

Mermithid nematodes as parasites of *Heliothis* spp. and other crop pests in Andhra Pradesh, India

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MS received 3 December 1984

Abstract. Insect pests were collected from cultivated and wild plant species to study their parasites in Andhra Pradesh, India. Besides insects, nematodes emerged as parasites. While *Hexameris* spp. were common in most lepidoptera, *Ovomermis albicans* (Siebold) was recovered from *Heliothis* spp. The nematodes were active, even more than insect parasites, during early monsoon. They were more active on light-soils than on heavy-soils. Against *Heliothis armigera* (Hubner) in particular, their incidence was more on "low-growing" crops like *Arachis hypogaea* (L.), and *Lycopersicon esculentum* (L.), and weeds. The nematode *Pentatomimermis* sp. was recorded from the bug *Nezara viridula* L.

Keywords. Mermithids; *Ovomermis albicans*; *Hexameris* spp; *Pentatomimermis* sp.; *Heliothis* spp.

1. Introduction

The mermithid nematodes, in general, are known to infect a wide range of insects in 15 different orders (Nickle 1972). Ramakrishnan and Kumar (1976) reported the association of species of *Mermis*, *Agamermis*, *Hexameris*, and *Geomermis* with 40 insect species in India. In this paper, observations on mermithids as parasites of some important insect pests on dry-land crops and their role in regulating the pests populations are described.

2. Material and methods

Insects were collected (1975–83) in their available stages from Medak, Rangareddy and Mahaboobnagar districts of Andhra Pradesh, India and reared in glass vials (9 × 2.5 cm) in the laboratory on the same natural hosts to study critically for nematode and insect parasites. The nematodes, when emerged, were preserved by the method suggested by IA Rubtsov (personal communication). The rates of nematode parasitism recorded over years in different months on different crops were calculated on the basis of total larvae in the samples which showed the nematodes.

3. Results and discussion

3.1 Nematode species and insect hosts

The mermithid nematode species identified from different insect hosts were as follows

<i>Ovomermis albicans</i> (Siebold)	<i>Heliothis armigera</i> (Hubner) <i>H. assulta</i> Guenee <i>H. peltigera</i> Schiff
<i>Hexamermis</i> spp	<i>Achaea janata</i> L. <i>Chilo partellus</i> Swinhoe <i>Cydia critica</i> Meyr. <i>C. ptychora</i> Meyr. <i>Lampides boeticus</i> L. <i>Marasmia suspicalis</i> Walker <i>Menochilus sexmaculatus</i> F. <i>Mythimna separata</i> Walker <i>Scirpophaga incertulas</i> Walker <i>Spodoptera exigua</i> Hubner <i>S. litura</i> F.
<i>Pentatomimermis</i> sp.	<i>Nezara viridula</i> L.

O. albicans was recovered from the larvae of all the three *Heliothis* species found in India. *Hexamermis* spp. were recovered from many insects including a coleopteran *M. sexmaculatus* which predares on eggs and larvae of some insect pests. *Pentatomimermis* sp. emerged from *N. viridula*. The nematodes also emerged from the adults of *H. armigera*, *N. viridula* and *S. incertulas*.

The nematodes recorded on *Heliothis* and *N. viridula* are new records for these are not listed by Poinar (1975, 1979) in his reviews on entomophagus nematodes.

3.2 Nematode parasitism in relation to season and host crops

The rates of nematode parasitism recorded in different insects on cultivated and uncultivated host plants in different months are given in table 1. Although the collection of insects was from almost all months of year, the nematode parasitism was seen only between June to December with peak activity generally during July–September.

Nematodes, in general, were more active on light-soils (alfisols) than on heavy-soils (vertisols). This is, however, comparable in our data only for *S. bicolor* (L.) Moench, *Zea mays* L., and *C. cajan* (L.) Millsp which are grown on both types of soils. *A. hypogaea* (L.) and *Lycopersicon esculentum* (L.) are normally grown on light-soils, and weeds are also most common on these soils.

Amongst weeds, *Heliothis* was greatly parasitised on *Acanthospermum hispidum* DC., *Gomphrena celosioides* Mart., and *Cleome gynandra* (L.) Briq., and relatively less on *Datura metel* L. It should be noted here that *H. peltigera* is more predominant on *A. hispidum* and *H. assulta* on *D. metel* (Bhatnagar and Davies 1978).

