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Comparison of tropical nematode communities from the three harbours, west coast of India.

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Condensed title: Marine nematodes from three Indian harbours

Abstract

We investigate the three major harbours from the central west coast of India for their benthic environmental status using nematodes as surrogate community. As these three harbours have shown deteriorated conditions revealed from macrobenthic community, our main objective was to investigate and inter-compare the nematode communities within these harbours and with other similar habitats worldwide. A total of 50 nematode species were encountered in the study area, wherein highest (34 species) were recorded at Mormugao harbour and lowest (23 species) at Ratnagiri harbour. The presence of dominant species like *Vasostoma* sp. (41%) *Sabatieria* sp.1 (23%) and *Sabatieria* sp.2. (20%) designate these harbours as altered benthic habitats under stress. The diversity indices demonstrate Ratnagiri harbour as the most stressed and Karwar being the least stressed comparatively. Intense anthropogenic activities and input of many pollutants such as heavy metals, pesticides, petroleum derivatives, TBT's and dredging activity in the harbours can be held responsible for the altered nematode community.

Keywords: Marine nematodes; harbour pollution; benthic health; indicator species; west coast; India.

Introduction

Harbours, as a major interface between coastal cities and the sea, are often under heavy pressure from human activities and increasingly suffer from environmental risks linked to poor water and sediment quality (Estacio et al. 1997). The central west coast of India has dense human habitation and is an industrial belt along with extensive agriculture. The harbours in this region have heavy traffic, which all together increases the stress on this environment. All the three harbours in the study area are situated on the river mouth.

Benthic communities have been extensively used in assessing the health of marine environment and biodiversity (Millward & Grant, 2000; Dovgal et al. 2008; Ingole et al. 2009) and in the present study area macrobenthos indicated a stressed benthic environment (Alongi, 1990; Ingole et al. 2009). Further investigations for a better picture of pollution status by using meiobenthic taxa for assessment have been suggested, which hold certain advantages (Gyedu-Ababio et al. 1999). No pelagic dispersal stages, higher species richness than macrofauna (Moore & Bett 1989) and exhibit differential response to stress makes meiofauna a sensitive indicator of stress (Gyedu-Ababio et al. 1999). Within meiobenthos, nematodes are an excellent taxon as ecological indicators of benthic environment (Schratzberger et al. 2000). They have a ubiquitous distribution, with high density and diversity (with a range from very tolerant to very sensitive species) and short generation time (Heip et al. 1985).

We investigated the three harbour sediments from the central west coast of India for the status of benthic environment using marine nematodes as surrogates. Ratnagiri, Mormugao and Karwar harbours from the west coast of India are peculiar in the nature of activities where Ratnagiri is mainly a fishing harbour. Mormugao is mainly used for ore transport as 80% of India's inland waterway traffic is in this estuarine system for ore transportation and it operated about 39 billion tonnes in the last 3 years. Karwar is an intermediate port with more than 6 lakh tonnes of traffic each year.

The objective of the present study was firstly, to investigate and inter-compare the benthic environment of the harbours using nematode communities and predefined pollution indicator species. Secondly, to document an inventory of nematode community from this tropical estuarine region and compare it with other similar habitats worldwide.

Methodology

Study area:

Field sampling was conducted at Mormugao, Karwar and Ratnagiri (Fig. 1). The Mormugao harbour is situated on the mouth of zuari estuary along the Goa coast (15°27'48''N; 73°38'64''E) one of the oldest major ports on the west coast of India ranks within the first 10 leading iron ore exporting ports of the world.

Ratnagiri harbour is situated (17°00'38''N and 73°15'34''E) along Maharashtra coast and deals with transport of cement, chemicals and petroleum products because of recent industrial development in the region. Karwar port is a natural all weather harbour situated in north Karnataka (14°50'36''N and 73°54'55''E) on the mouth of the river Kali.

Sample collection:

Samples were collected onboard *CRV Sagar-Sukti* (SaSu-105) during January 2006 with a van-Veen grab (0.11 m²). Five grabs were operated in each harbour at approximately 100m distance. Two sub-samples from each grab were collected up to 5cm depth with an acrylic core (4.5 cm diameter) for the analysis of meiobenthic nematodes. Samples were immediately preserved in 5% buffered Rose Bengal formalin solution. In laboratory, the samples were sieved with a 45 μ mesh sieve and all the nematode specimens were handpicked and temporary glycerol mount were prepared for taxonomic identification. Identification was done up to lowest possible level using pictorial key by Warwick et al. (1998). Depth, temperature and salinity were measured at each sampling station using a CTD (Seabird[®]). Bottom water dissolved oxygen was measured by Wrinkler's method. At each station, sediment sample was taken separately with an acrylic core (ϕ 4.5 cm) for the analysis of sediment chlorophyll, phaeo-pigment and organic carbon. Chlorophyll-*a* (Chl-*a*) and phaeo-pigment were analysed by acetone extraction method and organic carbon was estimated with CO₂ Coulometer after acidification of sediment to remove the inorganic carbon. All the environmental parameters for water and sediment were taken in duplicate for each harbour.

