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Insect control with 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 for use as biological insect controls.

Among the insect pests most effectively controlled by insect parasitic nematodes 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 of nematodes exist that are capable of killing insects in this process and some are being marketed as a type of biological control agent.

The use of insect parasitic nematodes to control soil insects, including many turfgrass and garden pests, has received increased attention in the past few years. Insect parasitic nematodes are also known 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 over 50 years. However, the increase in availability of the nematodes and rising public demand for alternatives to insecticide controls has raised interest in parasitic nematodes.

Nematodes as Insect Control Agents

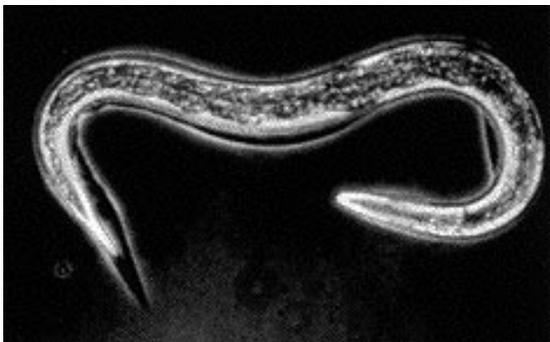
Nematodes are a type of animal known as the roundworms, the Phylum *Nematoda*. This is a different order of animals from the segmented worms, such as earthworms (*Annelida*) and flatworms (*Platyhelminthes*). Nematodes are an abundant animal life form, particularly in soils. Many feed on bacteria, some attack plants and others can be parasites of animals. However, each species is usually specific in their habits. The insect parasitic

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1. Whitney Cranshaw, Colorado State University Cooperative Extension entomologist and associate professor; entomology; Rick Zimmerman, research associate, Rogers Mesa Experiment Station, Hotchkiss, Colorado. 5/94. ©Colorado State University Cooperative Extension. 1994. For more information contact your county Cooperative Extension office. Some recommendations change regularly. Contact your Colorado State University Cooperative Extension county office for current recommendations.

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 1930's. Recent attention has shifted to include the genus *Heterorhabditis*. Both groups of nematodes are classified in the order Rhabdita, the bacteria feeding nematodes. This includes a large number of common, but frequently overlooked soil infesting nematodes that assist in organic matter breakdown.



Nematode.

Insect parasitic nematodes are mobile, and move small distances in search of host insects. (*Heterorhabditis* is known to have much greater mobility than *Steinernema*). CO₂ and perhaps other chemicals produced in waste products of insects are used as cues during host finding. Nematodes in the genera *Steinernema* and *Heterorhabditis* kill their host (various arthropods) by releasing bacteria into it (strains of *Xenorhabdus* species) associated with the nematode. The bacterium develops within the body cavity of the susceptible host and the host dies within a few days by blood poisoning.

The dead insect generally maintains its original shape and does not decay in a typical manner since these specialized bacteria fill the body of the dead insect. Associated color changes may occur; for example caterpillars parasitized by *Heterorhabditis* may have a reddish-brown color. The nematode develops by feeding upon the bacteria and degraded host tissues.

The stage of the nematode that is active and capable of invading an insect is the juvenile (dauerlarva) stage. These infective juveniles are the stage 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 similarly enter natural openings but are also capable of entering insects by piercing the body wall.

Once inside the infected insect, nematode development is rapid and may be completed within five or more days, depending on host quality and temperature. Normally one to two generations of the nematode occur in a host insect and 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.

