Soil-inhabiting Nemafauna: Irreplaceable Organisms in Enhancing Soil Fertility

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Abstract

An opportunistic survey was conducted in the state of Goa, to study the importance of nemafauna in enhancing the soil fertility, from August 2011 to December 2011, August 2012 to December 2012 and from August 2013 to December 2013. For the present study 75 soil samples were collected from various landscapes, covering all the 12 talukas of the state. Permanent slides were prepared after extraction of nematodes using Cobb's decanting and sieving method and modified Baermann's Funnel method. The study resulted in recording 62 species belonging to 8 orders. Most of the species were predators predating on other nematodes mostly on those that are parasites of plants; also on other parasites of plants. These were from the soil samples collected from agricultural and paddy fields. Species diversity was more in the soil samples collected from landscapes where local manure was used for the fertilization of soil.

Introduction

There is a tendency amongst the world's conservationists to focus on large charismatic species, often failing to recognize the agroecosystem and the species they contain as part of world's biodiversity (Vandermeer and Perfecto, 1997). The loss of inconspicuous species is the very base of biodiversity crisis. In most terrestrial ecosystems, the belowground biota supports a considerable greater diversity of organisms than the aboveground biota (Wardle, 2006). Diversity of soil fauna is one of the important factors influencing the sustainability of agroecosystem.

One of the important soil biota groups which play a leading role as regulators of energy is the nematode population (Chew, 1974). They are the most numerous components of the mesofauna in agricultural soils. Nematodes occupy an important and central position in the soil detritus food web (Ingham et al, 1985; Freckman, 1988; Moore and de Ruiter, 1991), taking a significant part in the decomposition of soil organic matter, mineralization of plant nutrients and nutrient cycling (Griffiths, 1994; Boag and Yeates,1998; Yeates and Bongers, 1999). They are abundant and trophically diverse acting as plant feeders, bacterial feeders, fungus feeders, predators and omnivores (Yeates et al, 1993). They are considered to be indicators of a variety of soil properties. They not only help in soil processes but also

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influence these processes (Bongers, 1990; Freckman and Ettema, 1993; Neher et al., 1995). The distribution of many soil nematode taxa has been found to be strongly influenced by factors such as soil texture (Hunt, 1993), soil temperature (Boag et al., 1991) and broad vegetation types (Boag and Orton Williams, 1976). Agriculture does seem to have produced a dynamic habitat in which a wide range of soil nematode species can survive and multiply (McNeely et al., 1995). As part of soil organic matter, nematodes are key soil components in soil fertility, crop productivity and ecosystem functioning, thus maintaining soil ecosystem health.

Goa is the smallest agrarian state of India by area, but has rich flora and fauna, owing to its location on the Western Ghats which has been internationally recognized as one of the Biodiversity Hotspot. Its geographical position is marked by 15°48'00"N and 14°53'54"N Latitude and 74°20"13"E and 73°40'33"E Longitude. Ensconced on the slopes of the Western Ghats, it is interspersed with extensive paddy fields and network of waterways.

Based on the results obtained the present study reports a total of 62 species of nematodes belonging to 8 orders. It was also observed from the gut contents that most of the species were predators of other nematode species and other parasites of plants. These were mostly from the soil samples collected from the agricultural and paddy fields. The study also reports that the species diversity and abundance was more in soil samples where local manure was used instead of chemical fertilizers of NPK from the market.

Materials and Methods

The nematodes collection was carried out from August 2011 to November 2011, from July 2012 to December 2012 and from August 2013 to December 2013 from all the 12 talukas of Goa, namely Canacona, Marmagoa, Quepem, Salcette, Sanguem, Pernem, Ponda, Tiswadi, Bardez, Sattari, Bicholim and Dharbandora. About 75 soil samples were randomly collected from 5 villages of each taluka covering various landscape elements (Table 1). From each type of landscape, soil samples of about 500 -1000g near the roots of the plants were collected by taking care to avoid the top soil of about 10 to 15cms depth. Each sample was collected in a self sealing plastic bag with a label containing necessary field information. They were either processed immediately or stored in the refrigerator at 4°C and were processed later. The processing involved soaking the samples in freshwater for a few minutes based upon the soil type and then collecting the nematodes from these samples by Cobb's decanting and sieving method (1919), followed by the modified Baermann's Funnel method (Thorne, 1961). The nematodes that were isolated were killed and fixed in warm 4% formalin and processed by slow glycerine method (Seinhorst, 1959). They were mounted in dehydrated glycerine after four to five weeks of dehydration and permanent slides of the specimens were prepared using paraffin wax ring method and numbered serially (Maeseneer and Herde, 1963). For classification the nematodes were listed according to Goodey (1963); Jairajpuri and Khan (1982); Jairajpuri and Ahmad

(1992); Andrassy (1999) and Siddiqi (2000); Choudhary, Ahmad and Jairajpuri (2010) and websites of NEMAPLEX. Diversity Indices that were applied to the study were Species Diversity, Shannon's Diversity, Simpson's Index, Evenness and Abundance (Table 2). The details of the feeding habits of the various species are given in Table 3.

