I N S E C T S E R I E S

HOME & GARDEN

Insect Parasitic Nematodes

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Quick Facts...

Insect parasitic nematodes are small round worms that kill insects but are harmless to other organisms.

Several species of these nematodes are being developed as biological insect controls.

Among the pests effectively controlled are most turf insects and several other insects that live in soil.

Insect parasitic nematodes are small, round worms that complete part of their life cycle in insects. Several species can kill insects in this process, and some are marketed as a biological control agent.

The use of insect parasitic nematodes to control soil insects, including many turfgrass and garden pests, has received increased attention recent years. Insect parasitic nematodes are also know as predator nematodes, beneficial nematodes or entomogenous nematodes. They are sold under such trade names as BioSafe, BioVector, Scanmask, Exhibit, Oti-Nem, and Guardian.

Insect parasitic nematodes have been studied for potential biological control of turf pests for more than 50 years. However, their increasing availability and rising public demand for alternatives to insecticides has heightened interest in parasitic nematodes.

Nematodes are a type of roundworm in the phylum Nematoda. This is a different order of animals from the segmented worms, such as earthworms and flatworms. Nematodes are abundant, particularly in soil. Many feed on bacteria, some attack plants, and others can be parasites of animals. However, each species is usually specific in its habits. Insect parasitic nematodes, for example, develop only in insects or other arthropods. They do not attack mammals, birds or plants.

Two genera of insect parasitic nematodes have been most actively considered for control of insect pests. *Steinernema* (previously known as *Neoaplectana*) has been thoroughly researched, including control studies for Japanese beetle conducted in the 1930s. Recent attention has shifted to include the genus *Heterorhabditis*. Both groups are in the order Rhabdita, the bacteria-feeding nematodes. It includes a large number of common but frequently overlooked soil-infesting nematodes that assist in organic matter breakdown.

Life Cycle

Insect parasitic nematodes are mobile and move short distances in search of host insects. *Heterorhabditis* is more mobile than *Steinernema*. Nematodes use carbon dioxide and perhaps other chemicals produced in waste products of insects as cues to find their hosts. Upon entering the insect the nematodes kill their host by releasing bacteria into it, strains of *Xenorhabdus* species that are associated with the nematode. The bacteria develop within the body cavity of the susceptible host. The host dies from blood poisoning within a few days.

The dead insect generally maintains its original shape and does not decay in a normal manner because its body is filled with these specialized bacteria. Associated color changes may occur. For example caterpillars parasitized by *Heterorhabditis* may have a reddish-brown color. The nematodes develop by feeding upon the bacteria and degraded host tissues.

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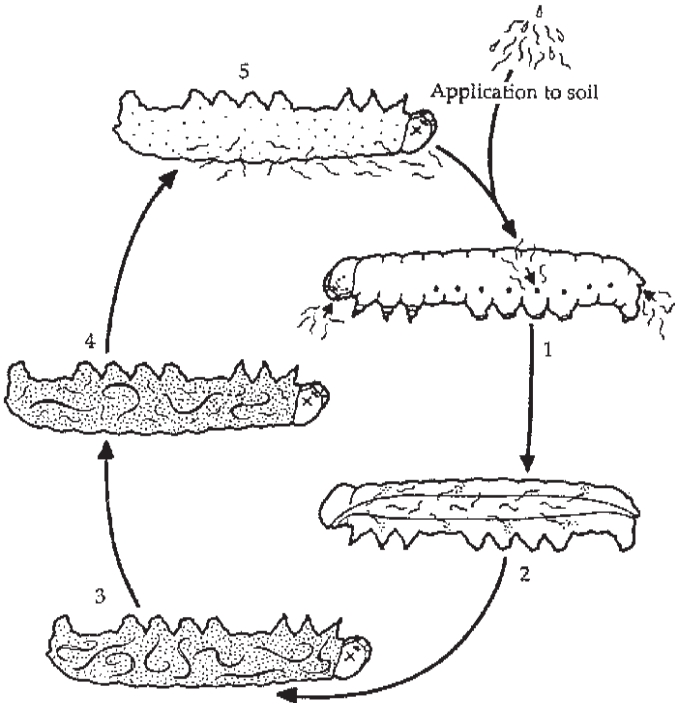

Figure 1: Life cycle of *Steinernema* nematodes. 1, 2: invasion and colonization of insect. 3,4: development within insect. 5: exit from dead insect and invasion of new host. Drawing courtesy of University of Illinois.

