sold to control thrips stages in soil.

Sources: 9, 12, 16, 19, 26, 30, 33, 34, 36, 37, 40, 42, 43, 45

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 is *Chrysoperla rufilabris*, a native of southeastern US mostly associated with trees/shrubs, and *C. carnea*, a native western species found most commonly in agricultural settings. *Chrysoperla 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, 2, 4, 7, 15, 16, 19, 21, 24, 26, 29, 30, 35, 37, 41
Sources (*C. carnea*): 1, 2, 9, 10, 11, 16, 21, 23, 24, 27, 30, 33, 36, 37, 40, 45
Sources (*C. comanche*): 21, 24
Sources (Unspecified *Chrysoperla* spp.): 3, 5, 6, 10, 12, 13, 17, 18, 20, 26, 28, 31, 34, 35, 42, 44

Chinese Mantid. The Chinese mantid, *Tenodera aridofolia sinensis*, is the only species of commercial trade. (The praying mantid/European mantid, *Mantis religiosa*, is not sold.) They are sold as egg cases (oothecae) each containing approximately 100-200 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 northern areas and may die out where winters are sufficiently harsh. 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, 3, 4, 7, 10, 12, 13, 14, 16, 17, 19, 21, 23, 24, 30, 31, 32, 34, 35, 37, 41, 42

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. *Aphidoletes 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, 3, 9, 10, 11, 12, 13, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 32, 33, 34, 35, 36, 37, 42, 43, 44, 45

Spider Mite Predator Midge. Larvae of another gall midge, *Feltiella acarisuga* (=*Therodiplosis persicae*), are sometimes sold for control of twospotted spider mite.

Sources (*Feltiella acarisuga* (=*Therodiplosis persicae*): 3, 9, 11, 16, 17, 19, 25, 26, 30, 32, 33, 36, 37, 42, 45

Sixspotted Thrips. The sixspotted thrips, *Scolothrips sexmaculatus*, is a predator of spider mites and thrips, reported to be adapted to hot and dry conditions.

Sources: 39

Spider Mite Predators/Predatory Mites. Several species of commercially available predatory mites (Phytoseiidae family) appear to have some particular applications particularly for greenhouse and interiorscape use where humidity is adequate. Each predatory mite species has a range of temperature and humidity under which they are most efficient, and some require humidity conditions rarely reached in arid areas of the country. The more experienced suppliers/producers can provide consultation as to appropriate species to consider.

Sources (*Neoseiulus californicus*): 2, 3, 4, 8, 9, 10, 11, 16, 17, 19, 21, 23, 24, 25, 26, 30, 31, 33, 34, 36, 37, 39, 40, 42, 44, 45
Sources (*Neoseiulus (=Amblyseius) fallacis*): 8, 9, 12, 13, 16, 17, 19, 20, 22, 26, 30, 34, 37, 42, 43, 44
Sources (*Amblyseius (Typhlodromips) swirskii)*: 36, 40, 45
Sources (Western predatory mite, *Galendromus* (=*Mesoseiulus) occidentalis*): 2, 3, 8, 10, 16, 17, 19, 21, 23, 26, 29, 30, 31, 37, 39, 42
Sources (*Mesoseiulus (=Phytoseiulus) longipes*): 2, 3, 4, 8, 9, 10, 11, 13, 16, 17, 19, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 40, 41, 42
Sources (*Phytoseiulus persimilis*): 2, 3, 4, 8, 9, 10, 11, 13, 16, 17, 19, 21, 22, 23, 24, 25, 26, 27, 29, 31, 33, 34, 35, 36, 37, 40, 41, 43, 44, 45
Sources (*Galendromus annectens*): 2, 8, 3-24, 34, 42
Sources (*Galendromus helveoulus*): 2, 8, 42
Sources (Predatory mites, unspecified and/or mixtures): 2, 16, 17, 18, 24, 26, 28, 33, 34, 36, 40, 41, 42, 44

Thrips Predators/Predatory Mites. Two species of commercially available predatory mites (*Neoseiulus (=Amblyseius) cucumeris*, *A. degenerans*) feed primarily on thrips, particularly flower thrips. Pollen may be an important part of the diet of these predators.

