A new entomogenous nematode for pest management systems

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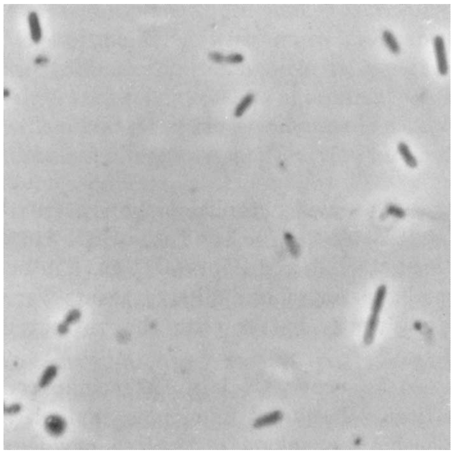

Fig. 1. Symbiotic bacteria carried by invasive juveniles of Heterorhabditis bacteriophora **Poinar.**

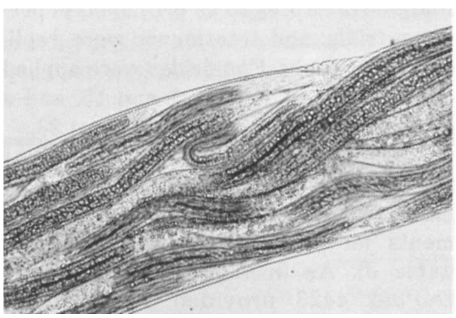

Fig. 2. Invasive juveniles inside the body of a hermaphroditic female.

TABLE 1. Hosts Supporting *Heterorhabditis* Development to Invasive Juvenile Release

Host			
Order	Family	Species	Host stage*
Coleoptera	Scolytidae	*Ips* sp.	L
Diptera	Culicidae	*Aedes sierrensis* (Ludlow)	L
		Culex tarsalis Coq.	
Lepidoptera	Arctiidae	*Estigmene acraea* (Drury)	L
		Hyphantria cunea (Drury)	L
	Dioptidae	*Phryganidia californica* Packard	
	Galleridae	*Galleria mellonella* (Linn.)	L
	Lasiocampidae	*Malacosoma californicum* (Packard)	L
		Malacosoma constrictum (Stretch)	L
	Liparidae	*Hemerocampa* sp.	L
	Noctuidae	*Heliothis punctigera* Wall.	L
		Pseudaletia unipuncta (Haworth)	
		Spodoptera praefica (Grote)	L
	Notodontidae	*Schizura concinna* (J. E. Smith)	L
	Pieridae	*Colias philodice eurytheme* Boisduval	L
	Pyralidae	*Anagasta kuehniella* (Zeller)	L
		Paramyelois transitella (Walker)	L
	Tortricidae	*Archips argyrospila* (Walker)	L
Orthoptera	Blattellidae	*Blatella germanica* (Linn.)	N, A
		Supella supellectilium (Serville)	N, A

*L = Larva, N = Nymph, A = Adult.

TABLE 2. Dosage-Mortality Effects of *Heterorhabditis bacteriophora* Invasive Juveniles on Fifth-Instar Larvae of the Red-Humped Caterpillar, *Schizura concinna*

Treatment	Replicate	Number of hosts exposed	$\overline{X}$ Dose (juveniles/cm² of soil surface)	Percent mortality
Control	1	20	—	55.0
Nema treated	1	20	795 ± 164	100.0
Control	2	20	—	50.0
Nema treated	2	20	795 ± 164	100.0
Control	1	23	—	30.4
Nema treated	1	23	208 ± 56	52.2
Control	2	28	—	42.9
Nema treated	2	27	208 ± 56	55.6

Target pest resurgence and secondary pest outbreaks which result from disruptive effects of chemical pesticides on natural enemies have caused increased interest in microbial control measures in pest management ecosystems. For such control, entomogenous nematodes offer promise as easily manipulatable mortality factors on insect pests. Of these nematodes, members of the genus *Neoaplectana* have been the most intensively studied. They are amenable to mass-production techniques, and in 75 percent of reported field trials their utilization has resulted in increased parasitization levels and significant reductions in pest-population densities and/or adequate plant protection. In 1975 a new nematode parasite, *Heterorhabditis bacteriophora* Poinar, was discoverd by D. E. Pinnock to be a significant mortality factor in populations of *Heliothis punctigera* inhabiting alfalfa fields near Brecon, South Australia. This nematode has been studied in the laboratory, and the present report discusses its biology, pathogenicity, and potential as a biological control agent.

The life cycle of *Heterorhabditis bacteriophora* Poinar has been studied by utilizing laboratory populations of the Greater Wax Moth, *Galleria mellonella*. The nematode exists in a symbiotic relationship with a gram-negative asporous rod-shaped bacterium (figure 1) which is released when invasive juvenile stages of the nematode penetrate into the hemocoel of a host. Host mortality occurs in 16 to 48 hours, depending on the initial nema dosage and ambient temperature. A temperature range of 16.8 to 29.5°C favors nematode development in the host.

After gaining entry into the host, the invading juveniles develop into hermaphroditic females, which then deposit some of their eggs in the fatty tissue of the host cadavers. These eggs develop into males and females. The remaining eggs are retained in the body of the hermaphroditic females where they utilize parental tissue and develop into mature juveniles (figure 2) before escaping into the fatty tissue where further development to second generation hermaphroditics takes place.

Both sexual and subsequent hermaphroditic females produce invasive juveniles that begin leaving the host cadavers within 8 to 10 days after host death. The LD_{50} for seventh instar larvae of the Greater Wax Moth is between three and six invasive juveniles. An initial dosage of 5 to 20 invasives produces approximately 350,000 juveniles per host cadaver.

The juveniles can be stored in saline and have survived in a 2.5 percent Ringers salt solution for 14 months at 7°C.

To determine the host range of *Heterorhabditis* in laboratory trials, candidate insects were exposed to approximately 6000 invasive stages placed on filter pads in petri dishes. Results (table 1) indicate that the nematode can utilize many different hosts, including many of major agricultural and medical importance.

Laboratory trials were conducted to assess the effect of invasive juveniles on fifth-instar larvae of the red-humped caterpillar, *Schizura concinna*, a pest of walnut, *Liquidambar* and red bud plantings. For these trials nemas were uniformly distributed on the surface of a 7-cm-deep stratum of U.C. Soil Mix overlaying a 2-cm-deep layer of coarse moist sand.

Results of two experiments (table 2) suggest a graded mortality response to varying nema dosages. It appears that 1 square foot of a comparable soil would require application of approximately 2000 invasive juveniles, and that a single host cadaver could yield enough invasives for treatment of 100 square feet of soil.

Laboratory evidence suggests that *Heterorhabditis* usually replicates in susceptible host cadavers, so it is conceivable that the invading nematodes might produce epizootics and thus eliminate the need for frequent treatment.

Continuing research will assess the impact of *Heterorhabditis* on non-target organisms and the action of biotic and abiotic factors on survival of this nematode in various soil ecosystems, but preliminary studies suggest that *Heterorhabditis* may prove to be a valuable adjunct in non-disruptive pest management systems.

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