Data analysis:

Margalef's species richness (d'), Shannon-Weiner diversity function (H'), Pielou's evenness (J') and Simpson's dominance ($1-\lambda'$). Bray-Curtis similarity cluster was constructed based on log transformed $\log_{10}(x+1)$ nematode species abundance. K -dominance curve were plotted for comparison between each harbours. Formal significance tests for differences in nematode community structure between habitats were performed using one-way ANOVA and one-way ANOSIM test. SIMPER analysis was conducted for the differences between the harbours based on

species dissimilarity. Percent species contribution was plotted using geometric class. All the diversity functions for nematode species were calculated using PRIMER 6 statistical package. The maturity index (MI) was calculated as the weighted mean of the individual taxon scores (Bongers et al. 1991):

$$MI = \sum v(i) \times f(i)$$

Where, v is the colonisers-persisters ($c-p$) value of taxon i (as given in Appendix A by Bongers et al. 1991) and f is the frequency of that taxon in a sample. They were sorted into functional groups according to Wieser (1953):

1A: selective deposit feeders: nematodes with a very small unarmed buccal cavity.

1B: non-selective deposit feeders: nematodes with unarmed buccal cavities of moderate size.

2A: epistratum feeders: nematodes with medium size buccal cavities, provided with small teeth.

2B: predators or omnivores: nematodes with wide buccal cavities, large teeth or other powerful buccal structures. 1B/2A ratio was calculated for knowing the status of harbours where 2A group are a constant factor but that contamination is associated with a relative increase in the 1B group. This can be conveniently expressed as a 1B/2A ratio.

Results

Environmental variables:

The average water depth at Ratnagiri and Karwar harbour was 20m whereas at Mormugao it was 25m. No much variation was observed for bottom water temperature (mean-26.6⁰C). Salinity was highest (35.43) at Mormugao and lowest (34.76) at Karwar. Bottom water dissolved oxygen was lowest (2.6) at Karwar and highest (4.4) at Ratnagiri (Table 1). The sediment chl-*a* values ranged from 0.18 to 0.35 $\mu\text{g.g}$ with highest values recorded at Mormugao and lowest at Ratnagiri harbour. Sediment organic carbon ranged from 1.4% to 3.5% with highest values at Mormugao.

Nematode community:

Overall the study area consisted of 50 nematode species, where Mormugao harbour was composed of highest (34 species) number and lowest (20 species) recorded at Ratnagiri (Table 2).

The results of one-way ANOSIM confirmed the difference within the three harbours where significant difference was observed between Ratnagiri and Karwar ($p < 0.01$; Table 3) followed by Karwar and Mormugao ($p < 0.01$; Table 3). The cluster analysis based on the nematode species abundance for Karwar showed a separate cluster within Ratnagiri and Mormugao (at 30% similarity).

The stations within Ratnagiri and Mormugao did not show similarity depicting varied abundance for both the harbours (Fig. 2).

The average diversity indices showed highest mean values at Mormugao (Table 4). The species richness (d') was highest at Mormugao (1.74) followed by Karwar (1.34). The Shannon-Weaver's diversity (H') was also highest at Mormugao (2.06) and Karwar (1.85) while all the indices including Maturity Index (MI) showed low values at Ratnagiri (Table 4).

There was a significant difference between the harbours for Shannon-Weaver diversity Index (H') ($F= 5.59$) at the level of 0.01. The Simpson's Index ($1-\lambda$) also showed a significant difference ($F= 7.26$) at 0.008 level of significance. Maturity Index (MI) was not highly significant ($F= 3.86$) at 0.05 level of significance (Table 5).

At Ratnagiri harbour *Vasostoma* sp. (219 nos.10cm² \pm 118SD; Table 2) was the most dominant contributing 37% of the total community followed by *Sabatieria* sp2 (62 nos.10cm² \pm 55SD; Table 2) constituting 11%. At Mormugao harbour *Vasostoma* sp. (211 nos.10cm² \pm 217SD) was the dominant species with 41% contribution followed by *Sabatieria* sp.1 (116 106) contributing 23%. At Karwar harbour *Vasostoma* sp. (86 nos.10cm² \pm 80SD; Table 2) was dominant with 17% of the total followed by *Sabatieria* sp.1 (106 nos.10cm² \pm 62SD; Table 2) with 20% contribution. 'Others' constituted 43% of the total community (Fig. 3). The cumulative dominance curve for the three harbours showed the difference with Ratnagiri harbour being the least diverse with more dominance whereas Mormugao harbour was with higher diversity and lower dominance (Fig. 4).

The Geometric class plot constructed depicts the least number of species with least abundance in the initial classes for all the three sites. Wherein the Ratnagiri and Karwar harbours are represented by 11 classes (Fig. 5) and Mormugao harbours is represented by 10 classes (Fig. 5).

