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Biodiversity of Meiofauna in the Intertidal Khe Nhan Mudflat, Can Gio Mangrove Forest, Vietnam with Special Emphasis on Free Living Nematodes

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Abstract – The ecological aspect of meiofaunal communities in Can Gio mangrove forest, Ho Chi Minh city, Vietnam has not been investigated before. The composition, distribution, density and biodiversity of meiofaunal communities were studied along an intertidal transect at the Khe Nhan mudflat. Each time, three replicate samples were collected in four stations along a transect following the water line from low tide level up to the mangrove forest edge. In total, 18 meiofaunal taxa were found with the dominant taxa belonging to Nematoda, Copepoda, Sarcomastigophora and Polychaeta. The densities of meiofauna ranged from 1156 inds/10 cm^2 to 2082 inds/10 cm^2. The increase in densities from the mangrove forest edge towards the low water line was significant. Along the mudflat transect, the biodiversity (expressed by different indices) was relatively high at different taxonomic levels but did not vary significantly along the mudflat except for taxa richness. Eighty nematode genera belonging to 24 families with Comesomatidae having the highest abundance 33.8 % were found. *Theristus* and *Neochromadora* decreased in densities from the lower water line towards the mangrove forest edge, while *Paracomesoma* and *Hopperia* are typical and more abundant at the middle of the mudflat. *Halalaimus* increased from high on the mudflat to the low water line.

Key words – Mangrove, meiofaunal communities, nematode biodiversity, indices

1. Introduction

Mangroves create unique ecological ecosystem that host rich assemblages of diverse taxa associated with different habitats. The muddy or sandy sediments are home to a variety of epibenthic or endobenthic, macro-invertebrates and meio-invertebrates. Nematodes dominate numerically in the mangrove endofauna, as they do in other benthic environments. They seem to be most successful among other benthic taxa in colonizing the organically enriched oxygen poor environments Alongi (1987) and Olafsson *et al.* (2000).

Many investigations on the structure of meiofaunal communities in mangrove habitats have been done in all subtropical continents of the world (Hodda 1987; Hopper *et al*. 1973; Decraemer and Coomans 1978; Hodda and Nicholas 1985; Dye 1983, but in Vietnam, only one paper concerning ecological data on meiofaunal assemblages from mangroves has been published so far, by Lai Phu Hoang *et al.* 2005). Taxonomic descriptions only of new nematode species in the Can Gio mangrove and adjacent regions of Southeast Vietnam were published by Doan Canh and Thanh (2000), Nguyen Thi Thu *et al.* (2004), Thanh and Gagarin (2004a, 2006), Gagarin *et al.* (2005). Several publications of these authors on the Ba Ria province (adjacent Can Gio mangrove) described the following : four species of the genus *Halalaimus* de Man, 1888 Gagarin and Thanh (2004b), three new species of the family Comesomatidae Filipjev, 1918 by Gagarin and Thanh (2006), four new species of the genus *Daptonema* Cobb, 1920 by Nguyen Thi Thu *et al.* (2004), three new species of the genus *Hopperia* Vitiello, 1969 by Gagarin and Thanh

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(2006a), three new species of the family Axonolaimidae Filipjev, 1918 by Gagarin and Thanh (2006b) and two new species of the genus *Halaphanolaimus* De Man, 1876 by Gagarin and Thanh (2006, in press) in Can Gio mangrove.

Can Gio mangrove was recognized as Viet Nam's first Mangrove Biosphere Reserve under the Man and the Biosphere Reserve Programme of the United Nations Education, Scientific, and Cultural Organization (UNESCO). Today, Can Gio is the largest area of rehabilitated mangrove forest in Vietnam. Recently, several research initiatives have started to inventory the biodiversity of fauna and flora in the Can Gio. While other scientists investigate the large-scale variation in meiofaunal composition and diversity at the low water line in the Can Gio mangrove biosphere reserve, this study focuses on the small scale variability in the intertidal zone. We selected one mud flat centrally in the core zone of the mangrove area and investigated to what extent meiofaunal communities and nematode genus composition and biodiversity in particular changed from the low water line to the mangrove forest edge.

2. Material and Methods

Samples collection and processes

Samples were collected between 11th and 17th of April 2005 during the dry season in the intertidal zone of the mudflat along a transect from the mangrove forest to the low water level line. Along the transect, four stations (stations CG1, CG2, CG3 and CG4) were sampled from the mangrove fringe to the low water line. Distance between stations was 100 meters. The coordinate of sampling transect located at 10°2'14"N–10°'09"N, 106°46'12"E–107°00'59"E in Khe Nhan mudflat (Fig. 1).