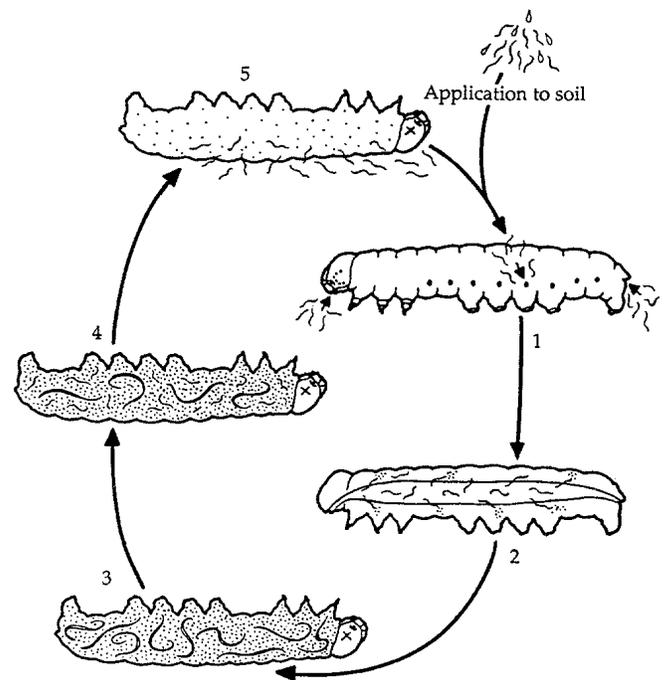


Figure 1: Life cycle of *Steinernema* sp. entomogenous nematodes. Drawing courtesy of University of Illinois.

Safety and Environmental Concerns

Insect parasitic nematodes do not appear to have any significant deleterious non-target effects on humans and other beneficial organisms. 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, this can include some of the natural enemies of insects as well as pest species.

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

A wide range of insects have been found to be susceptible to infection by insect parasitic 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 pests in these insect groups.

One of the greatest factors to determine susceptibility under field conditions is the environment where the pest insect occurs. Since the insect parasitic 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 are infected poorly during 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 make drenches of soil or inject them into plants. Regular spray equipment can be used, since they are quite tolerant of pressures found in many sprayers.

Steinernema species of nematodes are the most widely researched group of nematodes for insect control. This species is currently the most readily available nematode for yard and garden use because they are easier to rear and handle. In field applications, nematodes in the

genus *Steinernema* tend to be most effective against caterpillar larvae. Sod webworms, cutworms, and certain borers (raspberry crown borer, carpenter worm) are controlled by this group of nematodes in laboratory and field trials. They also have been effective against billbug larvae in Colorado State University trials. Other research indicates that adult billbugs also may be infected.

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

Nematodes in the genus *Heterorhabditis* are less commonly available because they are more difficult to rear and more susceptible to environmental extremes. However, field trials consistently show that this genus consistently outperforms *Steinernema* species for control of white grubs.

Heterorhabditis species/strains also are highly effective for control of many root-zone feeding nursery pests, such as black vine weevil and citrus-infesting root weevils.

Effects of Environment on Performance of Nematodes

Effective use of insect parasitic nematodes for insect control highly depends on environmental conditions during and following application. The most important one is the presence of adequate moisture. 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.

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

In soil applications, movement of nematodes to the target pest depends on conditions of the soil and thatch. Adequate moisture is essential and pre-treatment irrigation is recommended. (Irrigation may also help cause soil insects, such as white grubs, to move higher in

the soil where they may be more easily contacted by the nematodes.) Nematode movement is more extensive in sandy soils with large pore size than clay soils. Penetration of nematodes 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 generally compatible with many chemicals used in lawn and garden care. Nitrogen fertilizers are essentially non-toxic to *Steinernema carpocapsae*. Insecticidal soaps and wetting agents similarly are non-toxic. Insecticides show variable effects on nematode survival, with most having little effect on nematodes. For example, diazinon appears essentially non-toxic to insect parasitic nematodes. The carbamate insecticides carbaryl (Sevin) and bendiocarb (Turcam) appear to be moderately toxic, particularly to nematodes in the genus *Heterorhabditis*. Among tested turfgrass insecticides, chlorpyrifos (Dursban), is among the most toxic to insect parasitic nematodes. (Mercurial fungicides are even more damaging to insect parasitic nematodes, and effects are persistent.)

Storage and Handling

Most insect parasitic nematodes currently 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 increased availability. Recently, systems to desiccate *Steinernema* nematodes for extended storage have been developed, a process that can increase storage life and eliminate the need for refrigeration. These are now being marketed in some nurseries and through mail order.

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 F).

Information is still lacking regarding the persistence of insect parasitic nematodes in turfgrass under Colorado conditions. Native nematodes do occur in Colorado. (One of the most spectacular is *Mermis nigrescens*, a large nematode, often over 4 inches long, that is a common parasite of grasshoppers.) However, 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 act to kill out nematodes under Colorado conditions. Furthermore, various soil organisms, including predatory mites, feed upon nematodes and may reduce populations to ineffective levels. In addition, there is some dispersal of insect parasitic nematodes either through their own movements or carried by insects and mites. At present, there are no reliable guidelines on nematode persistence. Applications of insect parasitic nematodes would essentially involve their use as a "biological insecticide", similar to *Bacillus thuringiensis*-based insecticides.