Results and Discussion

In the present study, about 600 slides were prepared. A total of 62 species of nematodes belonging to 8 orders were recorded. Table 1 indicates that all the talukas were equally represented by the various landscapes that were sampled. Table 2 indicates that the abundance and species diversity is more in five out of the 12 talukas: Canacona, Ponda, Sattari, Tiswadi and Pernem; the highest being in Sattari Taluka. These were the talukas where mostly local manure was used by the farmers though from all the talukas soil samples from paddy fields and agricultural areas were collected and assessed. Pernem Taluka has more abundance than Tiswadi Taluka though species diversity is same in both. The lowest abundance and species diversity was observed in Dharbandora Taluka. In terms of taxonomic groups, among the 62 species identified 45% belonged to Dorylaimida followed by Mononchida, 19%. Among predators the orders Dorylaimida and Mononchida were most prevalent and mostly these were predators on other nematodes as was observed in the gut contents. In terms of feeding habit abundance, predaceous nematodes were dominant; about 68% species were predators. Dorylaims dominated in terms of species as well as abundance. Sattari and Pernem Talukas are to the North of Goa and both these talukas have the highest abundance and species diversity. This is due to the high stability of these two talukas, which has been free of human intervention especially in regards to the fertilization of the soil where local manure was used by the agriculturists and paddy cultivators. Earlier reports say that populations of dorylaimids in the nematode community are sensitive to disturbance (agricultural practices such as ploughing, fertilizers and pesticides) and therefore used as indicators of environmental disturbances. (Thomas, 1978; Sohlenius and Wasilewska, 1984). A high percentage of dorylaims indicates scarce human intervention in the field (Gomes et al., 2003). Dorylaimids and mononchids may also be more directly sensitive than other nematode groups to disturbances-induced changes and to the physico-chemical conditions of the soil environment (Forge and Simard, 2001). The presence of strong and abundant predators indicates that the predatory groups play a major role in undisturbed landscapes of the soil ecosystem. Algal and fungal feeders are predominant secondary decomposers as is observed in table 3. Shannon-Weaver Diversity Index showed highest results in Sattari Taluka and lowest in Salcette Taluka. The nematode species were almost evenly distributed; though highest distribution observed in Dharbandora Taluka and lowest in Marmagoa Taluka. The Simpson Diversity Index showed highest distribution in Bardez and Salcette Talukas and lowest in Sattari, Ponda and Canacona Talukas.

Table 1: Details of Sampling Sites And Various Landscapes

*Vegetable Plants: Chillies, tomatoes, sweet potatoes, brinjals, ladyfingers, cucumber, raddish, beans, different gourds etc.

SR. NO.	LOCATION TALUKAS VILLAGES	LANDSCAPES
1.	Marmagoa: i) Chicalim	Flower gardens, banana grove
	ii) Consua	Bushy plants, *Acacia* plantation
	iii) Sao Jacinto Island	Coconut plantation, near the roots of vegetable plants*
	iv) Cortalim	Cashew plantation, banana plantation
	v) Vasco	Coconut plantation, paddy fields
2.	Salcette: i) Raia	Flower gardens, arecanut plantation
	ii) Nuvem	Banana plantation, cashew plantation, *Acacia* plantation
	iii) Carmona	*Casuarina* plantation, near roots of vegetables plants*
	iv) Curtorim	Paddy fields, roadside weeds
	v) Loutolim	Rubber plantation, chikoo (sapota) plantation
3.	Quepem: i) Ambaulim	Bamboo reeds, *Terminalia* species
	ii) Balli	Scrub jungle, roadside weeds
	iii) Quepem	Teak plantation, *Acacia* plantation
	iv) Avedem	Paddy fields, cashew plantation
	v) Xeldem	Mango plantation, jackfruit plantation
4.	Canacona: i) Agonda	Forest area, bamboo reeds, cashew plantation
	ii) Loliem	Arecanut plantation, banana plantation
	iii) Cabo da Rama	*Casuarina* plantation, paddy fields
	iv) Butpal	Near the roots of vegetable plants*
	v) Palolem	Paddy fields, roadside weeds
5.	Sanguem: i) Netorli	Coconut plantation, flower gardens
	ii) Udolxem	Forest area, roadside weeds
	iii) Sanvordem	*Acacia* plantation, bushy plants
	iv) Uguem	Forest area, paddy fields, *Casuarina* grove
	v) Rivona	*Acacia* plantation, coconut plantation
6.	Pernem: i) Arambol	*Casuarina* plantation, forest area
	ii) Querim	Betelnut plantation, Near the roots of vegetable plants*
	iii) Patradevi	Cashew plantation, paddy fields
	iv) Tiracol	Cashew plantation, mango plantation
	v) Morjim	Paddy fields, Near the roots of vegetable plants
7.	Ponda: i) Borim	Roadside weeds, paddy fields
	ii) Banastari	Betelnut plantation, coconut plantation
	iii) Curti	Paddy fields, Near the roots of vegetable plants*
	iv) Tisk	Palmolein plantation,
	v) Cundaim	Coconut plantation, Near the roots of vegetable plants*