Simper analysis revealed the contribution of the important species for the dissimilarity between the harbours where the species cumulative contribution of more than 50% were considered. The average dissimilarity between all the harbours ranged between 68.30 to 78.5%. Between Karwar and Ratnagiri harbour the major species contributing dissimilarity was *Vasostoma* sp. (23.25%) followed by *Sabatieria* sp.1 (13.93%) and the same two species contributed for difference between Karwar and Mormugao (17.93 and 12.41% respectively). *Vasostoma* sp. (22.67%) and *Sabatieria* sp.1 (13.8%) for difference between Ratnagiri and Mormugao (Table 6).

Epistrate feeders (2A) were the most dominant feeding group contributing 44% at Ratnagiri, 55% at Mormugao and 52% at Karwar. The second dominant feeding type was Non-selective deposit feeders (1B) at Ranagiri and Mormugao with 26% each, whereas at Karwar it was

Predatory/omnivores (2B) with 22% contribution. The ratio for 1B/2A varied from 0.24 to 0.42 at all the three harbours (Table 4).

Discussion

The meiobenthic nematodes are bound to the sediment throughout their life history and therefore are sensitive to many toxicants (Coull & Chandler 1992). They are considered to be good candidate organisms for environmental quality assessment of harbours (Liu et al. 2008; Moreno et al. 2008) because the overall community response is species specific.

Present study accounted for a total 50 nematode species from the three estuarine benthic environments where there was influence of river discharge, harbour activities and other anthropogenic inputs. We compare the species richness with other estuarine areas where same numbers of genera were recorded from Swartkops estuary (Gyedu-Ababio et al. 1999) but a subtropical harbour had 127 species (Liu et al. 2008). Fewer species (43 and 44 genus/species) were observed at Genoa-Voltri Ligurian Sea and Ems estuary, respectively (Moreno et al. 2008) in the heavily polluted estuaries. Around 200 species were recorded for 5 unpolluted estuaries of Western Europe (Soeteart et al. 1995). Very low (27) species were reported from an estuarine region, which was organically polluted (Essink & Romeyn 1994) and accordingly it may be conclude from the low number of species that the present study area seems to be a grossly polluted benthic environment.

Low nematode species diversity was observed at Ratnagiri harbour, which was conformed by the *k*-dominance plot recommended to be used after using diversity indices in a polluted habitat (Platt et al. 1984). Within Karwar harbour, a very similar nematode community (Fig. 2) suggests a homogeneous environment compared to Ratnagiri and Mormugao. Karwar harbour showed a significant difference with the other two harbours (Table 3) as Ratnagiri and Mormugao both had a high abundance of dominant species. The dominant species in the present study were *Vasostoma* sp., *Sabatieria* sp.1, *S.* sp.2, *Merylinnia* sp. and *Daptonema* sp. Which are all members of epistrate and non-selective deposit feeder (Wieser 1953) and have been reported dominant mostly from anoxic, degraded and polluted habitats. The indicator species encountered in the present study such as *Sabatieria* sp., (Mirto et al. 2002; Vincx et al. 1990; Vanreusel 1990; Boyd et al. 2000), *Merylinnia* sp. (Mahmoudi et al. 2007) and *Sphaerolaimus* sp. (Gyedu-Ababio et al. 1999) are again known to inhabit stressed and anoxic sediments. And also the presence of many subdominant species (Table 2) was an indication of pollution and dredging activity viz; *Terschellingia* sp. (Vincx et al. 1990; Vanreusel 1990), *Dorilaimopsis* sp. (Mirto et al. 2002; Vincx et al. 1990), *Daptonema* sp. (Vanreusel and

Vincx, 1989; Boyd et al. 2000), *Axonolaimus* sp. (Gyedu-Ababio et al. 1999), *Oxystomina* sp. (Mirto et al. 2002), *Theristus* sp. (Gyedu-Ababio et al. 1999).

The analysis of variance showed a significant differentiation between the harbours for the diversity indices such as the Shannon-Weaver (H') and Simpson's indices (Table 5) overall suggesting that the three harbours are influenced at varying degrees resulting in different communities.

Although these harbours are known to have high organic inputs which influenced the macrobenthic community (Ingole et al. 2009), the nematode community showed lower 1B/2A ratios (less than 0.5, Table 4) which suggest that more of fresh productivity was consumed by nematode community rather than the organic matter. This depicts that unlike macrofauna (Alongi, 1990; Ingole et al. 2009) high input of organic matter does not necessarily influence the nematode community structure.

Pollutants have shown considerable influence on nematodes (Millward and Grant, 2000) and the impact of a single factor (organic matter in the present case) cannot be considered valid for the community as these harbours have combinations of pollution inputs. High abundance of many species and few representatives of rare species (Fig. 5) can be due to the integrated impact of several anthropogenic activities in the harbour region (Alongi, 1990). The altered diversity, average lower MI (Table 4; Heip et al. 1985) and the presence of many pollution indicator species in the three harbours can mainly be attributed to the toxic inputs in the region and not the organic input shown by the lowered feeding ratios (Fig. 4). Reportedly high input of pollutants in these harbour sediments such as petroleum hydrocarbons, pesticides (Sarkar et al. 2008), organotins (Jadhav et al. 2009), metals (Ramaiah & De 2003; Nair et al. 2003; Mesquita & Kaisary 2007) and dredging activity is mainly responsible for deterioration of the harbour environment. Many nematode species such as *Rhynchonema* sp. and *Araeolaimus* sp. are known to be sensitive to pollutants (Hermi et al. 2008) and such species were absent from the study area but were reported from the adjacent habitats from the same region (Ingole et al. 2006).