The active stage of the nematode that invades an insect is the juvenile (dauerlarva) stage. These infective juveniles are applied for insect control. *Steinernema* nematodes enter the insect through natural openings, such as the mouth, spiracles and anus, then penetrate into the body cavity. *Heterorhabditis* nematodes use natural openings but also can enter by piercing the body wall.

Once inside the infected insect, nematodes develop rapidly, in five or more days, depending on host quality and temperature. Normally, one to two generations occur in a host insect. Thousands of nematodes can be produced following a single infection. Ultimately, the body wall of the dead host insect ruptures and releases the nematodes. Insect parasitic nematodes typically kill their host insect within two to three days after invading the body cavity.

Safety and Environmental Concerns

Insect parasitic nematodes do not appear to have any significant harmful effects on other beneficial organisms or people. Arthropods appear to be the only hosts for these organisms, so plants and most wildlife are not likely to be directly affected by nematode applications. However, hosts can include some natural enemies of insect pests, as well as the pest species themselves.

They cannot attack or cause disease in birds, mammals or fish. There appear to be minimal effects against noninsect arthropods, such as sowbugs and millipedes. Earthworms are occasionally infected after wounding, but there is no evidence to suggest that insect parasitic nematodes harms earthworm populations in field applications.

Insect parasitic nematodes have been exempted from federal and state registration requirements (Vol. 47, Fed. Reg. 23928, 1982), greatly facilitating their development and distribution for insect control. This means that insect parasitic nematodes, like predatory and parasitic insects, can legally be used on all crops without restriction.

Insect Parasitic Nematodes for Insect Control

Insect parasitic nematodes are a biological insecticide similar to *Bacillus thuringiensis*-based insecticides. A wide range of insects are susceptible to these nematodes, at least in laboratory studies. Various caterpillars and large beetle larvae are among the more susceptible groups of insects. Wax moth larvae, commonly sold as fish bait, are commonly used in rearing insect parasitic nematodes.

Maggots, crickets, grasshoppers and termites appear less susceptible to the commonly available strains of these nematodes. However other nematode strains may hold future promise against these pests.

One of the greatest factors to determine susceptibility under field conditions is the environment where the pest insect occurs. Because the nematodes are susceptible to drying and ultraviolet light, they are most effective against insects that occur in moist, dark locations. This includes various soil insects or borers within woody plants. Insects on foliage may be susceptible in laboratory settings but control is poor in field applications.

Insect parasitic nematodes are sold in the infective juvenile dauerlarva stage, which are barely visible to the unaided eye. They typically are used at rates of 250 million to 2 billion per acre (approximately 6,000 to 46,000 per square foot). To apply, dilute the nematodes in water and drench the soil or inject them

into plants. Regular spray equipment can be used — nematodes are quite tolerant of pressures found in many sprayers.

Steinernema

Steinernema is the most widely researched species for insect control. It is the most readily available for yard and garden use because it is easier to rear and handle. In field applications, *Steinernema carpocapsae* tend to be most effective against caterpillar larvae. In laboratory and field trials, it has controlled sod webworms, cutworms and certain borers (raspberry crown borer, carpenter worm). It also has been effective against billbug larvae in Colorado State University trials. Other research indicates that adult billbugs may be controlled as well.

Steinernema *are effective against caterpillar larvae, sod webworms, cutworms, certain borers, and billbug larvae.*

Heterorhabditis *controls black vine weevil, citrus-infesting root weevils and white grubs.*

Another speices, *Steinernema feltiae* is effective against certain fly larvae. It is sometimes used to control fungus gnats and other soil dwelling insects of greenhouse-grown plants.