8.	Tiswadi: i) Panjim	Bushy plants, paddy fields
	ii) Agassaim	Sweet potato plantation, chilly plantation
	iii) Miramar	*Casuarina* grove, wild palm tree plantation
	iv) Carambolim	Paddy fields, near the roots of vegetable plants*
	v) Chorao	Paddy field, brinjal plantation
9.	Bardez: i) Mapusa	Paddy fields, mango grove
	ii) Aldona	*Acacia* plantation,
	iii) Britona	Coconut plantation
	iv) Anjuna	*Casuarina* plantation
	v) Tivim	Paddy fields, sugarcane cultivation
10.	Satari: i) Birondem	Banana plantation, chikoo (sapota) plantation
	ii) Anjunem	Roadside weeds, paddy fields
	iii) Bondir	Coconut grove, paddy fields
	iv) Satorem	Mango plantation, jackfruit plantation
	v) Onda	Near the roots of vegetable plants*
11.	Dharbandora: i) Collem	Terminalia species, wild bamboo reeds
	ii) Usgao	Paddy fields
	iii) Mollem	Forest area
	iv) Codli	Teak plantation
	v) Dharbandora	Cashew grove
12.	Bicholim: i) Amona	Paddy fields
	ii) Surla	Near the roots of vegetable plants*
	iii) Sanquelim	Roadside weeds
	iv) Maem	Paddy fields
	v) Mulgaon	Coconut grove

Table 2: Taluka-wise Diversity Indices Of Soil Inhabiting Nematode

MAR-Marmagoa; SAL-Salcete; QUE-Quepem; CAN-Canacona; SAN-Sanguem; PON-Ponda; TIS-Tiswadi; SAT-Sattari; BIC-Bicholim; BAR-Bardez; PER-Pernem; DAR-Dharbandora

Sr. No.	INDICES	MAR	SAL	QUE	CAN	SAN	PON	TIS	SAT	BIC	BAR	PER	DAR
1	Abundance	353	344	357	512	328	552	480	598	353	316	572	311
2	Species Diversity	39	29	33	47	31	47	45	49	38	29	45	30
3	Shannon's Diversity	3.594	3.316	3.456	3.794	3.395	3.817	3.760	3.828	3.573	3.324	3.752	3.376
4	Simpson's Index	0.029	0.037	0.033	0.023	0.035	0.023	0.024	0.023	0.029	0.037	0.025	0.035
5	Evenness	0.981	0.985	0.988	0.985	0.988	0.991	0.988	0.983	0.982	0.987	0.986	0.992

Table 3: The Various Feeding Habits of the Nematode Species

Sr. No.	ORDERS	SPECIES	Omnivores	Predators	Bacterial Feeders	Fungal Feeders	Algal Feeders	Plant Feeders	Total
I	DORYLAIMIDA	1. *Amphidorylaimus infecundus* (Cobb, 1936) Andrassy, 1960	+	+					2
		2. *Afrodorylaimus bwana* Andrassy, 1964	+	+					2
		3. *Prodorylaimus longicaudatus* (Butschli, 1874) Andrassy, 1959	+	+					2
		4. *Prodorylaimus obesus* Ahmad & Jairajpuri, 1982	+	+					2
		5. *Mesodorylaimus mesonyctius* (Kries, 1930) Andrassy, 1959	+	+					2
		6. *Thornenema baldum* (Thorne, 1939) Andrassy, 1959	+	+					2
		7. *Thornenema lissum* (Thorne, 1939) Andrassy, 1959	+	+					2
		8. *Coomansinema dimorphicauda* Ahmad & Jairajpuri, 1989	+	+					2
		9. *Baqriella qaiseri* Ahmad & Jairajpuri, 1988	+	+					2
		10. *Ecumenicus monohystera* (De Man, 1880) Thorne, 1974	+	+					2
		11. *Labronema ferox* Thorne, 1939	+	+					2
		12. *Eudorylaimus himalus* Jairajpuri & Ahmad, 1982	+	+					2
		13. *Discolaimus texanus Cobb, 1913*	+	+					2
		14. *Discolaimus laksi* Khan & Laha, 1982	+	+					2
		15. *Enchodelus constrictus* Jairajpuri & Loof, 1968	+	+					2
		16. *Enchodelus longidens* Jairajpuri & Loof, 1968	+	+					2
		17. *Oriverutus labiatus* Ahmad & jairajpuri, 1987					+	+	2
		18. *Oriverutus paragus* Ahmad & Jairajpuri, 1987					+	+	2
		19. *Aporcelaimellus obscures* (Thorne & Swanger, 1936) Heyns, 1965	+	+					2
		20. *Aporcelaimellus baqrii* Ahmad & Jairajpuri, 1982	+	+					2
		21. *Aporcelaimus regius* (De Man, 1876) Thorne & Swanger, 1936	+	+					2
		22. *Longidorus brevicaudatus* (Schur. Stek, 1951) Khan, 1987	+						1
		23. *Longidorus elongatus* (De Man, 1876) Thorne & Swanger, 1936	+						1
		24. *Xiphinema insigne* Loos, 1949	+	+			+	+	4