Mormugao harbour is constantly subjected to contaminants from the shipping industry such as TBT, DBT and organotins (Jadhav et al. 2009) which have shown negative impact on the nematode community (Schratzberger et al. 2002) and deposition of metals such as Fe and Mn from the mining activity in the region (Mesquita & Kaisari 2007) are also known to harm the nematode species (Gyedu-Ababio et al. 1999). Recent reports reveal an increase in the concentration of heavy metals such as mercury (Ramaiah & De 2003) and high concentration of arsenic in all the three harbours (Nair et al. 2003). At Ratnagiri, sediments had significantly high PHC's (Chouksey et al. 2004), which had shown deleterious impact on the benthic community due to shipwrecks in this region

(Ingole et al. 2006; Sivadas et al. 2008). Nematode species composition shows the dominance of opportunistic community due to stress at all the three harbours. Anthropogenic activities had gross influence in the harbours where the co-contamination of several toxicants such as petroleum products, heavy metals and pesticides show cumulative effects (Millward & Grant 2000). Moreover, the influence of toxicological synergisms will increase with mechanical disturbance in the harbours caused by dredging. These factors together show their imprints in the nematode community of the three harbours where altered diversity and presence of dominant indicator species suggest the impact of pollution and harbour activities. Investigating such benthic indicators for the precise determination of different anthropogenic impacts on the benthic community can increase monitoring efficiency and reduce cost of scientific analysis in the future.

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Table 1: Environmental parameters at the three harbours.

	Depth (m.)	Temp (⁰ C)	Salinity (PSU)	DO (ml/l)
Ratnagiri	20	26.6	35.30	4.40
Mormugao	25	27.5	34.76	3.00
Karwar	20	26.7	35.43	2.60

Table 2: Abundance (nos.10cm²) of nematode species at the three harbours
(Feeding types are according to Wieser 1953)

Species	Feeding type	Ratnagiri		Mormugao		Karwar	
		Mean	±SD	Mean	±SD	Mean	±SD
<i>Sabatieria</i> sp1	1A	0.0	0.0	116.8	106.8	106.0	62.5
<i>Terschellingia longicaudata</i>	1A	10.9	15.1	1.8	4.1	13.5	20.3
<i>Terschellingia</i> sp.	1A	0.0	0.0	0.0	0.0	0.0	0.0
<i>Siphonolaimus</i> sp.	2B	16.2	19.9	8.4	13.9	9.7	21.8
<i>Paramonhystera</i> sp.	1B	15.8	31.1	7.5	16.8	1.4	3.2
<i>Daptonema</i> sp.	1B	32.8	42.6	11.5	17.9	20.7	28.5
<i>Dorylaimopsis</i> sp.	2A	2.0	4.4	0.0	0.0	0.0	0.0
<i>Hopperia</i> sp.	2A	0.2	0.4	0.0	0.0	0.0	0.0
<i>Paramesonchium</i> sp.	2B	1.6	3.6	0.0	0.0	7.1	15.8
<i>Sphaerolaimus</i> sp.	2B	48.7	56.9	13.7	15.6	16.9	22.2
<i>Cheironchus</i> sp.	2B	5.9	13.3	0.0	0.0	0.7	1.6
<i>Bathyeurystomina</i> sp.	1B	0.0	0.0	0.0	0.0	1.4	3.2
<i>Polygastrophora</i> sp.	2B	0.0	0.0	2.0	4.6	16.9	18.4
<i>Oxystomina</i> sp.	1A	2.0	4.4	0.0	0.0	0.7	1.6
<i>Linhomoeus</i> sp.	1B	0.0	0.0	0.0	0.0	0.7	1.6
<i>Sabatieria</i> sp2	1B	62.3	55.9	0.0	0.0	6.4	14.3
<i>Marylynnia</i> sp.	2A	52.1	73.3	0.0	0.0	3.2	5.3
<i>Vasostoma</i> sp.	2A	219.3	118.7	211.7	217.3	86.6	80.6
<i>Adoncholaimus</i> sp.	2B	26.5	36.5	0.0	0.0	7.2	10.7
<i>Actarjania</i> sp.	2A	7.9	17.7	0.0	0.0	0.0	0.0
<i>Microlaimus</i> sp.	2A	3.6	5.0	0.0	0.0	0.0	0.0
<i>Comesomoides</i> sp.	2A	2.0	4.4	0.0	0.0	0.0	0.0
<i>Enoplolaimus</i> sp.	2B	14.2	17.1	0.0	0.0	0.0	0.0
<i>Chromadorita</i> sp.	2A	0.0	0.0	0.2	0.4	0.0	0.0
<i>Paralinhomoeus</i> sp.	1B	0.0	0.0	0.2	0.4	0.0	0.0
<i>Halalaimus</i> sp.	1A	0.0	0.0	12.4	16.4	12.1	17.2
<i>Axonolaimus</i> sp.	1B	4.7	10.5	15.2	16.8	20.8	23.0
<i>Theristus</i> sp.	1B	9.5	15.4	23.2	34.0	7.1	16.0
<i>Paracomesome</i> sp.	2A	4.7	10.5	11.9	15.4	11.6	16.6
<i>Metacomesome</i> sp.	1B	2.4	5.3	0.0	0.0	0.0	0.0
<i>Pierrickia</i> sp.	1A	30.8	68.8	0.0	0.0	0.0	0.0
Unidentified 2	2A	12.3	27.5	3.7	8.2	0.0	0.0
Microlaimidae	2A	0.0	0.0	40.0	45.7	17.0	23.7
<i>Quadricoma</i> sp.	1A	0.0	0.0	0.0	0.0	0.0	0.0
<i>Metacyantholaimus</i> sp.	2A	0.0	0.0	2.0	4.6	50.9	107.7
<i>Viscosia</i> sp.	2B	0.0	0.0	0.8	1.9	0.0	0.0
<i>Chromadora</i> sp.	2A	0.0	0.0	0.2	0.4	0.0	0.0