The meiofaunal samples were collected using cores of 3.5 cm diameter (10 cm^2 surface area) and 30 cm height. The cores were pushed down into the sediment for 10 cm. Per station, 3 replicates were taken and collected in plastic bottles. The samples were fixed in 60° C hot of 4 % formalin solution and gently stirred.

Samples were sieved through a 38 μm mesh and extracted by flotation with Ludox-TM50 (specific gravity of 1.18). Each time, 200 nematodes were used for making slides and identification. Meiofauna was identified to higher taxa level (phylum, class or order) under a stereomicroscope, based on Higgins, R. P. and H. Thiel (1988). Nematodes were identified to genus level using high magnification microscopes, Axioskop-2 plus and Olympus CH30RF200, and, with the help of the taxonomy literatures for identification, nematode of Wieser,1956, 1959; Platt and Warwick, 1983; Platt and Warwick, 1988; Warwick, Platt and Somerfield, 1998 and Lorenzen, 1994.

Data analyses

Data were analyzed using univariate and multivariate techniques. The abundance, composition, Margalef diversity, Shannon-Wiener diversity (log_2), Hill indices and Pielou's (J) evenness were used as univariate measures of the community structure. The significant differences in univariate measures between sites was tested using one-way ANOVA. In order to test the assumption of homogeneity of variances, Levene's tests were applied and data were log transformed. Tukey's multiple comparison tests were used when significant differences were detected ($p < 0.05$). Ranked lower triangular similarity matrices were constructed using the Bray-Curtis similarity measure on square root transformed data. Ordination was done by non-metric multidimensional scaling (MDS).

3. Results

Meiofauna

Meiofaunal composition and densities

Meiofaunal density was lowest in station 2 (1156 inds/ 10 cm^2 on the average) and highest in station 4, situated at the low water line (2082 inds/10 cm^2 on the average). The results indicate that the density of the meiofauna increases gradually from the mangrove forest to the low water line of the mudflat (from station 1 to station 4).

The significant difference of meiofaunal densities between stations was showed by one way ANOVA analysis ($p < 0.05$). Tukey HSD showed that meiofaunal densities are different between station 4 and station 2 ($p=0.023$). One way ANOVA analysis was also used for testing the significance of difference in densities of dominant taxa separately like Nematoda, Polychaeta, Copepoda and Sarcomastigophora but only Copepoda densities were significant different ($p=0.03<0.05$) (A Tukey HSD test (Post hoc Comparison) showed that Copepoda densities in station 4 differed significantly from those at station 1 and station 2).