Table 1. Occurrence of nematode parasitism (%) in insect pests on cultivated and wild host plants in Andhra Pradesh, India (1975-83).

Insect	Plant species	Month	Light soils (Alfisols)	Heavy soils (Vertisols)
<i>Ovomermis albicans</i> (Siebold)				
<i>Heliothis armigera</i>	<i>Arachis hypogaea</i> (L.), Groundnut	Jun.	3.8 (424) ²	—
		Jul.	20.5 (677) ⁴	—
		Aug.	30.0 (1035) ⁷	—
		Sep.	39.4 (279) ³	—
	<i>Cajanus cajan</i> (L.) Millsp., Pigeonpea	Jul.	—	0.2 (444) ¹
		Sep.	—	1.4 (418) ¹
		Oct.	2.4 (817) ³	—
		Nov.	1.0 (960) ³	—
	<i>Cicer arietinum</i> (L.), Chickpea	Aug.	1.3 (382) ¹	—
		Oct.	—	0.2 (429) ¹
	<i>Helianthus annuus</i> L., Sunflower	Aug.	—	0.4 (237) ¹
	<i>Ipomoea batatas</i> (L.) Lam., Sweet potato	Sep.	—	16.6 (6) ¹
	<i>Lycopersicon esculentum</i> (L.), Tomato	Jul.	52.0 (50) ¹	—
		Aug.	42.5 (153) ¹	—
	<i>Sorghum bicolor</i> (L.) Moench., Sorghum	Aug.	0.7 (400) ¹	2.9 (35) ¹
		Sep.	1.0 (798) ³	0.5 (206) ¹
	<i>Vigna aureus</i> (Roxb.) Hepper., Mungbean	Aug.	18.2 (11) ¹	—
	<i>V. radiata</i> (L.) Wilczek., Black gram	Aug.	—	3.3 (150) ¹
	<i>Zea mays</i> L., Maize	Aug.	31.2 (16) ¹	1.0 (1122) ²
		Sep.	8.3 (132) ¹	—
		Aug.	5.9 (17) ¹	—
	<i>Acalypha indica</i> L.*	Aug.	5.9 (17) ¹	—
	<i>Cleome gynandra</i> (L.) Briq.*	Jun.	1.1 (94) ¹	—
		Jul.	57.8 (1404) ²	—
		Aug.	33.5 (176) ¹	—
	<i>Gomphrena celosioides</i> Mart.*	Jun.	4.3 (138) ¹	—
		Jul.	61.9 (698) ¹	—
		Aug.	18.0 (1626) ²	—
		Sep.	1.0 (400) ¹	—
<i>Leucas aspera</i> L.*	Aug.	6.3 (16) ¹	—	
<i>Tridax procumbens</i> L.*	Jul.	50.0 (2) ¹	—	
<i>H. assulta</i> **	<i>Datura metal</i> L.*	Jul.	4.0 (297) ²	—
		Aug.	0.4 (526) ²	—
<i>H. peltigera</i> **	<i>Acanthospermum hispidum</i> DC.*	Jun.	1.3 (80) ¹	—
		Jul.	43.1 (788) ⁴	—
		Aug.	46.1 (475) ⁴	—
		Sep.	19.0 (79) ¹	—
		Nov.	4.2 (24) ¹	—
<i>Hexamermis</i> Spp.				
<i>Achaea janata</i>	<i>Ricinus communis</i> L., Castor	Aug.	25.7 (140) ²	—
<i>Chilo partellus</i>	<i>Sorghum bicolor</i> (L.) Moench., Sorghum	Jul.	20.6 (475) ⁵	—
		Aug.	9.0 (575) ⁴	2.3* (220) ²
		Dec.	15.4 (13) ¹	—
<i>Cydia critica</i>	<i>Cajanus cajan</i> (L.) Millsp., Pigeonpea	Aug.	—	3.0 (162) ²
		Sep.	3.3 (180) ¹	1.2 (240) ¹
<i>C. ptychora</i>	" "	Aug.	50.0 (6) ¹	—

Table 1. (Contd.)