Sources (*Neoseiulus (=Amblyseius) cucumeris*): 2, 3, 9, 10, 11, 12, 13, 16, 17, 19, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, 35, 36, 37, 40, 42, 43, 44, 45
Sources (*Amblyseius degenerans*): 9, 12, 25, 26, 33, 36, 40, 42, 45

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 two species are sold commercially.

Sources (*Orius insidiosus*): 3, 9, 11, 12, 13, 16, 17, 19, 20, 22, 26, 29, 30, 33, 36, 37, 42, 44, 45
Sources (*Orius laevigatus*): 11
Sources (*Orius majusculus*): *not found in current survey; previously available*
Sources (Unspecified *Orius* spp.): 10, 23, 24, 25, 32, 34, 35, 40

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 that has been commercially available.

Sources: *No sources for this insect were found in 2007; suppliers were noted in the 2002 survey*

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

Sources: 24, 35

Whitefly Predator Bug. The mirid bug, *Macrolophus caliginosus*, is a predator of whiteflies. Both adults and larvae feed on all stages of whiteflies and are sometimes used in crops such as tomato, eggplant, peppers, and ornamentals. This species is reported to be effective at lower temperatures than some other biological controls of whiteflies.

Sources: *This insect is now illegal to distribute in the USA.*

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: 3, 9, 16, 19, 30, 33, 35, 36, 37, 42, 45

Soil Predator Mite. The soil dwelling mite, *Hypoaspis miles*, is a generalist predator of mites and 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 (*Hypoaspis miles*): 9, 10, 12, 13, 16, 18, 19, 20, 22, 23, 24, 25, 26, 29, 30, 33, 35, 36, 37, 42, 43, 44, 45
Sources (Unspecified *Hypoaspis* spp.): 3, 9, 11, 17, 25, 32, 33

Parasites/Parasitoids of Insects

Trichogramma Wasps. Several species of *Trichogramma* wasps exist, all of which attack and kill various kinds of insect eggs. Insect larvae already hatched are not susceptible to *Trichogramma* attack. Eggs that *Trichogramma* will parasitized are from insects in the order Lepidoptera (moths and butterflies), which includes cutworms, codling moth, cabbageworms and armyworms. 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, 10, 13, 15, 16, 18, 30, 35, 36, 37
Sources (*Trichogramma brassicae*): 9, 13, 16, 17, 19, 22, 26, 29, 30, 33, 34, 35, 36, 37
Sources (*Trichogramma platneri*): 2, 9, 10, 16, 21, 24, 26, 33, 34, 35, 36, 37, 42
Sources (*Trichogramma pretiosum*): 1, 2, 9, 10, 13, 15, 16, 17, 18, 19, 20, 21, 22, 24, 30, 33, 34, 35, 36, 37, 42
Sources (*Trichogrammatoidea bactrae*): 4, 10, 42
Sources (Unspecified *Trichogramma* spp.): 3, 5, 6, 14, 15, 17, 23, 34, 25, 28, 31, 32, 34, 42

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 that develop on manure produced where livestock is kept. They are most widely marketed to suppress flies in horse facilities.

Sources (*Muscidifurax raptor*): 16, 30
Sources (*Muscidifurax raptorellus*): 30, 37
Sources (*Muscidifurax zaraptor*): 10, 30, 31
Sources (*Spalangia endius*): 1, 20, 31
Sources (*Nasonia vitripennis*): 10, 31, 40
Sources (Unspecified mixtures of fly parasites): 2, 10, 16, 17, 19, 23, 24, 28, 29, 31, 32, 34, 37, 38, 42

Aphid Parasites. Several small parasitic wasps 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*): 9, 16, 19, 22, 25, 26, 30, 33, 36, 37, 40, 42, 45
Sources (*Aphidius colemani*): 3, 9, 10, 11, 12, 13, 16, 17, 19, 21, 22, 23, 25, 26, 27, 29, 33, 35, 36, 37, 40, 42, 44, 45

Sources (*Aphidius matricariae*): 9, 12, 13, 16, 19, 22, 24, 26, 32, 37, 42, 43, 44
Sources (*Aphidius ervi*): 9, 11, 16, 19, 22, 23, 25, 26, 29, 30, 33, 36, 37, 42, 45
Sources (Unspecified *Aphidius* species or mixture): 10, 20, 25, 26, 30, 33, 36, 40, 45

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 72^0F). The whitefly parasite is supplied on cards, as developing wasps within whitefly nymphs. The latter turn black when hosting this parasite.

