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Noneffective Results of Steinernematid and Heterorhabditid Nematodes Against Pill bug, *Armadillidium vulgare* (Isopoda : Armadillidae)

Steinernematid와 Heterorhabditid 선충의 쥐며느리에 대한 비효용적 결과

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ABSTRACT Steinernematid and heterorhabditid nematodes were not effective to control the pill bug, *Armadillidium vulgare* although these nematodes were able to infect pill bugs. *Steinernema carpocapsae* Pocheon strain and *S. glaseri* Dongrae strain were more effective than *S. carpocapsae* All strain or *Heterorhabditis bacteriophora*. Nematode concentration was more important factor than host density to develop infectivity.

KEY WORDS pill bug, *Armadillidium vulgare, Steinernema carpocapsae, Steinernema glaseri, Heterorhabditis bacteriophora*, host density

초 록 Steinernematid와 heterorhabditid 선충은 쥐며느리에 침입하여 치사 시킬수는 있었지만 효과는 없었다. *Steinernema carpocapsae* 포천 strain과 *S. glaseri* 동래 strain이 *S. carpocapsae* All strain과 *Heterorhabditis bacteriophora* 보다 효과가 있었으며, 병원성 발현에서 선충의 접종농도가 기주의 밀도보다 중요한 요인이었다.

검 색 어 쥐며느리, *Armadillidium vulgare, Steinernema carpocapsae, Steinernema glaseri, Heterorhabditis bacteriophora*, 기주밀도

Entomopathogenic nematodes in the families Steinernematidae and Heterorhabditidae offer an alternative to chemical insecticides for a number of insect pests (Begley 1990). These nematodes cause septicemia to host insects with bacterial symbionts, *Xenorhabdus* to steinernematids and *Photorhabdus* to heterorhabditids and result in rapid death of hosts within 48 hours. Because of their broad host spectrum and safe to environments, they have been used for the control of house garden pests.

The pill bug, *Armadillidium vulgare*, is omnivorous and sometimes damages young seedlings or buds of vegetables growing in the house garden because house garden serves favourable habitat to pill bugs. Besides, Korean house garden situations are not appropriate to spray insecticides. Thus, this study was carried out to check the control effect of steinernematids or heterorhabditids against pill bugs.

Nematodes and pill bugs

Steinernema carpocapsae All and Pocheon strains, *S. glaseri* Dongrae strain, and *Heterorhabditis bacteriophora* were used in this study. The nematodes were reared on the last instar of great wax moth (*Galleria mellonella*) larvae (Dutky *et al* 1964) and harvested using white traps. Infective juveniles were stored in distilled water at 10°C for 7~21 days before use (Woodring and Kaya 1988). Pill bugs were collected from under the chestnut trees or shrubs in gardens.

Virulent and dose study of nematode species

One pill bug was placed into 6 cm petri dish containing filter paper (Whatman #2) and each petri dish received 0.5 ml of nematode suspension of each

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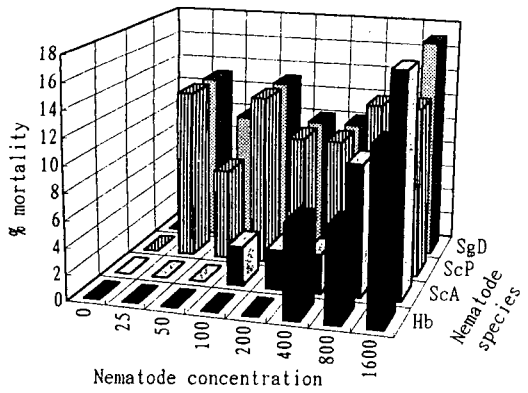

Fig. 1. Lethal effect of nematode species or concentration on pill bugs Hb; *Heterorhabditis bacteriophora*, ScA; *Steinernema carpocapcae* All strain, ScP; *S. carpocapcae* Pocheon strain, and SgD; *S. glageri* Dongrae strain.

species at rates of 0, 25, 50, 100, 200, 400, 800, or 1600 infective juveniles (Ijs). These petri dishes were kept at 25±2°C incubator for 8 days and dissected under the microscope to make sure nematode infection. The treatments were made as 3 replicates with 10 petri dishes per treatment.