Insect	Plant species	Month	Light soils (Alfisols)	Heavy soils (Vertisols)
<i>Lampides</i>	<i>Vigna radiata</i> (L.) Wilczek., Black	Jul.	—	20.0 (45) ¹
<i>boeticus</i>	gram	Aug.	—	6.0 (50) ¹
<i>Marasmia</i>	<i>Sorghum bicolor</i> (L.) Moench.,	Oct.	3.4 (89) ¹	—
<i>suspicalis</i>	<i>Sorghum</i>			
<i>Menochilus</i>	" "	Aug.	6.7 (330) ²	5.3 (342) ³
<i>sexmaculatus</i>				
<i>Mythimna</i>	" "	Jul.	50.0 (100) ¹	—
<i>separata</i>		Aug.	24.5 (233) ²	25.9 (309) ²
<i>Spodoptera</i>	<i>Cicer arietinum</i> (L.), Chickpea	Jul.	59.0 (52) ¹	—
<i>exigua</i>		Oct.	—	1.0 (100) ¹
<i>Spodoptera</i>	<i>Arachis hypogaea</i> (L.), Groundnut	Aug.	2.0 (50) ¹	—
<i>litura</i>		Sep.	12.5 (24) ¹	—
	<i>Pentatomimermis</i> sp.			
<i>Nazara</i>				
<i>viridula</i>	<i>Pennisetum americanum</i> (L.) Leeke., Millet	Oct.	—	3.1 (96) ¹

* : Weeds.

** : 90–95 % in total *Heliothis* larvae on the weed.

Figures in parentheses give the total collection in samples showing parasitism over years. Superscripts 1–7 refer to the number of years of data available.

3.3 Nematode and insect parasitism

The overall level of nematode parasitism recorded in *Heliothis* spp. irrespective of host plants on alfisols at ICRISAT Center are shown in figure 1. It was higher than insect parasitism in the early part of the season and ceased subsequently to almost nil by October. Amongst *Heliothis* spp., *H. peltigera* was most vulnerable, and *H. assulta* the least. In August 1979, *Heliothis* collection from one of the light-soil grazing areas, about 45 km from ICRISAT Center and uncultivated for at least 15 years, showed as high as 92.4 % ($n = 305$) nematode parasitism on *A. hispidum*, but no parasitism due to insects. The weed was growing as 18 plants/m² and had as many as 74 *Heliothis* larvae/100 plants.

The multiple parasitism, involving the nematodes and insects, was rare. Nematodes were recorded only twice in association with hymenopterans *Campoletis chloridaeae* Uchida and *Microchelonus curvimaculatus* Cameron in *Heliothis* larvae collected in August on *A. hispidum*.

3.4 Nematode activity and distribution in the soil

Nematodes were common on lepidoptera than on other insects. One to four nematodes emerged from a majority of *Heliothis* larvae, but as many as 63 nematodes were recorded from a larva of *H. peltigera* collected on *A. hispidum* (table 2). Usually one nematode emerged from a larva of *H. assulta*. The nematodes that emerged from

