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Host range of entomopathogenic nematodes

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Abstract
The aim of our research work was to study the host range of entomopathogenic nematodes against different insect pests. The efficacy of the entomopathogenic nematodes, *viz*., *Heterorhabditis indica* and *Sterinernema glaseri* were studied against three orders insect pest. Seventeen insect species belonging to three orders, *viz*., Lepidoptera, Coleoptera, Hemiptera and one slug were recorded as hosts for *H. indica* and *S. glaseri*. *H. indica* was found to be more virulent to *Spodoptera litura* and *Helicoverpa armigera* than *S. glaseri*.
H. indica and *S. glaseri* were able to infect, develop and complete their life cycle on 17 insect species in the orders *viz*., Lepidoptera, Coleoptera and Hemiptera and one slug. *H. indica* and *S. glaseri* did not multiply on *F. virgate* and *O. rhinoceros*.

Keywords: Host range, entomopathogenic nematodes

Introduction
Entomopathogenic nematodes (EPN) belonging to the genera *Heterorhabditis* Poinar, 1976 [10], *Neosteinernema* Nguyen and Smart, 1994 [9] and *Steinernema* Travassos, 1927 [14] (Nematoda: Rhabditidae) are obligate pathogens of insects. Application of entomopathogenic nematodes as biological control agents against insect pests has increased rapidly because of the remarkable attributes such as an ideal biological control agent, broad host range, high virulence, host seeking ability and ease of mass production.
About 250 species of insects belonging to 75 families of 10 orders have been reported to be susceptible to entomopathogenic nematodes. Entomopathogenic nematodes have certain advantages over chemicals as biocontrol agents. The nematodes are non-polluting, environmentally safe and acceptable compared to chemical insecticides. They are more virulent which cause mortality of the host within 48 -72 h after infection. Infective juveniles are applied with conventional equipment in which they are compatible to most of the pesticides (Rovesti and Desco, 1991) [12]. Infective juveniles find their hosts either actively or passively in soil and cryptic habitats and sometimes in soil, they have proven superior to chemicals in controlling the target insect pest.
The entomopathogenic nematodes are able to infect, develop and complete its life cycle on a number of insects belonging to the orders, Lepidoptera, Coleoptera, Orthoptera, Diptera, Thysanoptera and Siphonaptera (Puza and Mracek, 2010) [11]. The host range of
H. indica is a possibility of wide host range among the insects of the orders, Lepidoptera, Coleoptera, Orthoptera and Dictyoptera. The virulence of entomopathogenic nematodes depend on the species and strain of the nematodes, variation in the species of symbiotic bacteria, bacterial inoculum carried by the nematodes and their activity. The behavioural, morphological and physiological defence strategies of insects affect the ability of the nematodes to infest the host which in turn influence the virulence of the nematodes.

Materials and Methods
Culture of *Corcyra cephalonica* Staint (Pyralidae: Lepidoptera)
Rice meal moth *C. cephalonica* Staint. (Pyralidae: Lepidoptera) was reared on bajra (*Pennisetum typhoides* L.) grains. Bajra grains (2½ kg) were broken and filled in 30cm× 20 cm plastic trays and eggs of *C. cephalonica* (0.5 cc/ tray) inoculated into the trays and covered with a muslin cloth. Fully grown larvae of *C. cephalonica* were collected after 30 days of inoculation and used for further studies.

Multiplication and maintenance of nematode culture

The entomopathogenic nematodes *viz*., *Heterorhabditis indica* and *Steinernema glaseri* were continuously sub-cultured on larva of rice meal moth, *C. cephalonica*, which were reared on broken bajra grains, in plastic basins. The insect larvae were exposed to the nematode as per the method described by Bedding (1984) [2]. About ten final-instar larvae of *C. cephalonica* were released into a Petri dish over two Whatman No.1 filter papers inoculated with infective juveniles stored in sterile distilled water at the rate of 20 per larva (1 ml suspension containing 200 infective juveniles). The Petri dishes were sealed with cling film and stored in polythene bags to conserve moisture.

Nematodes were extracted from the cadavers five days later, using a White's trap for *H. indica* and by modified method using plaster of paris for *S. glaseri*, after three days. Nematodes were recovered from the traps daily until exit of infective juveniles ceased. These juveniles were washed and rinsed several times with sterile distilled water and stored in a BOD incubator at 20±1 ºC for *H. indica* and in a refrigerator at 10 ºC for *S. glaseri* in 500ml conical flask until use. The nematode cultures were aerated and changed to fresh sterile distilled water at weekly intervals.

Host range of entomopathogenic nematodes under laboratory conditions

Eighteen insect species (five from each species) were collected from the field to observe the host range of entomopathogenic nematodes, *viz*., *H. indica* and *S. glaseri*. Each insect species (five for each nematode) were exposed to infective juveniles of nematodes by filter paper exposure method at temperature range of 25±3 ºC (Wooring and Kaya, 1988) [15]. The cadavers were examined 10 days later for nematode development and multiplication.