Sources: 2, 3, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 40, 42, 43, 44, 45

Sweetpotato Whitefly Parasite. A 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. Another whitefly parasite, *E. mundus*, also is used to control *Bemisia* spp.

Sources (*Eretmocerus eremicus*): 2, 3, 9, 11, 13, 16, 17, 19, 22, 23, 25, 26, 29, 30, 33, 36, 37, 40, 42, 44, 45
Sources (*Eretmocerus mundus*): 9, 11, 16, 33, 36, 37, 44, 45

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 go into winter dormancy and thus rarely, if ever, survives winters.

Sources: 3, 13, 16, 19, 26, 37, 40

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.

Sources (*Leptomastix dactylopii*): 9, 16, 19, 23, 24, 25, 30, 33, 36, 37, 42, 44, 45
Sources (*Leptomastidea abnormis*): 26
Sources (*Anagyrus pseudococci*): *Not found in most current review of suppliers*

Armored Scale Parasite/Golden Chalcid. A small parasitic wasp, *Aphytis melinus*, develops in many armored scales associated with interiorscape plants.

Sources: 2, 3, 13, 16, 19, 20, 22, 23, 24, 26, 30, 31, 34, 37, 42, 44

Soft Scale Parasite. A parasitic wasp, *Metaphycus helvolus*, is useful for managing black scale and hemispherical scale on interiorscape plants. The parasitic wasp, *M. flavus*, is an endoparasitoid of soft scales including brown scales. It practices ovicide and will destroy eggs

of other wasps using its ovipositor.

Sources (*Metaphycus helvolus*): 13, 14, 24, 30, 44
Sources (*Metaphycus flavus*): 30

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*): 40, 42
Sources (*Cotesia plutellae*): 16, 36, 37, 40

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, 3, 9, 13, 16, 19, 23, 25, 26, 30, 31, 33, 35, 36, 37, 42, 45
Sources (*Dacnusa sibrica*): 2, 3, 9, 16, 19, 20, 23, 25, 26, 30, 31, 33, 36, 37, 42, 45

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: *No sources of this species were noted for sale in the 2007 survey; this was available in 2002.*

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 Foray, among others. 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 nurseries and mail order garden catalogs.

Sources: 11, 16, 24, 30, 35, 37, 45 and most nurseries

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 house flies, blow flies, shore flies and many other fly species.) Formulations sold for use as a soil drench to control fungus gnats include Knock-Out Gnats and Gnatrol. Vectobac, Mosquito Dunks, Mosquito Rings, Aquabac, and Bactimos Briquets are sold for use in water to control mosquitoes and black flies. Increasingly formulations to control mosquito larvae in water are available through nurseries; formulations for fungus gnats apparently are only available through mail order.

Sources: 3, 4, 10, 11, 14, 16, 19, 24, 25, 30, 31, 35, 37 and many nurseries

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. Formulations sold as Novodor and Colorado Potato Beater are available from some suppliers.

Sources: 3, 19, 24, 35 and a few nurseries

Milky Spore. Milky spore is a bacterium (*Paenibacillus* (=*Bacillus) popillae*) that is applied to soil to infect larvae of the Japanese beetle.

Sources: 3, 4, 14, 16, 19, 32, 35, 37

Parasitic (Predatory) Nematodes/*Heterorhabditis* species. 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*) (e.g., HeteroMask, Grub-Away, BioStrike Hb, GrubStake Hb), *H. indica* (e.g., Grub Stake Hi), *H. marelatus*, and *H. megidis.*

Sources (*Heterorhabditis bacteriophora*): 3, 7, 9, 10, 13, 16, 18, 19, 20, 22, 24, 27, 29, 30, 33, 34, 35, 36, 37, 40, 42, 45
Sources (*Heterorhabditis indica*): 16, 29, 37, 42
Sources (*Heterorhabditis marelatus*): 16, 24, 29, 37, 40, 42
Sources (*Heterorhabditis megidis*): 4, 9, 11, 13, 30, 33, 36, 40, 45, 46
Sources (Unspecified *Heterorhabditis* spp.): 16, 31, 34, 37, 46

Parasitic (Predatory) Nematodes/*Steinernema* species. 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*) (e.g., 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. *Steinernema scapterisci* is used for control of mole crickets.