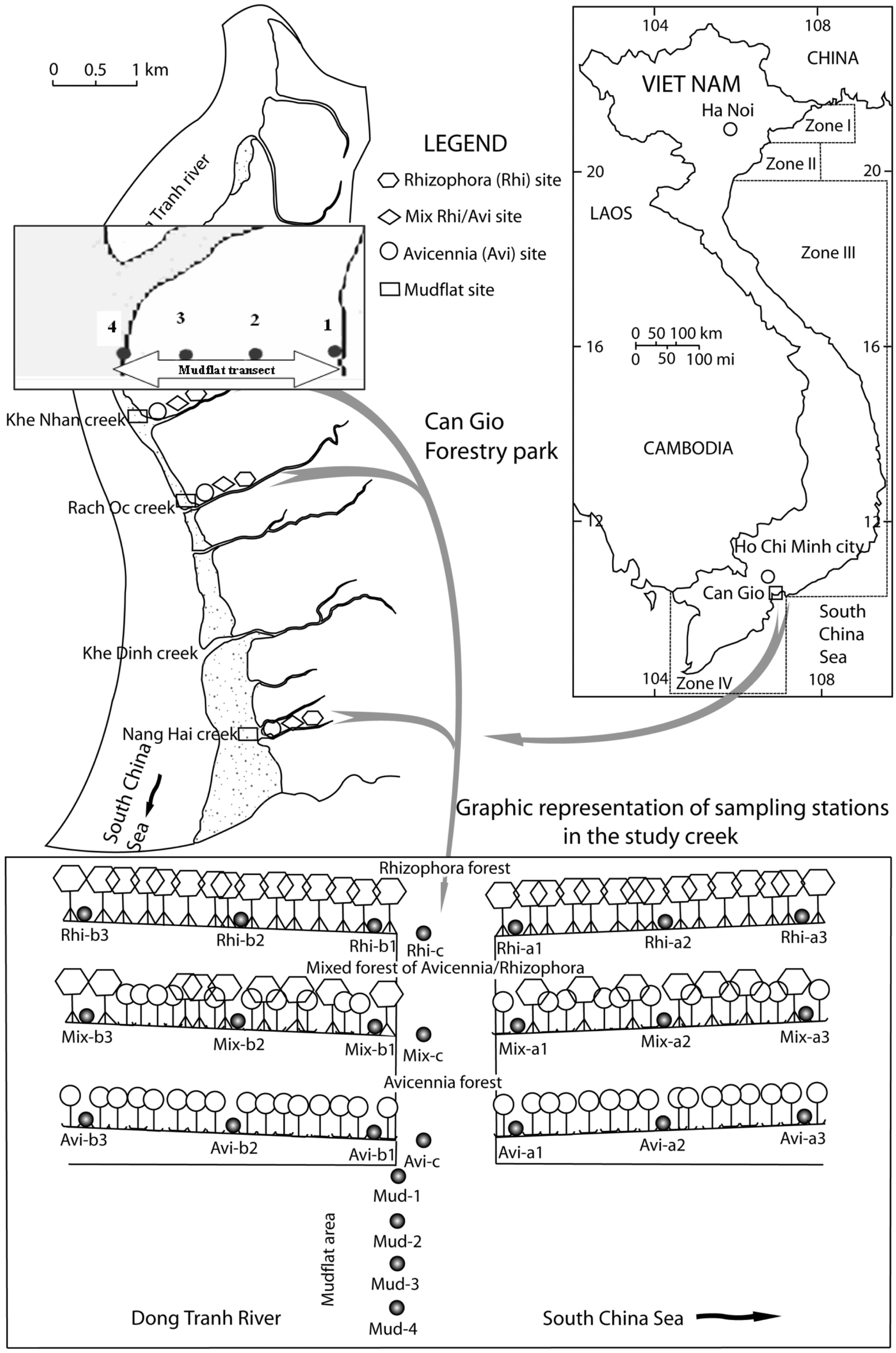

Fig. 1. Map of sampling site.

Meiofaunal diversity

The Shannon – Wiener index, Margalef index and the Pielou's evenness index of the meiofauna at higher taxa level are shown in Fig. 2. In total, 11 taxa are found, varying from mangrove forest edge to lower water line. The Margalef index decreased from station 1 (1.45) to station 3 (1.31) but increased again in station 4 (1.62). Meanwhile, the Shannon – Wiener index and the Pielou's

Table 1. Meiofaunal composition with densities (inds/10 cm^2)

No.	Taxa	CG1	CG2	CG3	CG4
1	Nematoda	1090±334.6	968.3±151.7	1354.7±400	1758.7±436.7
2	Polychaeta	31.7±3.8	28.7±16.9	22.7±10.3	64.7±16.9
3	Copepoda	52.3±15	54±20.8	61.7±20.5	154.7±47.5
4	Ostracoda	14.3±4.	9±8.9	15.3±5.6	7.3±4
5	Oligochaeta	13.7±9.6	17±7	36.3±12.5	9.3±5.7
6	Sarcomastigophora	43.7±23.2	36±31	44.3±20.1	27±14
8	Bivalvia larvae	17±8.5	17±2.6	8.3±6.3	5.7±2.3
9	Gastropoda	2.3±0.6	3±1	2.3±1	-
10	Tunicata	29±15.7	20.7±11.7	24±10.6	16.3±3.2
11	Nauplius	8.5±7.8	-	-	29.3±23.3
	Total meiofauna	1301.7±309	1155.7±200.6	1576±460.7	2081.7±396.3

- means presenting one time

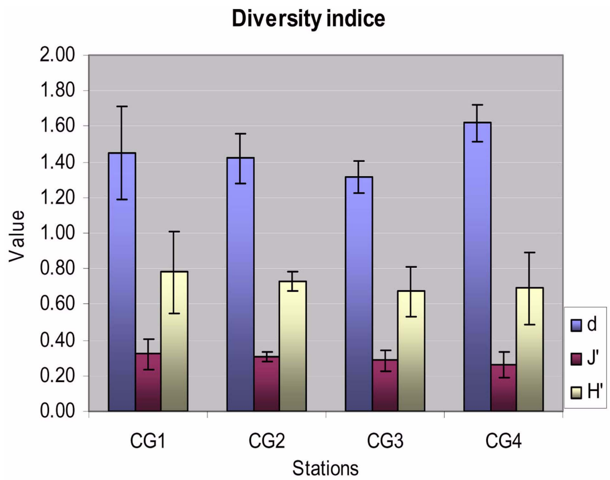

Fig. 2. Biodiversity indices.

