BENEFICIAL NEMATODES FOR BIOLOGICAL CONTROL OF INSECT PESTS

CAROL S. GLENISTER

IPM Laboratories, Inc.
Locke, NY 13092-0099

INTRODUCTION

The major commercial nematode is currently named *Steinernema carpocapsae*, first collected and described in both the United States and Czechoslovakia in 1954. It has also recently been called *S. feltiae*, and *Neoaplectana carpocapsae*. The name *S. feltiae* has now been assigned to what used to be known as *S. bibionis*, so the distinction is important.

LIFE CYCLE

Juvenile steinernematids called infectives enter through natural openings on the insect body, often through the mouth. Once inside, they shed their protective skin, penetrate the gut wall and get into the insect's blood system, and secrete a toxin that rapidly kills the insect. At the same time, the steinernematids carry a special bacterium into the insect. Once in the blood system, the bacteria begin to multiply and also contribute to host death. The bacteria provide a food supply which supports the nematodes' sustenance and reproduction.

The nematodes enter their reproductive phase in the insect's blood system and subsequently grow and molt through a third and fourth juvenile stage before becoming adults. The adults mate and produce a first generation of nematodes that usually molts only three times and quickly creates a second generation of adults.

This is where the unique aspect of steinernematid nematodes becomes evident: when the insect cadaver becomes crowded with nematodes, the normal life cycle shunts into a long-term survival strategy (Figure 1) that allows the nematodes to survive until they can find another insect host. Second stage nematodes grow into ''infective'' nematodes, a non-feeding, survival stage with closed mouth, collapsed gut and thick skin that can even withstand some slow drying. Infectives can survive several years in the soil, wriggling toward chemical cues from insects, and attempting to enter the insects.

From our perspective, the infectives are the most important stage. They are the only stage that can attack and kill the insect and they allow a product shelf-life of at least 6 months. In aerated 50° F water they can be held for several years with little loss of viability. The infective stage has made it possible for several companies to produce them commercially.

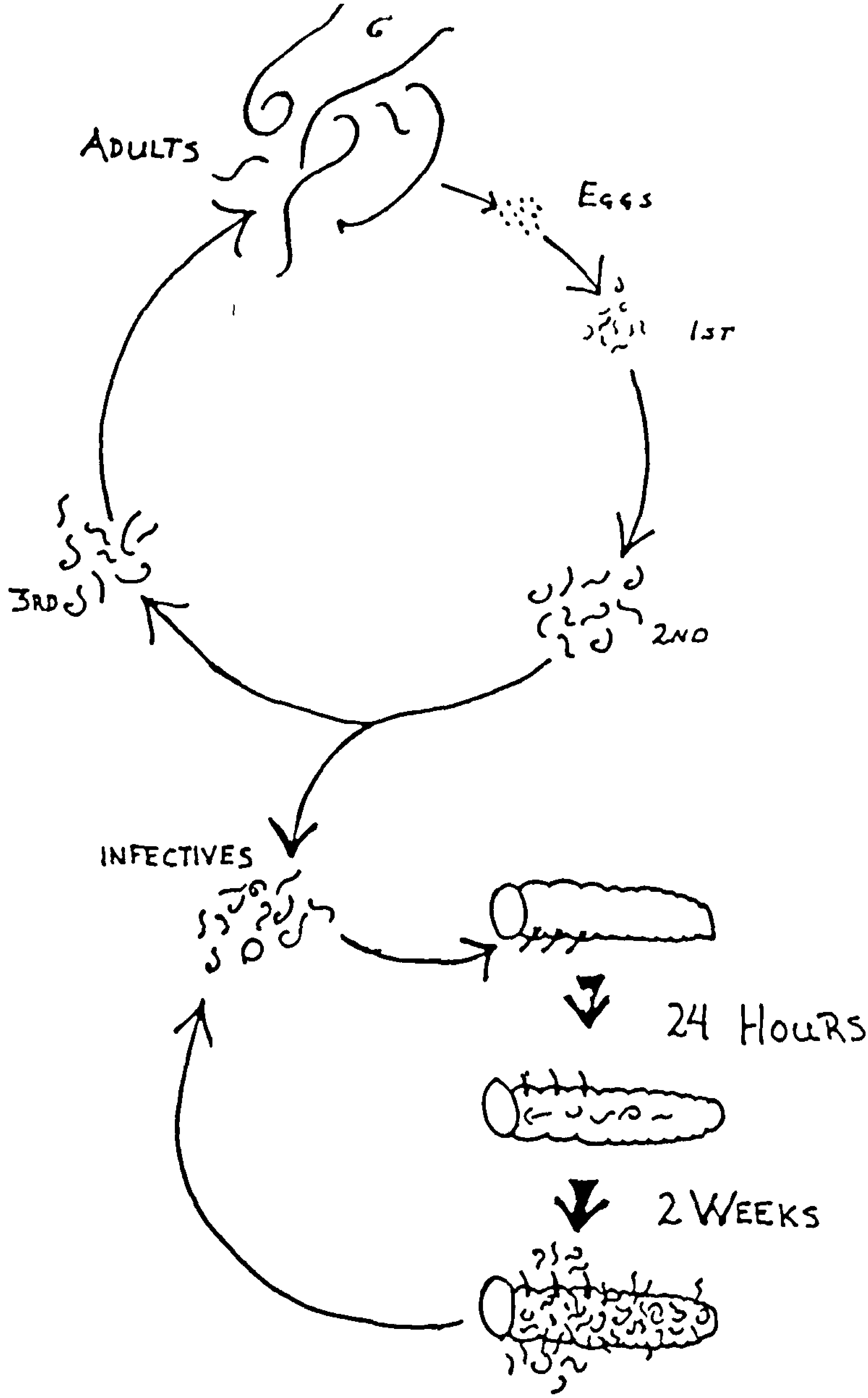

Figure 1. Life cycle of *Steinernema carpocapsae* nematode

PRODUCERS

The two major producers in the United States are BioLogic, a private firm founded in 1985 in Pennsylvania, and Biosys, a public California firm founded in 1983. Both firms produce billions of nematodes per year.