Results and Discussion

The nematodes *H. indica* and *S. glaseri* were tested for their host range against 18 insect pests comprising of 10 Lepidoptera, 6 Coleoptera and one each in Hemiptera and slug which caused mortality of all the test insects. The nematodes *H. indica* and *S. glaseri* killed all the 18 insect species tested under laboratory condition. Both the species of *H. indica* and *S. glaseri* infected and completed their life cycle on the larvae of *Spodoptera litura* (Lepidoptera: Noctuidae), *Helicoverpa armigera* (Lepidoptera: Noctuidae), *Plutella xylostella* (Lepidoptera: Plutellidae), *Leucinodes orbonalis* (Lepidoptera: Pyralidae), *Earias vittella* (Lepidoptera: Noctuidae), *Orthaga exvinascea* (Coleoptera: Noctuidae)**,** *Eublemma versicolor* (Lepidoptera: Noctuidae), *Papilio polytes* (Lepidoptera: Papilionidae), *Exelastis atomosa* (Lepidoptera: Pterophoridae), *Oryctes rhinoceros* (Lepidoptera: Scarabaeidae), *Hymenia recurvalis* (Lepidoptera: Pyraustidae), *Anomala communis* (Coleopteran: Scarabaeidae), *Agrotis ipsilon* Hufnagel. (Lepidoptera: Noctuidae), *Cosmopolites sordidus* (Coleoptera: Curculionidae), *Aulacophora faveicollis* **(**Coleoptera: Chrysomelidae), *Ferrisia virgate* (Hemiptera: Pseudococcidae) and garden slug *Deroceras reticulatum* (Agriolimacidae) The nematode multiplication was observed in all the 15 insect species except *O. rhinoceros*, *F. virgata* and *D. reticulatum* insects which were killed by both *H. indica* and *S. glaseri* in which no nematode multiplication was observed (Table 1).

The observations in the present study showed that the nematodes are able to infect, develop and complete their life cycle on a three insect orders *viz*., Lepidopteran, Coleopteran and Hemiptera and they are recorded as hosts for *H. indica* and *S. glaseri*. *H. indica* caused mortality of all the 18 insects and the nematode multiplication was observed in all the 15 insects except *F. virgate*, *O. rhinoceros* and *D. reticulatum* which were killed but there was no nematode multiplication. Earlier reports reveals that *Oryctes rhinoceros*, *Holotrichia serrata*, *S. litura*, *H. armigera*, *Periplaneta americana* and *Mantis religiosa* were reported as hosts of native isolates of *H. indica* (Karunakar *et al*., 1999 and Subramanian (2000) [7, 13].

The nematode is capable of infecting all the 18 insects and multiplied on 15 insects except *F. virgate*, *O. rhinoceros* and *D. reticulatum*. Similar observations were also recorded by Banu (2001) [3] where *S. glaseri* did not develop on *E. mollifera* and *O. rhinoceros*. Klien (1990) [8] reported several insects as hosts. Choo *et al*. (2002) [4] reported that Steinernematids can infect most of the lepidopteran insects. This was supported by Kaya *et al*. (2006) [6]. The LC_{50} value of 85 IJ/larva for *S. litura* was recorded in the case of *S. thermophilum* (Kalia *et al*. 2014) [5]. In contrast, *S. thermophilum* caused 100% mortality in *H. armigera* and *G. mellonella* was observed by Ali *et al*. (2008) [1].

H. indica and *S. glaseri* were able to infect, develop and complete their life cycle on 17 insect species in the orders *viz*., Lepidoptera, Coleoptera and Hemiptera and one slug.

H. indica and *S. glaseri* did not multiply on *F. virgate* and *O. rhinoceros*. Since a number of insects belonging to four orders were recorded as hosts, there is a wide scope to use these nematodes as potential biocontrol agents.

Table 1: Host range of entomopathogenic nematodes

S. No	Insects	Stage	*H. indica*	*S. glaseri*
	Lepidoptera			
1	*Spodoptera litura*	Larva	++	++
		Pupa	++	++
2	*Helicoverpa armigera*	Larva	++	++
3	*Plutella xylostella*	Larva	++	++
4	*Leucinodes orbonalis*	Larva	++	++
5	*Earias vittella*	Larva	++	++
6	*Orthaga exvinascea*	Larva	++	++
7	*Eublemma versicolor*	Larva	++	++
8	*Papilio polytes*	Larva	++	++
9	*Exelastis atomosa*	Larva	++	++
10	*Hymenia recurvalis*	Larva	++	++
	Coleoptera			
1	*Holotrichia serrata*	Grub	++	++
2	*Anomala communis*	Grub	++	++
3	*Agrotis ipsilon*	Grub	++	++
4	*Oryctes rhinoceros*	Larva	+	+
5	*Cosmopolites sordidus*	Grub	++	++
6	***Aulacophora faveicollis***	beetle	++	++
	Hemiptera			
	Ferrisia virgata	bug	+	+
	Slug			
	Gray garden slugs - *Deroceras reticulatum*	Slug	+	+

(+) Insect dead but no nematode multiplication

(++) Insect dead, nematode multiplication

Conclusion

The efficacy of the entomopathogenic nematodes, *viz*., *Heterorhabditis indica* and *Sterinernema glaseri* were studied against three orders insect pest. Seventeen insect species belonging to three orders, *viz*., Lepidoptera, Coleoptera, Hemiptera and one slug were recorded as hosts for *H. indica* and *S. glaseri*. *H. indica* and *S. glaseri* were able to infect, develop and complete their life cycle on 17 insect species in the orders *viz*., Lepidoptera, Coleoptera and Hemiptera and one slug. *H. indica* and *S. glaseri* did not multiply on *F. virgate* and *O. rhinoceros*.

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