Density study

Density study was made two ways; one was fixed total nematode concentration with different host densities (A group) and the other was fixed nematode concentration per host with different host densities (B group). In the A group, 30 ml plastic cup was filled with 25 cc of sand (11% w/w soil moisture, -10kPa water potential). 5, 10, 20, or 40 bugs were placed into each cup with 400 Ijs of nematodes. A small piece of melon leaf (*Cucumis melo*) was also placed into each cup for food. In the B group, a treatment cup received 20 Ijs of nematodes per bug. All the cups were kept at 25±2°C incubator for 8 days. Pill bugs were dissected under the microscope to confirm nematode infection. These studies were made as 4 replicates with 10 cups per replicate.

Virulent and dose study of nematode species

Although entomopathogenic nematode species or strains slightly differed in their virulence, pill bugs were generally not susceptible to steinernematids and *H. bacteriophora* (Fig. 1). Mortalities of pill bugs were lower in *H. bacteriophora* treatments than *Steinernema* treatments. Out of *Steinernema* species, *S. carpocapsae* Pocheon strain and *S. glaseri* Dongrae strain were more effective than *S. carpocapsae* All strain.

Table 1. Lethal effect of the nematode species on pill bugs with different densities

Host density	% mortality of pill bugs	
	Steinernema carpocapsae (Pocheon)	*Steinernema glaseri* (Dongrae)
5	53.3±11.6a	46.7±11.6a
10	36.7±5.8b	43.3±5.8a
20	36.7±2.9ab	35.0±8.7ab
40	27.5±2.5b	27.5±4.3b

*Percentages followed by different letters in a coloum are significantly different according to Duncan's multiple range test. Each host density group of pill bugs was exposed to 400 infective juveniles of nematodes.

Density study

The pill bug mortality was influenced by nematode concentration rather than host density (Table 1). When pill bugs were exposed to 400 infective juveniles of *S. carpocapsae* Pocheon strain or *S. glaseri* Dongrae strain, higher mortalities were recorded at 5 host densities (80 Ijs/host) by 53.3±11.6% or 46.7±11.6%, respectively. The mortalities were low at high host density, 40 pill bugs per cup (10 Ijs/host), in both species. When pill bugs were exposed to 20 Ijs/host, mortality was not significantly different between nematode species and concentrations (Fig. 2).

Although entomopathogenic nematodes are potential biological agents and frequently utilized for the control of many agricultural pests, these microorganisms were not effective against pill bugs. Over 800 Ijs per host are high concentration against insect pests. However, even over 800 Ijs were not adequate concentration to pill bug and the pill bug was not suitable as host for steinernematid and heterorhabditid nematodes. Mortality was low even at 1600 Ijs/host in this study. Poinar and Paff (1985) already pointed out that terrestrial isopods, sow bug and pill bug, were not suit-

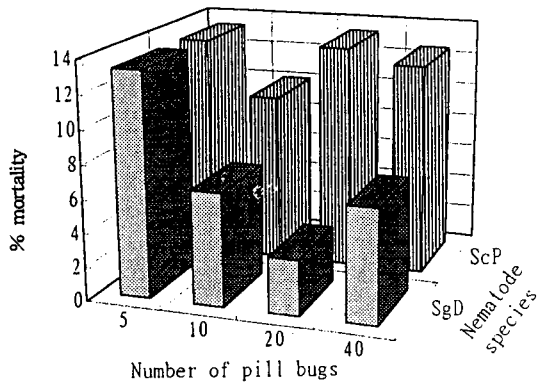

Fig. 2. Lethal effect of fixed nematode concentration per host on pill bug. Pill bugs were exposed to 20 infective juveniles of nematodes per host. ScP; *Steinernema carpocapcae* Pocheon strain and SgD; *S. glaseri* Dongrae strain.

able hosts. Because competitive limitations may be due to crowding within the species in wild populations, competition for space may increase stress and promote pathogenicity of nematodes. Our results did not support the hypothesis that high host density might result in high mortality of hosts. On the contrary, nematode concentration was more important factor than host density. Steinernematid or heterorhabditid nematodes have different pathogenicities to pests by species or strains (Bauer *et al* 1995, Choo *et al* 1995). In terrestrial isopods, the sow bug, *Porcellio* spp., were more susceptible to *S. carpocapsae* than to *H. bacteriophora* or to *S. glaseri* at high concentration, 2,000 Ijs/host (Poinar and Paff 1985). Our investigation showed no differences in pathogenicity according to nematode species. *S. glaseri* was ineffective to sow bugs or pill bugs in the Poinar and Paff's experiment (1985) but *S. glaseri* Dongrae strain was more effective than *H. bacteriophora* or *S. carpocapsae* All strain in our observation. In addition, mortalities of pill bugs were variable according to experimental conditions.

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