<i>Araeolaimus</i> sp.	1A	0.0	0.0	2.0	4.6	0.0	0.0
Unidentified	2A	0.0	0.0	6.1	13.7	16.7	20.4
<i>Odontophora</i> sp.	1B	0.0	0.0	11.6	17.0	2.5	5.5
<i>Pomponema</i> sp.	2A	0.0	0.0	7.5	16.8	9.7	21.8
Unidentified 3	1A	0.2	0.4	0.0	0.0	0.0	0.0
<i>Paralinhomoeus</i> sp.	1B	0.0	0.0	0.0	0.0	2.5	5.5
<i>Anticyathus</i> sp.	1B	0.0	0.0	0.0	0.0	2.5	5.5
<i>Trichotheristus</i> sp.	1B	0.0	0.0	0.0	0.0	23.9	37.6
<i>Choanolaimus</i> sp.	2B	0.0	0.0	0.0	0.0	4.9	11.0
<i>Polysigma</i> sp.	2A	0.0	0.0	0.0	0.0	24.4	42.5
<i>Trissonchulus</i> sp.	2B	0.0	0.0	0.0	0.0	2.2	5.0
<i>Platycoma</i> sp.	2A	0.0	0.0	0.0	0.0	9.7	21.8
<i>Enoplolaimus</i> sp.	2B	0.0	0.0	0.0	0.0	0.2	0.4
Total species	50		20		34		23
Percent diversity	100		26		44		30

Table 3: ANOSIM for the difference between each harbour based on nematode species abundance (Global R=0.329).

	R	% Significance
Karwar, Ratnagiri	0.62	0.8
Karwar, Mormugao	0.41	0.8
Mormugao, Ratnagiri	0.01	42.9

Table 4: Diversity indices and percent feeding types (Wieser 1953) at each harbour (mean of 5 replicates)

Diversity indices	Ratnagiri		Mormugao		Karwar	
	Mean	±SD	Mean	±SD	Mean	±SD
Species (S)	21	3.36	32	2.30	23	1.79
Abundance (N)	510	476.88	518	2335.17	588	336.87
Richness (d')	1.26	0.46	1.74	0.43	1.34	0.36
Evenness (J')	0.80	0.11	0.85	0.04	0.84	0.06
Shannon-Weaver (H')	1.62	0.23	2.06	0.25	1.85	0.12
Simpsons Index ($1-\lambda$)	0.73	0.06	0.84	0.05	0.79	0.03
Maturity Index (MI)	2.25	0.09	2.57	0.29	2.29	0.16
Feeding types (%)						
1A	13		5		19	
1B	26		26		7	
2A	44		55		52	
2B	17		14		22	
Ratio 1B / 2A	0.39		0.24		0.42	

Table 5: One way ANOVA for all the nematode diversity indices (*df*: 2 and residual error for *df*: 12).

Source of Variation	<i>F</i>	<i>P-value</i>
Species (<i>S</i>)	1.90	0.190
Abundance (<i>N</i>)	0.85	0.448
Richness (<i>d'</i>)	1.87	0.195
Evenness (<i>J'</i>)	0.72	0.505
Shannon-Weaver (<i>H'</i>)	5.59	0.019
Simpsons Index (<i>1-λ</i>)	7.26	0.008
Maturity Index (MI)	3.86	0.050

Table 6: Percent contribution of dominant nematode species by SIMPER analysis for each harbour representing cumulative dominance of more than 50%.