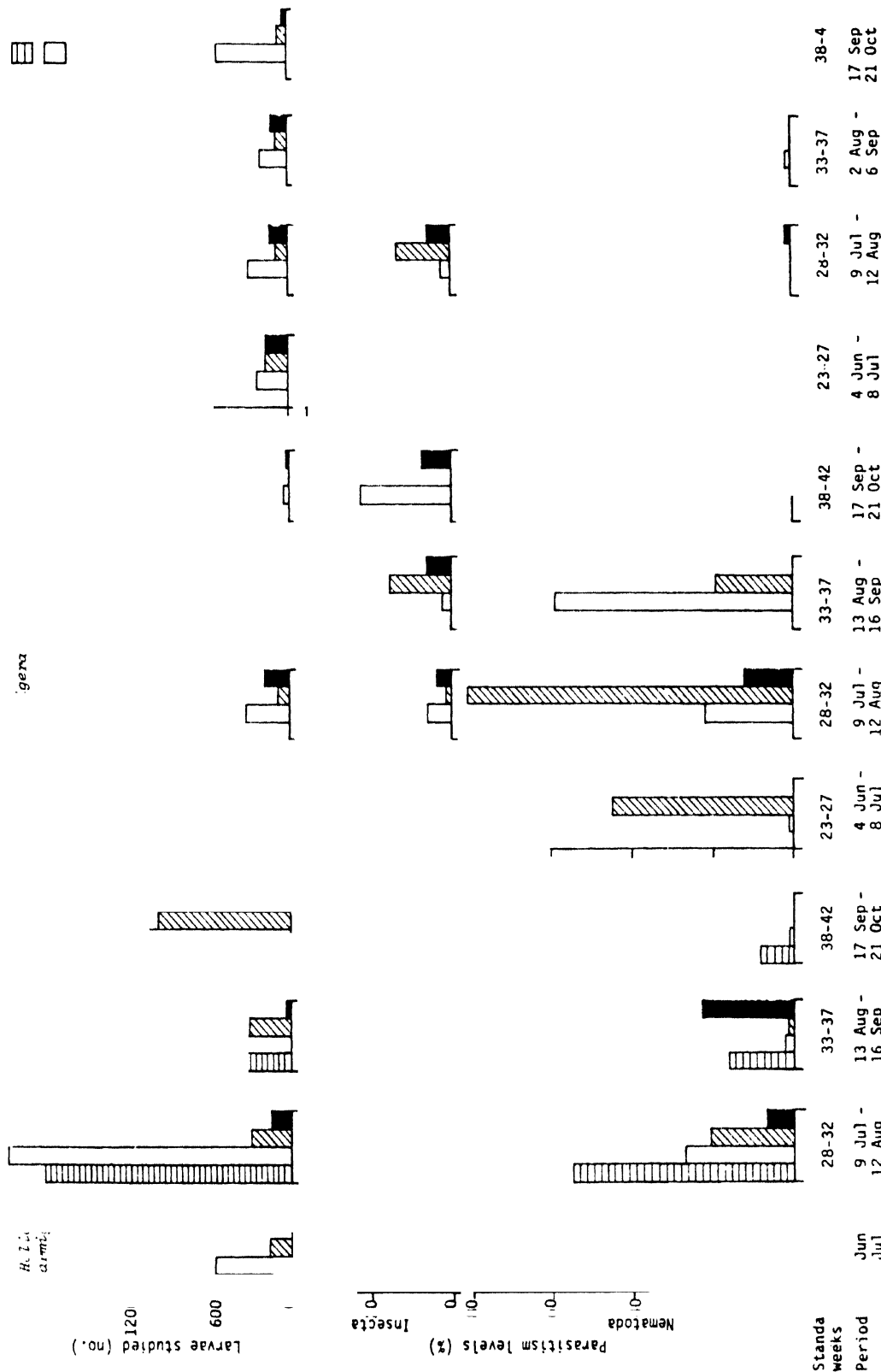


Figure 1. Rainy season incidence of insect and nematode parasitoids on larvae of *Heliothis* spp obtained from crop and weed hosts in alfisol, ICRISAT Centre (1975-78).