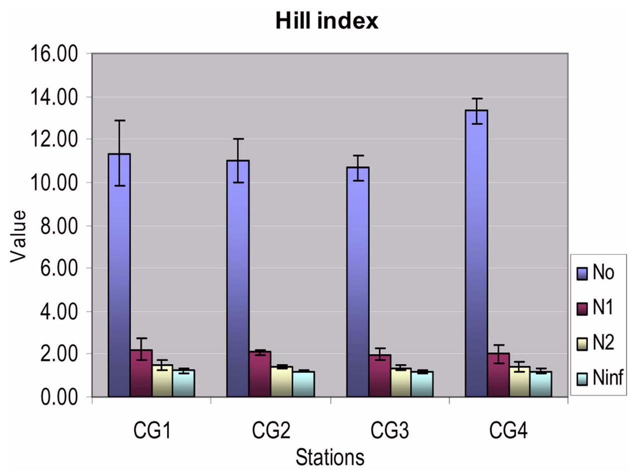

Fig. 3. Hill index.

evenness index decreased gradually, following the transect from the mangrove forest edge to the low water line (Fig. 2). Hill index also showed a decrease from station 1 to station 3 and an increase in station 4 whereas N1, N2 and Ninfinity did not vary along the transect (Fig. 3).

An ANOVA analysis one factor test combined with a Post Hoc comparison showed only a significant difference in taxa richness (S = No) between station 3 and 4.

MDS and SIMPER analysis of meiofaunal communities

The MDS pattern illustrates the gradual change from station 4 at the low water line to the higher part of the mudflat. This is mainly explained by the Nematoda densities, which are the dominant taxa. Their densities decrease towards the mangrove forest edge (station 1). The pattern is similar for Copepoda and Polychaeta except that they are much lower in abundance especially from station 1 to station 3 while they concentrate in the wettest part of the mudflat near station 4. On the contrary, almost of Sarcomastigophora tend to concentrate in the middle of mudflat (station 2 and 3).

To identify the taxa that are responsible for similarity and dissimilarity between stations, SIMPER analysis was used. The results show that average similarity within each

Table 2. P value of ANOVA analysis for biodiversity indices

Diversity indices	S=No	d	J'	H'(loge)	N1	N2	Ninf
P value	0.04	0.23	0.73	0.86	0.84	0.9	0.91

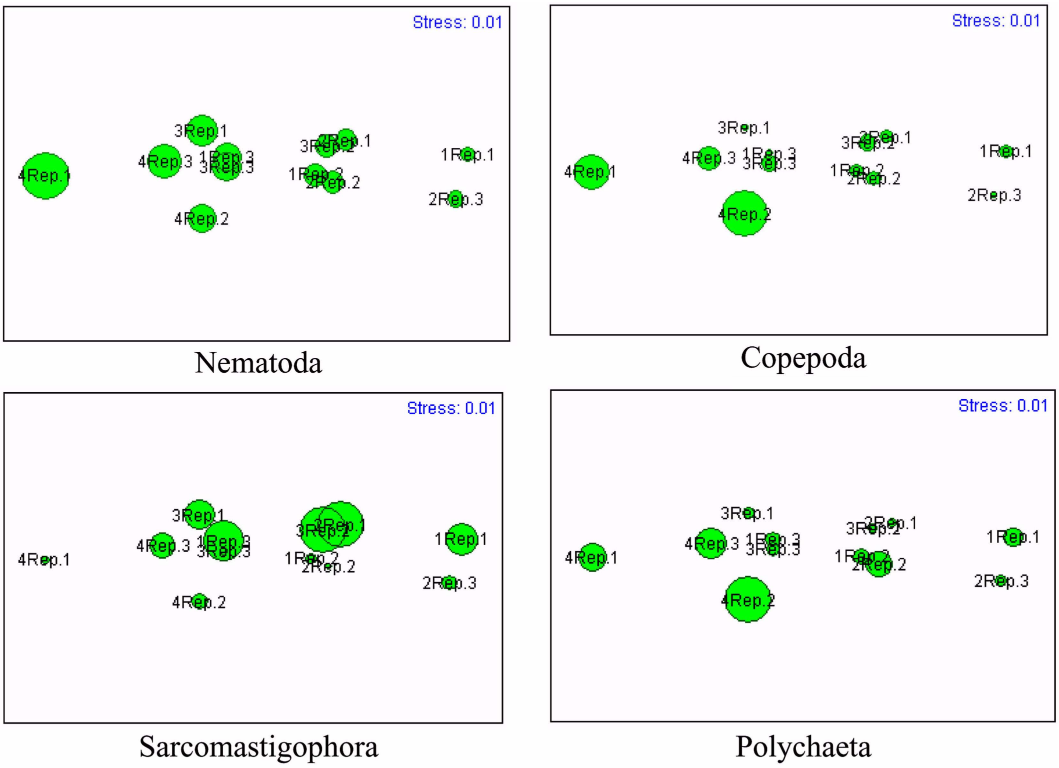

Fig. 4. MDS on meiofauna taxa composition with densities of the dominant taxa indicated as bubble plots.