	Group 1 Avg. Abund	Group 2 Avg. Abund	Av diss	Diss SD	Contri b%	Cum %
Groups Karwar & Ratnagiri						
Average dissimilarity = 71.07						
<i>Vasostoma</i> sp.	219.32	211.66	16.52	1.79	23.25	23.25
<i>Sabatieria</i> sp1	0.0	116.78	9.90	1.64	13.93	37.18
<i>Sabatieria</i> sp2	62.25	0.00	6.78	1.28	9.54	46.72
<i>Marylynnia</i> sp.	52.09	0.00	3.98	0.72	5.6	52.32
Groups Karwar & Mormugao						
Average dissimilarity = 78.59						
<i>Vasostoma</i> sp.	219.32	86.60	14.09	1.56	17.93	17.93
<i>Sabatieria</i> sp1	0.0	105.97	9.75	1.84	12.41	30.34
<i>Sabatieria</i> sp2	62.25	6.38	5.33	1.57	6.78	37.12
<i>Metacantholaimus</i> sp.	0.0	50.93	4.43	0.50	5.64	42.76
<i>Marylynnia</i> sp.	52.09	3.16	3.88	0.82	4.94	47.70
<i>Sphaerolaimus</i> sp.	48.67	16.93	3.68	1.28	4.68	52.37
Groups Ratnagiri & Mormugao						
Average dissimilarity = 68.30						
<i>Vasostoma</i> sp.	211.66	86.60	15.48	1.56	22.67	22.67
<i>Sabatieria</i> sp1	116.78	105.97	9.42	1.67	13.8	36.47
<i>Metacantholaimus</i> sp.	2.04	50.93	5.06	0.50	7.41	43.88
Microlaimidae	39.98	16.96	3.42	1.25	5.00	48.88
<i>Polysigma</i> sp.	0.00	24.40	2.55	0.59	3.73	52.61

Figure legends

Fig. 1: Location of the study sites (*-showing the harour locations).

Fig. 2: Cluster analysis based on the nematode species abundance for all sampling stations from the three harbours (r- Ratnagiri, m-Mormugao and k-Karwar).

Fig. 3: Percent contribution of dominant species in the three harbours.

Fig. 4: Cumulative species dominance for the three harbours (□- Karwar, +- Ratnagiri, O- Mormugao).

Fig. 5: Geometric class of nematode species abundance from the three harbours.