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<i>litura</i>		Sep.	12.5 (24) ¹	—
	<i>Pentatomimermis</i> sp.			
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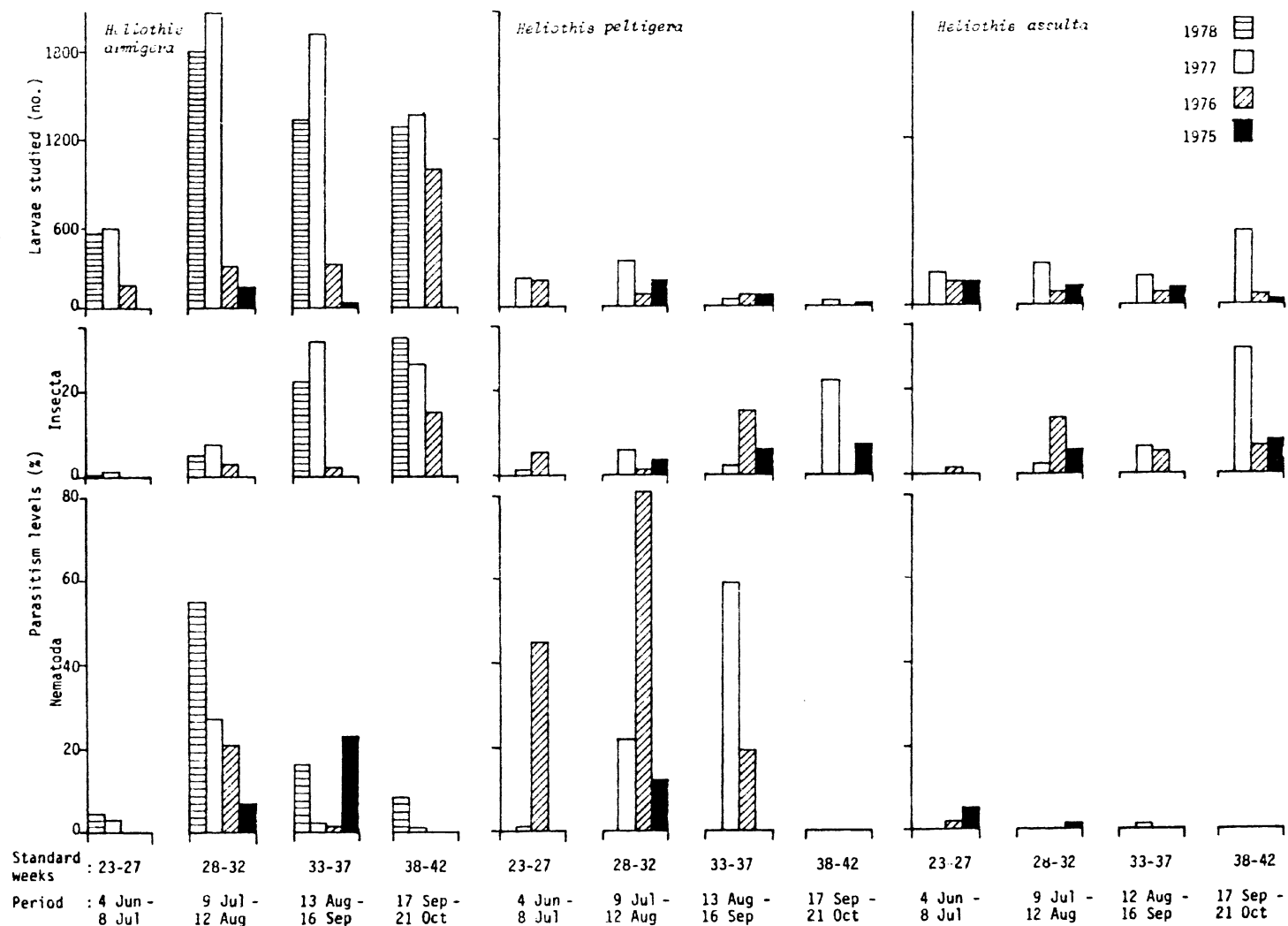


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Table 2. Number of nematodes emerged from *Heliothis* larvae (1976-77)

No. of Nematodes	Number of larvae								
	<i>Heliothis armigera</i>			<i>Heliothis peltigera</i>			<i>Heliothis assulta</i>		
	Jul	Aug.	Sep.	Jul.	Aug.	Sep.	Jul.	Aug.	Sep.
01-05	36	15	3	53	143	14	2	0	1
06-10	3	3	0	64	22	1	0	0	0
11-15	3	1	0	62	4	0	0	0	0
16-20	0	0	0	60	1	0	0	0	0
21-25	0	0	0	19	0	0	0	0	0
26-30	0	0	0	9	0	0	0	0	0
31-35	0	0	0	2	0	0	0	0	0
50-60	0	0	0	2	0	0	0	0	0
> 60	0	0	0	1	0	0	0	0	0
Cumulative average of nematodes/larva	3.6	3.5	2.3	13.9	3.4	2.0	1.5	0.0	1.0

Heliothis, measured 3-22 cm in length. The nematode number declined from July to September.

Nematode activity appeared to be stimulated by the arrival of the premonsoon showers in June, and varied seasonally remaining often localised. In soil samples from 1-30 cm depth, collected only in alfisols, more nematodes were recovered from 20-30 cm, and more so in July when the monsoon is normally well set. Nematodes frequently had a patchy distribution and varied in population.

Heliothis larvae parasitised by nematode were creamy yellow and sluggish and ate little. They survived for one to two days when juvenile nematodes emerged, but died soon with the emergence of adults. Emergence was observed both during the day and night. The nematodes emerged usually from the abdominal region of insects.