station is very high (78.2 % to 86.3 %). Analyzed results showed that Nematoda and Copepoda are the most representative within each station. In addition, dissimilarity also show that Nematoda and Copepoda are the taxa responsible for the dissimilarity of stations. The dissimilarity in each pair of station is also low (from 15.5 % to 31.4 %).

Nematode

Nematode composition and diversity

In total, 80 genera belonging to 24 families (Fig. 5) and 7 orders (Enoplida, Chromadorida, Desmodorida, Desmocolecida, Plectida, Monhysterida, Araeolaimida) were found, in which Comesomatidae had the highest abundance 33.8 %. The subdominant families were Xyalidae (18.6 %), Oxystomatidae (10.4 %), Desmodoridae (7.7 %) and Sphaerolaimidae (5.6 %). The percentage of the remaining families ranged from 0.03 % to 4.9 %.

Nematode diversity

Nematode densities increase gradually along the transect from the forest edge to the low water line, but the diversity indices decrease slightly in this direction. Fig. 6-7 shows that most indices illustrate a decreasing nematode diversity from the mangrove forest edge to the low water line. However, this trend was only shown by averaged values while standard deviations are quite high in station 1 and 2. A one-way ANOVA analysis was applied and showed no meaningful differences between stations.

Nematode age structure and trophic structure

The percentage of juvenile nematodes is similar or much higher (49.9-66.8 %) than that of adult nematodes. In each station located at the higher mudflat (station 1, 2 and 3), the percentage of males (12.8-24.4 %) and females (20.1-25.6 %) was approximately equal but at the lower station (station 4), females tend to increase in relative abundance percentage. Also juveniles increase here in abundance.

On the mudflat, feeding type 1B (non-selective deposit feeders) and 2A (epistrate feeders) were dominant (1B: 14.9 %-53.6 % and 2A: 28.7 %-56.5 % in average) while 1A and 2B were generally lower in abundance, ranging from 7.3 % to 20.7 % per station. Feeding types 1A, 2A and 2B tend to decrease in station 4, with 1B representing more than 53 % of the total population. Especially, feeding type 2A decreased to lower water line (from

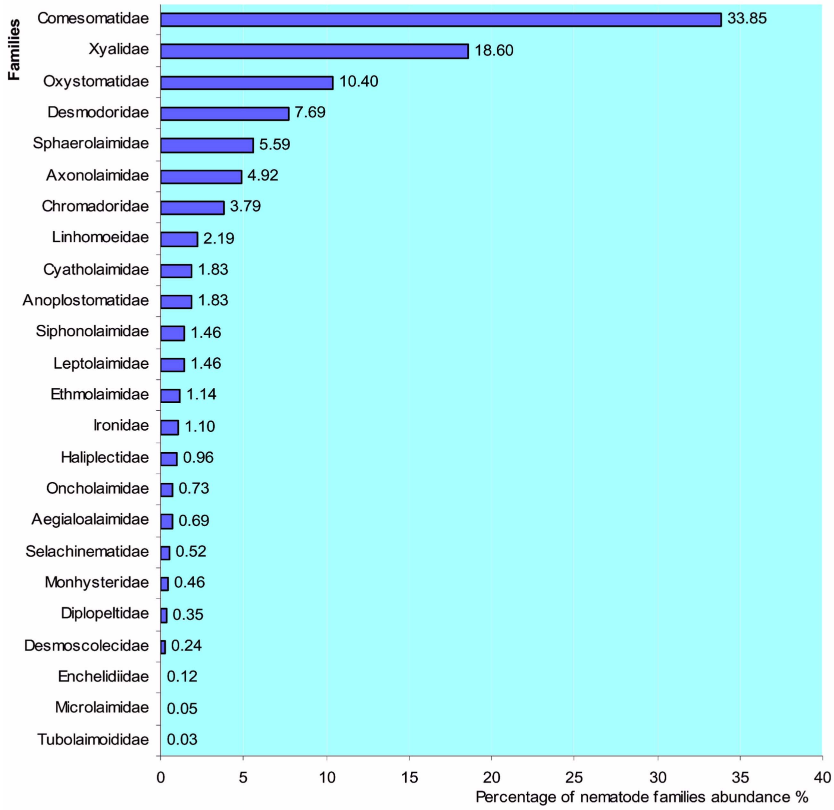

Fig. 5. Nematode family composition.