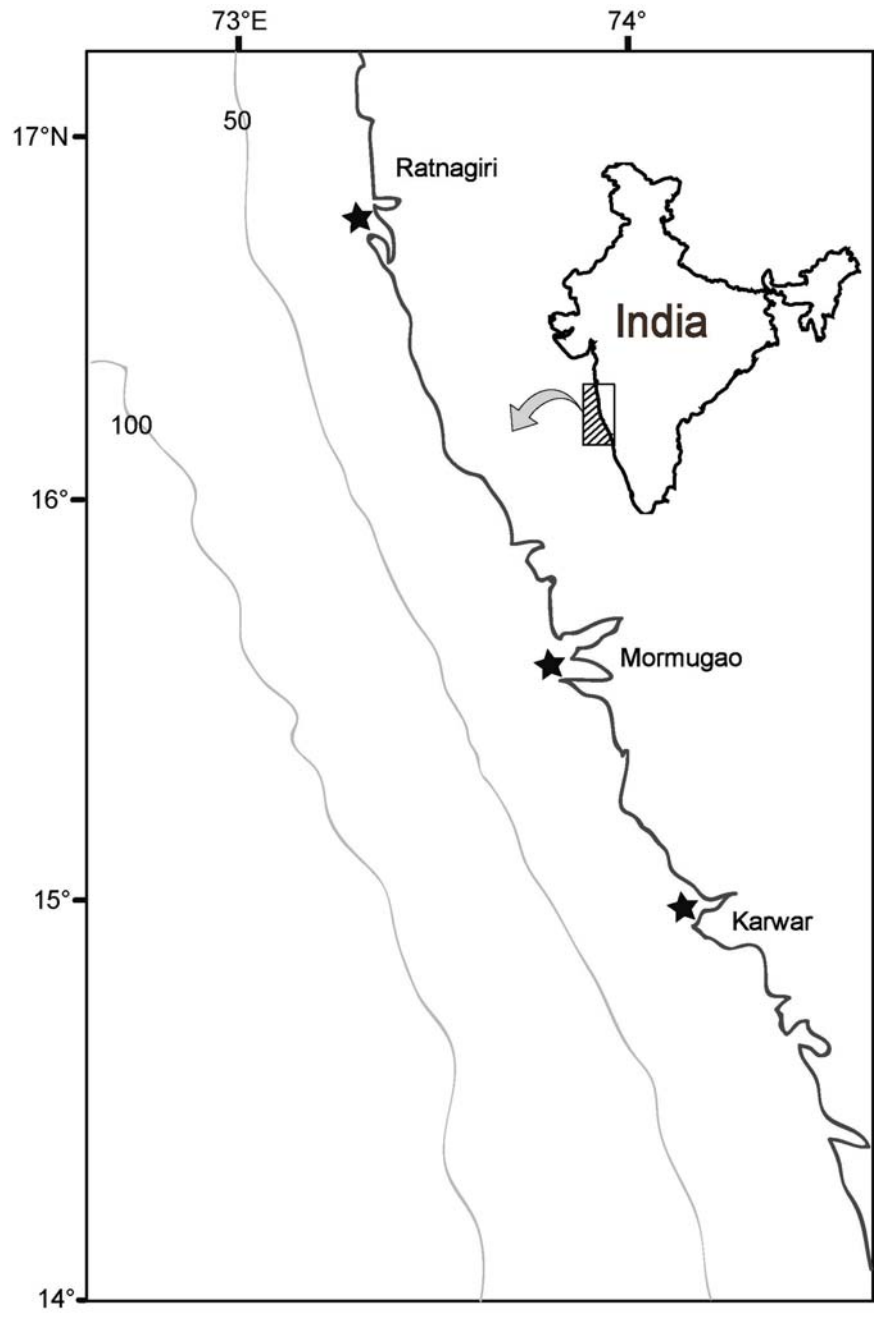


Figure 1

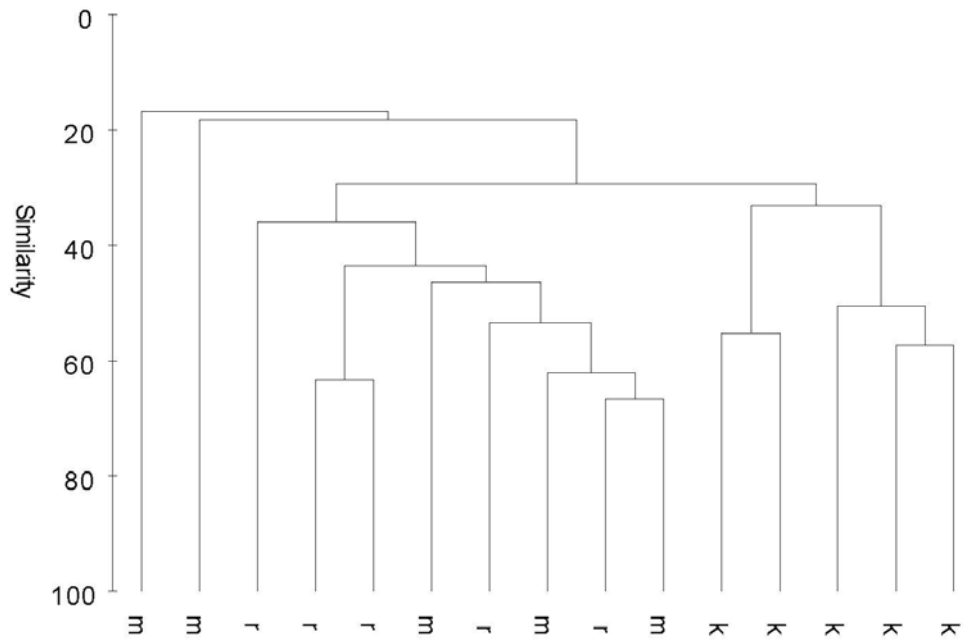


Figure 2

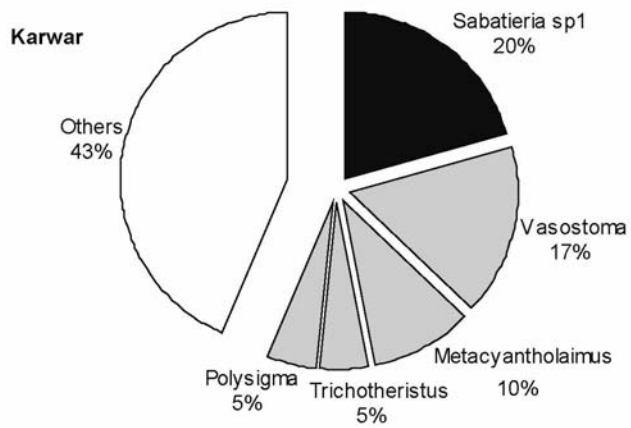
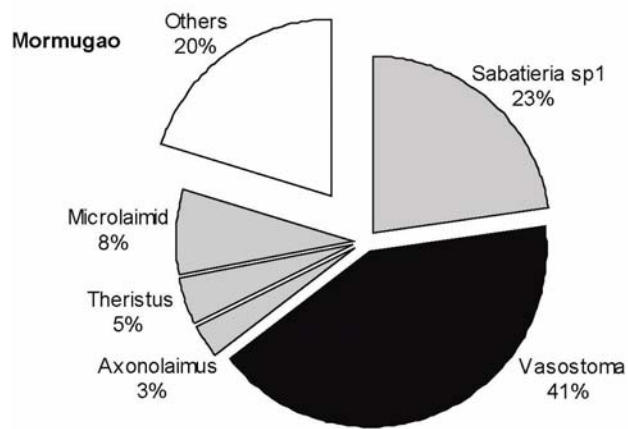
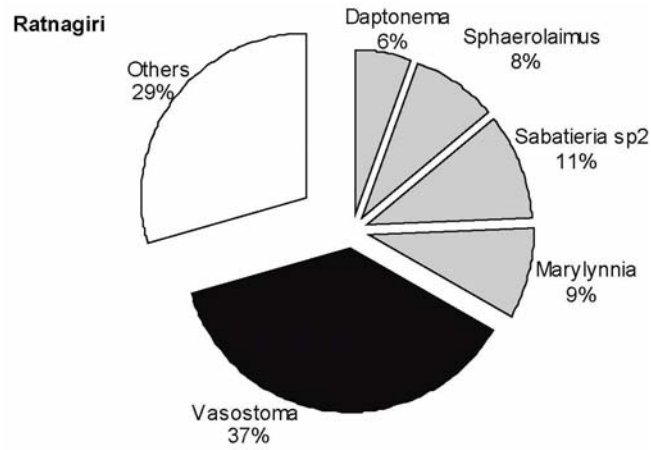