Biosys produces BioSafe™ as its homeowner package and BioVector™ as its bulk package. Both packages consist of the ''All'' strain of *S. carpocapsae.*

BioLogic produces ScanMask™ and EcoMask™. The ScanMask consists of the ''Umea'' strain of *S. carpocapsae*, which was originally isolated near the Arctic circle in Sweden, hence the name ''Scan'' (for Scandinavia), ''Mask'' (Swedish for nematode). ''ScanMask'' is more climatically adapted to colder northern soils, noticeably larger than the ''All'' strain, and more expensive to produce. ''EcoMask'' is a hybrid comparable in length, price and temperature tolerance to the ''All'' strain.

EFFECTS ON NON-TARGET ORGANISMS

These nematodes have been termed beneficial because they have no ability to harm warm-blooded animals since they cannot tolerate high temperatures. The next question an organic grower will ask is ''What about earthworms?'' Tests of immensely high numbers of nematodes against earthworms resulted in healthy earthworms.

ENVIRONMENTAL CONSTRAINTS

Nematodes are most successful for those who respect their constraints. They are extremely sensitive to ultraviolet light. For this reason, we recommend that applications be made early in the morning or in the evening.

Although infectives can withstand controlled drying, they are harmed by sudden drying and have had very erratic success in dry environments. The best results to date have been in moist environments: against black vine weevil and other soil insects in pots and cranberry bogs, against grubs in well-watered lawns, against wood and cane borers in their tunnels, and against fungus gnats in greenhouses. Perhaps the problem here is that the nematodes need a film of water to move down into the soil and hence avoid radiation.

Like moisture, temperature affects the nematodes ability to move towards its host and away from dryness and sunlight. Moderate temperatures are optimum for their survival and activity. Different strains have different temperature ranges. The ''All'' strain is effective from 60 to about 86° F whereas the ''Umea'' strain is active down to 50° F. The reported optimum temperature for nematode activity and growth is about 75° F.

Soil type affects the nematodes' mobility also. They move most easily through moisture films in coarse sand (but drying could present problems here) and have the most difficulty moving through clay and silty clay loam. Thus success may be limited in soils with very small pore spaces.

APPLICATION

Sprays are the most popular form of application. People have successfully used conventional pump sprayers, hose-end sprayers, and fertilizer injectors, as well as watering cans. The soil is wet down before application to give the nematodes a water film to move in. Then, a suspension of the nematodes is sprayed out with constant agitation and all the screens off the nozzles. It is important to water the nematodes in again after the application. This washes them off foliage that they may have become stranded on. A squeeze bottle, shaken frequently, works well for squirting nematodes into holes of wood borers.

APPLICATION SITE

One interesting field study showed just how important nematode placement could be. When Dr. Albert Pye of BioLogic was researching control of *Hylobius abietus*, a weevil like the Pales weevil, on pine in Sweden in the 1970's, he found that dipping an entire tray of plugs into an agitated nematode suspension had much greater effectiveness than spraying the nematodes onto the soil surface after the plugs had been planted. On later examination, he found that the nematodes had slipped down the sides of the plugs in the plug trays, and been able to enter the plugs from all angles. In contrast, the soil surface application had only one surface treated, a surface exposed to ultraviolet light.

APPLICATION TIMING

Timing can be extremely important in determining the kill on a single pest generation. The nematodes are not as effective against non-active insect stages such as pupae. Thus a treatment applied during the pest's pupal stage will allow the adults of that generation to emerge. The nematodes could only start killing pest larvae after those adults had laid their eggs and new larvae hatched. In contrast, an application timed for the pest's larval stage would kill the pest before it pupated and not allow the next generation of adults to emerge.

CONCLUSIONS

Success in using *S. carpocapsae* for pest control depends on careful attention to keeping them alive. They must not be subjected to quick drying, or to ultraviolet radiation. Other factors that affect their effectiveness are temperature, soil texture, application site, and application timing.

REFERENCES

1. Capinera, J L , S.L. Blue, and G.S. Wheeler, 1982. Survival of earthworms exposed to *Neoaplectana carpocapsae* nematodes. *Jour. of Invertebrate Pathology,* 39.419-421.

2. Gaugler, R. 1981 Biological control potential of *Neoaplectanid nematodes Jour. of Nematology,* 13(3)·241-249

3. Georgis, R and G.O. Poinar, Jr 1983. Effect of soil texture on the distribution and infectivity of *Neoaplectana carpocapsae* (Nematoda· Steinernematidae). *Jour. of Nematology,* 15(2)·308-311

4. Kaya, H.K. 1988 Princes from toads *Amer. Nurs.*, September 1, 1988:63-69.

5. Poinar, G.O. 1979 Nematodes for biological control of insects CRC Press, Inc Boca Raton, FL. 277 pp.

6. Pye, A E and N L. Pye. 1986 Different applications of the insect parasitic nematode, *Neoaplectana carpocapsae* to control the large pine weevil, *Hylobius abietis. Nematologica,* 31:109-116.