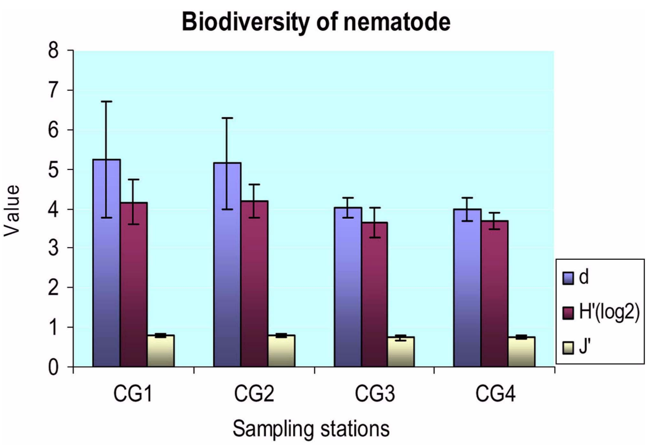

Fig. 6. Diversity indices.

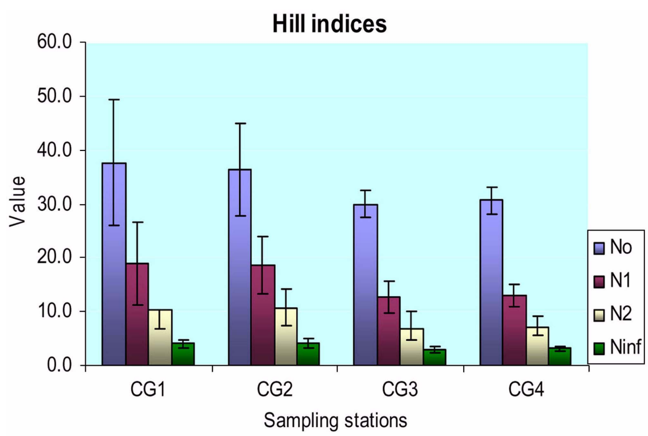

Fig. 7. Hill indices.

52.2 % to 28.7 %).

Multi dimension scaling (MDS) and SIMPER analysis of nematode distribution

A multi dimension scaling (MDS) was used for investigating the distribution of nematode communities along the mudflat. Fig. 10 shows that the 3 replicates of station 4 group in a close cluster separating from all other stations. The three remaining stations are also organized in one tight group. The nematode communities at the low water line (station 4) are very different from those at the higher part of the mudflat. The spatial distribution of the nematode communities on the higher mudflat was quite regular, showing a gradual shift between the 3 stations.

When the densities of the five dominant genera are plotted in the MDS graph it is shown that *Theristus* and *Neochromadora* decrease in densities from the lower water

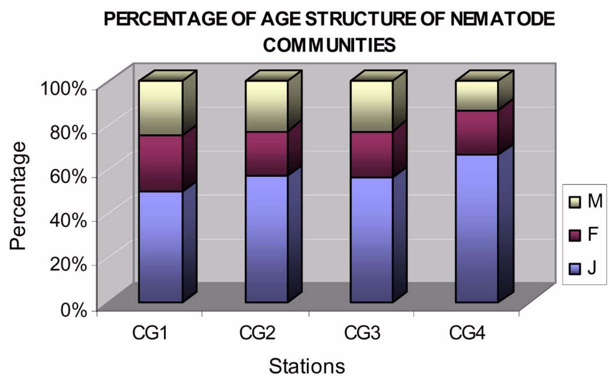

Fig. 8. Age structure.

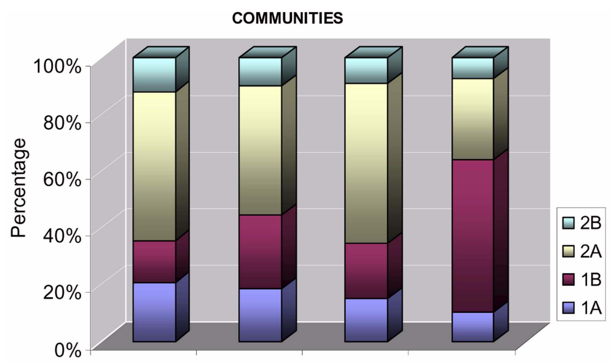

Fig. 9. Trophic structure.

line towards the mangrove forest edge, while *Paracomesoma* and *Hopperia* are typical and more abundant at the middle of the mudflat. *Halalaimus* tends to distribute with high densities at the low mudflat. The pattern in *Paracomesoma* and *Halalaimus* is very similar.