Glaser *et al* (1942) recorded *Neoplectana chresima* Steiner as a natural endoparasite of *Heliothis* spp. including *H. armigera* from the USA. Poinar (1979) considered *N. chresima* as a strain of *N. carpocapsae* Weiser. It should be noted here that *H. armigera* is present only in the old world and the report from USA could be because of the taxonomic confusion during that time (Hardwick 1965; Nye 1982). In India, Achan *et al* (1968) identified the nematode parasitic on *H. armigera* as *Hexameris* sp., and specific identification was considered difficult for want of adult nematodes. However, in the present study it was possible because of recovery of sufficient number of adult nematodes. The nematode has been identified as *Ovomermis albicans* (Siebold).

Achan *et al* (1968) considered the nematode on *H. armigera* to be specific on *L. esculentum*. However, the present investigation shows that the nematode is parasitic on all the three *Heliothis* species in India, and is associated with many host plants. Achan *et al* (1968) recorded a maximum of six juvenile nematodes from a larva of *H. armigera*, but our record is of 14 juveniles from a larva of *H. armigera*, and of as many as 63 juveniles from a larva of *H. peltigera*.

Laumond *et al* (1979) reported the infectivity of *N. carpocapsae* to *N. viridula* in the

laboratory, but there is no record of its natural occurrence on this bug, at least from India. *Hexamermis* sp. has been identified in general from pentatomid bugs (Gokulpure 1970). The nematode *Pentatomimermis* sp. is a new record on *N. viridula*.

4. Conclusions

The occurrence of nematode parasites early in the season and their higher incidence on alfisols, and on "low growing" crops like groundnut, tomato and weeds are important findings of this study. This should help plant protectionists to plan effective utilisation of the total parasitic fauna of the pest in nature, and particularly in integrated management of pests like *H. armigera* which attack many crops in succession. The soil application of insecticides to control a few insect pests in some crops needs to be investigated for their effects on entomophagous nematodes.

In view of the importance of mermithid nematodes as parasites on insect pests, a clearcut information is required on individual species in relation to a given insect host to consider their utility in pest management. Further a gathering of base data with large samples from farmers' fields is essential to know how beneficial these mermithids could be in suppressing the pest in nature.

Acknowledgements

The assistance of Prof. I A Rubtsov of the Academy of Science, USSR in identifying the nematodes is gratefully acknowledged. The pest scouts of the Cropping Systems Entomology are also acknowledged.

References

- Achan P D, Mathur K C, Dharmadhikari P R and Manjunath T M 1968 Parasite of *Heliothis* spp. in India. *Tech. Bull.* No. 10, Commonwealth Institute of Biological Control, Bangalore, India, pp. 120-149
- Bhatnagar V S and Davies J C 1978 Factors affecting populations of gram pod borer, *Heliothis armigera* (Hubner) (Lepidoptera: Noctuidae) in the period 1974-77 at Patancheru, Andhra Pradesh; *Bull. Entomol.* **19** 52-64
- Glaser R W, McCoy E E and Girth H B 1942 The biology and culture of *Neoaplectana chresima*, a new nematode parasitic in insects; *J. Parasitol.* **28** 123-129
- Gokulpure R S 1970 Some hosts of a juvenile mermithid of the genus *Hexamermis* Steiner; *Indian J. Entomol.* **32** 387-389
- Hardwick D F 1965 The corn earworm complex; *Mem. Entomol. Soc. Canada* **40** 1-127
- Laumond C, Mauleon H and Kermarrec A 1979 Donnees nouvelles sur le spectre d'hotes et le parasitisme du nematode entomophage *Neoaplectana carpocapse*; *Entomophaga* **24** 13-20
- Nickle W R 1972 A contribution to our knowledge of Mermithidae (Noctuidae); *J. Nematol.* **4** 122-146
- Nye I W B 1982 The nomenclature of *Heliothis* and associated taxa (Lepidoptera: Noctuidae): Past and present. *Proc. Int. Workshop on Heliothis Management*. ICRISAT, Patancheru, A.P., India pp. 3-8
- Poinar G O Jr (ed.) 1975 *Entomogenous nematodes. A manual and host list of insect-nematode associations*. (Leiden: Brill) 317 pp
- Poinar G O Jr (ed.) 1979 *Nematodes groups. Nematodes for biological control of insects* (Florida, California: CRC Press) 11-198
- Ramakrishnan N and Kumar S 1976 Biological control of insects by pathogens and nematodes; *Pesticides* pp. 32-47