Sources (*Steinernema carpocapsae*): 3, 7, 10, 13, 16, 18, 19, 22, 24, 29, 30, 33, 34, 36, 37, 42, 45, 46
Sources (*Steinernema feltiae*): 3, 4, 7, 9, 10, 11, 16, 19, 24, 29, 30, 33, 34, 35, 36, 37, 42, 44, 45, 46
Sources (*Steinernema riobrave*): 30
Sources (*Steinernema scapterisci*): 46
Sources (Unspecified *Steinernema* spp.): 1, 25, 27, 34, 40
Sources: (Unknown predatory nematodes): 15, 31

***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: 3, 10, 16, 23, 24, 29, 31, 34, 35, 37

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. 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: 16, 37

Insect Viruses. The commercial availability of viruses to control insects is new and they do not yet appear to be distributed through the sources of this survey. However, they can be acquired by direct contact of the manufacturers. Two present manufacturers include Certis USA (www.certisusa.com) and BioTEPP (www.biotepp.com) and three viruses are distributed. All are allowed for use in certified organic production (OMRI listed).

Codling moth *Granulosis* virus: CYD-X (Certis USA), Virosoft (BioTEPP)
NPV virus of *Heliothis/Helicoverpa*: Gemstar LC (Certis USA)
NPV virus of *Spodoptera*: Spod-X (Certis USA)

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, Twospotted Lady Beetle, 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 Predators, Green Lacewings, Armored Scale Parasite/Golden Chalcid
Soft Scales	Scale Predators, Green Lacewings, Soft Scale Parasite
Thrips	Thrips Predators/Predatory Mites, Pirate Bugs, Sixspotted Thrips, Soil Predator Mite, Parasitic (Predatory) Nematodes/*Steinernema* spp., Fungus Gnat Predator
Spider Mites	Spider Mite Destroyer, Spider Mite Predator Midge, Sixspotted Thrips, Spider Mite Predators/Predatory Mites, Pirate Bugs
Leaf Beetles	Green Lacewings, Spined Soldier Bug, Predatory Plant Bug, *Bacillus thuringiensis* var. *san diego*, *Beauveria bassiana*
Mexican Bean Beetles	Green Lacewings, Predatory Plant Bug, Mexican Bean Beetle Parasite, Spined Soldier Bug
Caterpillars	Green Lacewings, Pirate Bugs, Predatory Plant Bug, Spined Soldier Bug, *Trichogramma* Wasps, Caterpillar Parasites, *Bacillus thuringiensis* var. *kurstaki*, Insect Viruses
Leafminers	Leafminer Parasites
White Grubs	Parasitic (Predatory) Nematodes/*Heterorhabditis* spp.
Grasshoppers	*Nosema locustae*/Grasshopper Spore, Chinese Mantid
Mole Crickets	*Steinernema scapterisci*
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)

Sources

US and Canada Suppliers of Biological Controls for Insects and Mites

1. A-1 Unique Insect Control
5504 Sperry Drive
Citrus Heights, CA 95621
Phone: (916) 961-7945
Fax: (916) 967-7082
Email: ladybugs@a-1unique.com
Web site: www.a-1unique.com

2. American Insectaries, Inc.
243 S. Escondido Blvd., #318
Escondido, CA 92025
Phone (760) 747-2920
Fax: (760) 498-0353
Email: betterbugs@cox.net
Web site: www.betterbugs.com

3. ARBICO Organics
P.O. Box 8910
Tucson, AZ 85738-0910
Phone: (800) 827-2847
Email: info@arbico.com
Web site: http://store.arbico-organics.com/

4. The Beneficial Insect Co.
P.O. Box 119
Glendale Springs, NC 28629
Phone: (336) 973-8490
Email: jimkluttz@thebugfarm.com
Web site: www.thebeneficialinsectco.com