SIMPER analysis is also used for identifying the taxa that are responsible for similarities and dissimilarities in each station. The average similarities within each station range from 63.2 % to 70.9 %. They are mainly explained by the dominance of genera like *Paracomesoma* and *Hopperia* from station 1 to station 3. The average abundance of *Paracomesoma* in station 3 was highest, leading to a high average similarity. Station 4 had a lower similarity (63.2 %), being influenced by *Theristus* (581.4 %) and *Paracomesoma* with a high value for average abundance (169.5 %).

The dissimilarity between nematode fauna between pair of stations is shown in Table 4, with values that range from 36.3 % between station 1 and 2 to 63.6 % between station 1 and 4. The larger distance between stations on the mudflat results in the highest dissimilarity. The average dissimilarity matrix also clearly shows the difference between station 4 and the rest while the differences between station 1, station 2 and station 3 are much lower.

The average dissimilarity was influenced by some dominant genera in each station. For station 1, station 2 and station 3, *Paracomesoma* and *Halalaimus* seem to be the main genera that cause dissimilarity. Meanwhile, 2 stations near the mangrove forest edge were different due to the higher abundance of the genus *Parodontophora* in station 2 and *Desmololex* in station 1. *Theristus* appeared as the most abundant genus that caused the dissimilarity of station 4, with the other stations. *Paracomesoma* and *Neochromadora* also supporting the dissimilarity of station 4 from the rest.

4. Discussion

Ecology of meiofaunal assemblages in Khe Nhan mudflat

The meiofaunal densities, composition and diversity

The meiofauna in Khe Nhan mudflat were studied in the intertidal region of the Can Gio mangrove forest, Ho Chi Minh city. This place had not yet been surveyed for ecological aspects of meiobenthic communities, so it provides a base line for further research.

The results showed meiofaunal densities in the intertidal areas of the Khe Nhan mudflat ranging from 1156 inds/10 cm^2

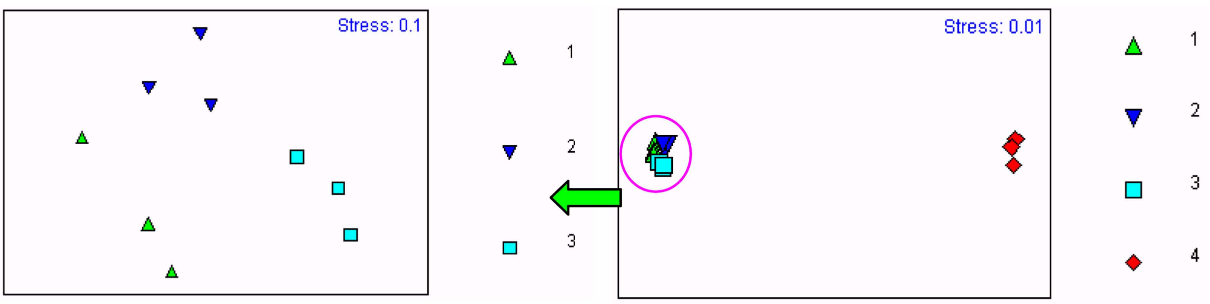

Fig. 10. MDS of nematode communities.