Figure 3

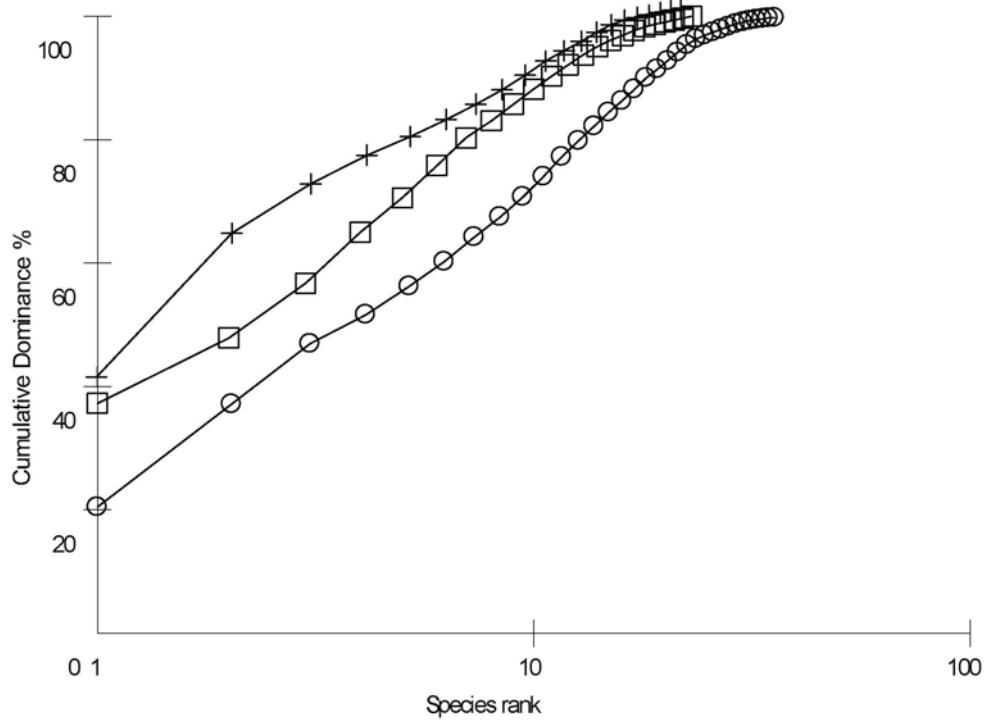


Figure 4

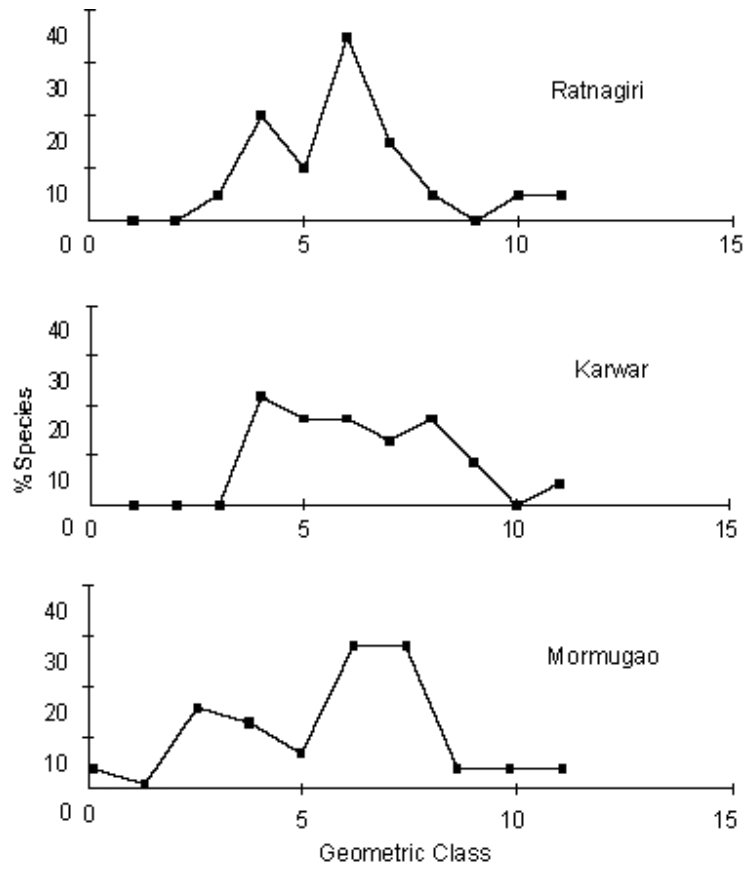


Figure 5