5. Beneficial Insectary
9664 Tanqueray Ct.
Redding, CA 96003
Phone: (530) 226-6300/(800) 477-3715
Fax: (530) 226-6310/(888) 472-0708
Email: bi@insectary.com
Web site: www.insectary.com

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

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

8. Biotactics, Inc.
25139 Briggs Rd.
Romoland, CA 92585
Phone: (951) 928-0215
Fax: (951) 928-2041
Email: sales@benemite.com
Web site: www.benemite.com

9. The Bug Factory, Ltd.
1636 E. Island Highway
Nanoose Bay, BC V9P 9A5
Canada
Phone: (250) 468-7912
Fax: (250) 468-9484
Email: ahale@thebugfactory.ca
Web site: www.thebugfactory.ca

10. Buglogical Control Systems
P.O. Box 32046
Tucson, AZ 85751-2046
Phone/Fax: (520) 298-4400
Email: info@buglogical.com
Web site: www.buglogical.com

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

12. Evergreen Grower's Supply
17592 South Palmer Road
Oregon City, OR 97045
Phone: (503) 522-0879
Email: sales@evergreengrowers.com
Web site: www.evergreengrowers.com

13. Extremely Green Gardening Company
P.O Box 2021
Abington, MA 02351
Phone: (781) 878-5397
Fax: (781) 878-5582
Email: info@extremelygreen.com
Web site: www.extremelygreen.com

14. Gardener's Supply Co.
128 Intervale Rd.
Burlington, VT
Phone: (888) 833-1412
Email: info@gardeners.com
Web site: www.gardeners.com

15. Gardens Alive!
5100 Schenley Pl.
Lawrenceburg, IN 47025
Phone: (513) 354-1482
Email: gardener@gardens-alive.com
Web site: www.gardensalive.com

16. Great Lakes IPM, Inc.
10220 Church Road
Vestaburg, MI 48891-9746
Phone: (989) 268-5693/ (800) 235-0285
Fax: (989) 268-5311
Email: glipm@nethawk.com
Web site: www.greatlakesipm.com

17. Greenfire
2725 A Hwy 32
W. Chico CA 95973
Phone: (800) 895-830
Fax: (530) 895-8317
Email: info@greenfire.net
Web site: www.greenfire.net

18. Green Home
850 24th Ave.
San Francisco, CA 94121
Phone: (877) 282-6400
Email: help@greenhome.com
Web site: www.GreenHome.com

19. Green Spot Ltd. /Green Methods The Green Spot Ltd.
93 Priest Rd.
Nottingham, NH 03290-6204
Phone: (603) 942-8925
Fax: (603) 942-8932
Email: Info@GreenMethods.com
Web site: www.GreenMethods.com

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

21. Harmony Farm Supply & Nursery
3244 Hwy. 116 North
Sebastopol, CA 95472
Phone: (707) 823-9125
Fax: (707) 823-1734
Email: info@harmonyfarm.com
Web site: www.harmonyfarm.com

22. Hummert International
4500 Earth City Expressway
Earth City, MO 63045
Phone: (800) 325-3055
Email: sales@hummert.com
Web site: www.Hummert.com

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

24. IFM (Integrated Fertility Management)
1422 N. Miller St.
Wenatchee, WA 98801
Phone: (800) 332-3179
Fax: (509) 662-6594
Email: phil@agrecology.com
Web site: www.agrecology.com

25. International Technology Services, Inc.
P.O. Box 75
Lafayette, CO 80026
Phone: (800) 375-1684
Email: rcg@greenhouseinfo.com
Web site: www.intertechserv.com

26. IPM Laboratories, Inc.
P.O. Box 300
980 Main Street
Locke, NY 13092-0300
Phone: (315) 497-2063
Fax: (315) 497-3129
Email: ipminfo@ipmlabs.com
Web site: www.ipmlabs.com

27. Koppert Biological Systems
28465 Beverly Rd.
Romulus, MI 48174
Phone: (734) 641-3763
Email: asktheexpert@koppertonline.com
Web site:
www.koppertonline.com/home.asp

28. Kunafin Trichogramma Insectaries
Rte. 1 Box 190
Quemado, TX 78877-0190
Phone: (800) 832-1113
Fax: (830) 757-1468
Email: office@unafin.com
Web site: www.kunafin.com