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Sr. No.	ORDERS	SPECIES	Omnivores	Predators	Bacterial Feeders	Fungal Feeders	Algal Feeders	Plant Feeders	Total
		25. *Xiphinema americanum* Cobb, 1913	+	+			+	+	4
		26. *Axonchium ampicolle* Cobb, 1920	+	+		+			3
		27. *Axonchium vulvulatum* Nair & Coomans, 1974	+	+		+			3
		28. *Dorylaimoides chamoliensis* Ahmad & Jairajpuri, 1983	+	+		+			3
II	MONONCHIDA	29. *Mononchus aquaticus* Coetzee, 1968		+					1
		30. *Mononchus tunbridgensis* Bastian, 1865		+					1
		31. *Iotonchus trichurus* (Cobb, 1917) Altherr, 1958		+					1
		32. *Iotonchus indicus* Jairajpuri, 1969		+					1
		33. *Iotonchus basidontus* Clark, 1960		+					1
		34. *Iotonchus shofii* Khan & Jairajpuri, 1980		+					1
		35. *Parahadronchus shakili* (Jairajpuri, 1969) Mulvey, 1978		+					1
		36. *Mylonchulus minor* (Cobb,1893) Andrassy,1958		+					1
		37. *Mylonchulus amurus* Khan & Jairujpuri, 1979		+					1
		38. *Coomansus indicus* Jairajpuri & Khan 1977		+					1
		39. *Coomansus parvus* (De Man, 1880) Jairajpuri & Khan, 1977		+					1
		40. *Clarkus elongatus* Jairajpuri & Khan, 1977		+					1
III	TYLENCHIDA	41. *Tylenchus filiformis* Butschli, 1873				+	+	+	3
		42. *Tylenchus indicus* Khan et al, 1969				+	+	+	3
		43. *Ottolenchus parvus* (Siddiqi, 1963) Siddiqi, 1979				+	+	+	3
		44. *Psilenchus minor* Siddiqi, 1963				+	+	+	3
		45. *Tylenchorhynchus elegans* Sidciqi, 1961				+	+	+	3
		46. *Hoplolaimus indicus* Sher, 1963				+	+	+	3
		47. *Hoplolaimus seinhorsti* Luc, 1958				+	+	+	3
		48. *Helicotylenchus indicus* Siddiqi, 1963				+	+	+	3
		49. *Criconemella xenoplax* (Raski, 1952) Luc & Raski, 1981				+	+	+	3

Sr.No	ORDERS	SPECIES	Omnivores	Predators	Bacterial Feeders	Fungal Feeders	Algal Feeders	Plant Feeders	TOTAL
IV	MONHYSTERIDA	50. *Prismatolaimus andrassyi* Khera & Chaturvedi, 1979		+	+				2
V	ALAIMIDA	51. *Alaimus primitives* De Man,1880			+				1
		52. *Alaimus hamulus* Siddiqi & Husain, 1967			+				1
		53. *Amphidelus novus* Baqri & Jairajpuri, 1968			+				1
VI	RHABDITIDA	54. *Caenorhabditis elegans* (Maupas, 1899) Dougherty, 1953			+				1
		55. *Cephalobus persegnis* Bastian, 1865			+				1
		56. *Acrobeles timmi* Chaturvedi & Khera, 1979			+				1
		57. *Panagrolaimus fuchsia* Ruhm, 1956			+				1
VII	ENOPLIDA	58. *Ironus longicaudatus* De Man, 1884		+					1
		59. *Ironus ignavus* Bastian, 1865		+					1
VIII	ARAEOLAIMIDA	60. *Plectus cirratus* Bastian, 1865		+	+				2
		61. *Plectus thornei* Ruhm, 1956		+	+				2
		62. *Chiloplectus indicus* Tasheen et al, 2004		+	+				2
		TOTAL	26	42	11	12	13	13	

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WEBSITE

NEMAPLEX: The Nematodes Plant Expert Information System.