Compatibility between *Forficula auricularia* and entomopathogenic nematodes

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Abstract

*Use of predators, parasitoids and entomopathogens as biocontrol agents in pome fruit production can lead to more efficient and sustainable pest management programs. The European earwig (*Forficula auricularia *Linnaeus* [*Dermaptera: Forficulidae]) is a major predator of key pests in pome fruit orchards, and entomopathogenic nematodes (EPNs) of the families* Steinernematidae *and* Heterorhabditidae *are obligate parasites of a large number of insect species. Therefore, the interaction between earwigs and EPNs can play an important role in pest management programs. Susceptibility of the European earwig to* Steinernema carpocapsae*,* Steinernema feltiae *(Steinernematidae) and* Heterorhabditis bacteriophora *(Heterorhabditidae) was evaluated.* S. carpocapsae *was the only tested EPN capable of killing the European earwig. An earwig deterrent activity in EPN-killed codling moth larvae that reduces the foraging of European earwig on insect cadavers containing nematodes and allows nematodes to complete their life cycle was also assessed with the three species of nematodes. These findings suggest a positive compatibility between the European earwig and EPNs.*

Keywords: Biological control, European earwig, deterrent activity, *Steinernema carpocapsae*, susceptibility.

Introduction

The inclusion of microbial control agents as a complementary or alternative method to chemicals can improve the safety for humans and other non target organisms, preserve natural enemies and increase biodiversity in managed ecosystems (Lacey *et al*., 2001). However, an interaction between entomopathogenic nematodes (EPNs) and non-target insects (predators and scavengers) may occur. Predation of nematode-killed insects may interrupt the life cycle of EPNs by aborting the production of infective juveniles (Kaya *et al*., 1998). To avoid this negative interaction, some EPN species can be protected from being eaten during their reproduction and development in the insect cadavers by one or more chemical compounds produced by the symbiotic bacteria that deter scavengers (the scavenger deterrent factor) (Gulcu *et al.*, 2012). This deterrent effect has been confirmed in insects such as ants (Baur *et al*., 1998), but nothing is known about this effect in the omnivorous *F. auricularia*. The aims of this study were to evaluate the susceptibility of the European earwig to three species of EPNs (*S. feltiae*, *S. carpocapsae* and *H. bacteriophora*) and to determine whether there is a deterrent activity that reduces the foraging of the European earwig on the insect cadavers containing nematodes.

Material and Methods

European earwigs were placed in Petri dishes and exposed to a dose of 50 infective juveniles/cm^2. Death of earwigs was recorded every 12 h. Only earwigs with nematodes inside were recorded as dead due to nematodes.

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The scavenger behavior of the European earwig on insect cadavers containing EPNs was evaluated in Petri dishes with last instar larvae of codling moth exposed to the three EPN species tested (*S. carpocapsae*, *S. feltiae* and *H. bacteriophora*). In each dish 20 larvae were exposed to 1000 IJs. Freeze-killed codling moth larvae were used as a control to compare the foraging of European earwig on the insect cadavers with and without nematodes. A choice test was carried out with one nematode-killed larva and one freeze-killed larva. After 48 h, predation of cadavers was visually evaluated and recorded. For each treatment (*S. carpocapsae*, *S. feltiae* and *H. bacteriophora*) 18 individuals were divided into three replications, and the experiment was conducted twice. To evaluate earwig susceptibility, a chi-square test of independence was used to compare mortality frequencies between nematode species. Percentage of codling moth predation by earwigs was used to evaluate the deterrent activity. All the percentages were arcsine transformed before the analysis and analyzed by one-way ANOVA. Means were compared at the P = 0.05 level, and a Tukey HSD test was used to separate means. Data were analyzed using the JMP statistical software package (Version 9; SAS Institute Inc., Cary, North Carolina).

Results and Discussion

European earwig was not affected by *H. bacteriophora* and *S. feltiae* at a dose of 50 IJs/cm^2 (Table 1). On the other hand, our results showed that in a filter paper assay, 50 IJs/cm^2 of *S. carpocapsae* kills up to 50 % of the European earwig population, either males or females, under laboratory conditions (Figure 1A).

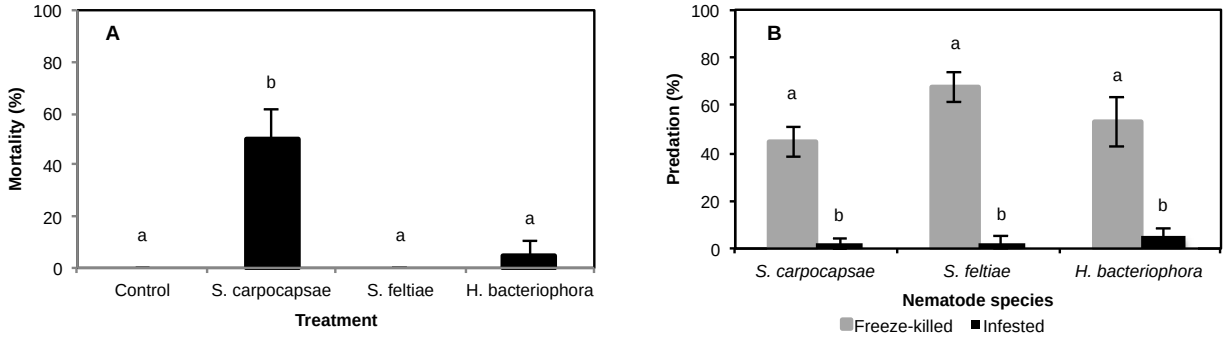

Figure 1. Susceptibility of European earwig to entomopathogenic nematodes (A) and percentage of predation by European earwig of freeze-killed or nematode-killed codling moth larvae (cadavers) (B). Mean (%) and SEM. Columns marked with the same letter are not significantly different (P > 0.05).

The significant preference of earwigs to predate freeze-killed insects instead of nematode-killed insects observed in our study confirms the presence of an earwig deterrent activity produced by the nematodes that reduces the foraging of the European earwig on insect cadavers with EPNs (Figure 1B).

Although the interaction under field conditions should be checked, these results provide evidence that using EPNs to control pests can be compatible with promoting the predator *F. auricularia* in pome fruit orchards.

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