Steinernema are less effective against white grubs, root maggots, rootworms and black vine weevil. Unfortunately, some commercial products make claims of effective control of some pest species based on research conducted solely in artificial environments, these often do not reflect performance in the field.

Heterorhabditis

Heterorhabditis is less commonly available because it is more difficult to rear and more susceptible to environmental extremes. However, field trials consistently show that this genus outperforms *Steinernema* for control of white grubs. Several species are sold including *Heterorhabditis bacteriophora, H. megadis,* and *H. indica.*

Heterorhabditis also effectively controls many nursery pests that feed in the root zone, such as black vine weevil and citrus-infesting root weevils.

Effects of Environment on Performance of Nematodes

Effective use of nematodes for insect control depends on environmental conditions during and after application. Adequate moisture is the most important factor. Insect parasitic nematodes require free water to move and are susceptible to death by drying. High humidity and free water are the primary conditions for effective use of insect parasitic nematodes.

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Insect parasitic nematodes also are susceptible to extreme temperature conditions. For example, short exposure to high temperatures (above 90 to 95 degrees F) can be lethal to commonly available strains of *Steinernama carpocapsae*. Low temperatures (below about 55 degrees) inactivate most *Heterorhabditis* species. Strain and species differ in temperature sensitivity.

In soil applications, nematode movement to the target pest depends on conditions of the soil and thatch. Adequate moisture is essential and pretreatment irrigation is recommended. Irrigation may also cause soil insects, such as white grubs, to move higher in the soil where they may be more easily found by the nematodes. Nematode movement is more extensive in sandy soils with large pore size than in clay soils. Nematode penetration may be expected to be poor in "tight" soils common to some regions. Extensive thatch accumulation may also prevent nematode penetration into the turf root zone where white grubs feed. A post-treatment irrigation may help push nematodes through the thatch layer.

Insect parasitic nematodes appear compatible with many chemicals used in lawn and garden care. Nitrogen fertilizers are nontoxic to *Steinernema carpocapsae*, as are insecticidal soaps and wetting agents. Insecticides show variable effects on nematode survival, with most having little effect. For example, the carbamate insecticides carbaryl (Sevin) and bendiocarb (Turcam) appear

to be moderately toxic, particularly to *Heterorhabditis*. Among tested turfgrass insecticides, chlorpyrifos (Dursban) is one of the most toxic to insect parasitic nematodes. Mercurial fungicides are even more damaging to insect parasitic nematodes, and effects are persistent. (Most of the pesticides that are seriously destructive to nematodes are no longer registered for use in turfgrass.)

Storage and Handling

Most insect parasitic nematodes packaged for sale have a shelf life of several weeks or even months if refrigerated. *Steinernema carpocapsae* is particularly tolerant of storage conditions, a major reason for its ready availability. Systems to dry *Steinernema* nematodes for extended storage have been developed, a process that can increase storage life and reduce the need for refrigeration.

Regardless, insect parasitic nematodes can be killed or inactivated by extreme temperatures. Never allow them to freeze or be exposed to high temperatures (above about 90 degrees).

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Information is still lacking regarding the persistence of insect parasitic nematodes in turfgrass under Colorado conditions. Native nematodes do occur in the state. One of the most spectacular is *Mermis nigrescens*, often over 4 inches long, which is a common parasite of grasshoppers. For more information see fact sheet 5.610, *Weird Worms: Horsehair Worm and the Grasshopper Nematode.*

Commercially available strains have originated from the southern United States or other mild climates. Those that reproduce can produce multiple cycles of infection during the growing season. However, it is likely that extremes of cold, drying or high summer temperatures would kill off nematodes under Colorado conditions.

Furthermore, various soil organisms, including predatory mites, feed on nematodes and may reduce populations to ineffective levels. In addition, there is some dispersal of insect parasitic nematodes either through their own movements or by insects and mites.

At present, there are no reliable guidelines on nematode persistence.

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