29. **M & R Durango, Inc. Insectary**
P.O. Box 886
Bayfield, CO 81122
Phone: (970) 259-3521/(800) 526-4075
Fax: (970) 259-3857
Email: mail@goodbug.com
Web site: www.goodbug.com

30. **Nature Insect Control (NIC)**
3737 Netherby Rd.
Stevensville, Ontario LOS, 1SO
Canada
Phone: (905) 382-2904
Fax: (905) 382-4418
Email: nic@niagara.com
Web site: www.natural-insect-control.com

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

32. Nature's Control
3960 Jacksonville Hwy.
P.O. Box 35
Medford, OR 97501
Phone: (541) 245-6033
Fax: (800) 698-6250
Email: info@NaturesControl.com
Web site: www.naturescontrol.com

33. Park Seed Co.
2 Parkton Av.
Greenwood, SC 29647
Phone: (800) 845-3366
Fax: (800) 209-0360
Email: lmurray@parkwholesale.com
Web site: www.parkwholesale.com

34. Peaceful Valley Farm Supply
P.O. 2209
Grass Valley, CA 95945
Phone: (530) 272-4769/(888) 784-1722
Email: helpdesk@groworganic.com
Web site: www.groworganic.com

35. Planet Natural
1612 Gold Ave.
Bozeman, MT 59715
Phone: (800) 289-6656/(406) 587-5891
Fax: (406) 587-0223
Email: info@plantenatural.com
Web site: www.planetnatural.com

36. Plant Products Co. Ltd.
6299 Meadowsweet Av. NW
Canton, OH 44718
Phone/Fax: (330) 966-0234
Email: sgraham@plantprod.com
Web site: www.plantprod.com

37. Rincon-Vitova Insectaries, Inc.
P.O. Box 1555
Ventura, CA 93022-1555
Phone: (800) 248-2847
Fax: (805) 643-6267
Email: bugnet@rinconvitova.com
Web site: www.rinconvitova.com

38. Spalding Laboratories
760 Printz Road
Arroyo Grande, CA 93420
Phone: (888) 880-1579
Fax: (866) 738-9632
Web site: www.spalding-labs.com

39. Sterling Insectary
30787 Perkins Ave.
McFarland, CA 93253
Phone: (661) 792-6810
Fax: (661) 792-6880
Email: kim@sterlinginsectary.com
Web site: www.sterlinginsectary.com

40. Syngenta Bioline, Inc.
P.O. Box 2430
Oxnard, CA 93034-2430
(wholesale distributor only)
Phone: (805) 986-8265
Email: dcahn@syngentabioline.com
Web site: www.syngentabioline.com

41. Territorial Seed Company
P.O. Box 158
Cottage Grove, OR 97424-0061
Phone: (800) 626-0866
Fax: (888) 657-3131
Email: tertri@territorial-seed.com
Web site: www.territorial-seed.com

42. Tip Top Bio-Control
P.O. Box 7614
Westlake Village, CA 91359
Phone: (800) 525.0004
Fax: (905) 482-7846
Email: tiptopbio@yahoo.com
Web site: www.tiptopbio.com

43 Applied Bio-Nomics
11074 W. Saanich Rd.
Sidney, BC V8L 5P5
Canada
Phone: (250) 656-2123/(877) 656-2123
Fax: (250) 656-3844
Email: brianabl@telus.net
Website: www.appliedbionomics.ca
(under construction)

44. EcoSolutions, Inc.
2948 Landmark Way
Palm Harbor, FL 34684
Phone/Fax: (727) 787-3669
Email: ecosolutions@mindspring.com
Website: www.ecosolutions.com

45. Biobest Biological Systems
2020 Fox Run Rd.
Leamington, ON N8H 3V7
Canada
Phone: (519) 322-2178
Fax: (519) 322-1271
Email: info@biobest.ca
Website: www.biobest.ca

46. Becker Underwood
801 Dayton Ave.
Ames. IA 50010
Phone: (515) 232-5907
Fax: (515) 817-0722
Email: info.us@beckerunderwood.com
Website: www.beckerunderwood.com

Another source of lists of biological control suppliers is the **Association of Natural Biological Control Producers**. The web site address is: ANBP.org