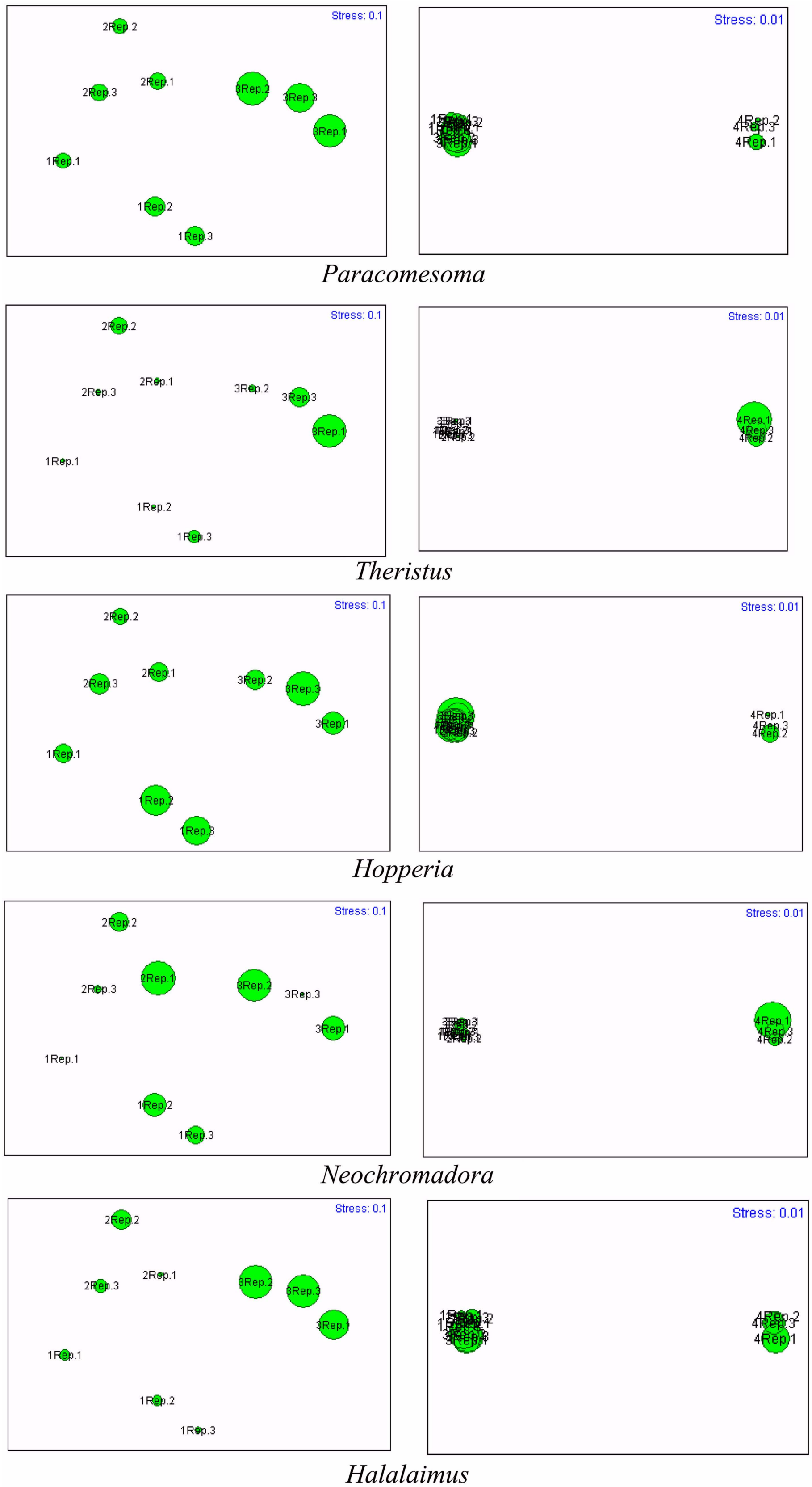

Fig. 11. MDS of nematode communities.

Table 3. Similarity and abundance of nematodes

Stations	Average similarity (%)	Average abundance
1	67.3	*Paracomesoma*(267.1), *Hopperia*(141.9)
2	70.1	*Paracomesoma*(238.1), *Hopperia*(102.8)
3	70.9	*Paracomesoma* (456.4), *Hopperia*(139.8)
4	63.2	*Theristus* (581.4), *Paracomesoma*(169.5)

Table 4. Dissimilarity between each station to the others

Group	Average disimilarity (%)	Abundance genus
1&2	36.3	*Parodontophora*(2), *Desmoscolex*(1)
1&3	41.3	*Paracomesoma* (3), *Halalaimus* (3)
2&3	40.1	*Paracomesoma* (3), *Halalaimus* (3)
1&4	63.6	*Paracomesoma* (1), *Theristus* (4)
2&4	55.9	*Theristus* (4), *Neochromadora* (4)
3&4	59.5	*Theristus* (4), *Paracomesoma* (3)

to 2032 inds/10 cm^2. Meiofaunal densities in intertidal mudflats are high all over the world (Heip *et al.* 1985). Because of the lack of data on meiofaunal densities in other locations of Can Gio mangrove forest, it can only be compared with other comparable locations in the world, such as in Australia where densities ranging from 217-2454 inds/10 cm^2 (Alongi 1987) to 14±8 inds/10 cm^2 and 1840± 2517 ind/10 cm^2 (Alongi 1990); mean densities in India reach 2130 inds/10 cm^2 (Kondalarao 1984), ranging from 205 to 5263 inds/10 cm^2 and on-average densities of 1493 ind/10 cm^2 are found in South Africa (Ólafsson 1995) (Table 5). According to Dye (1983) the highest densities of meiofauna reach ± 1000 inds/100 cm^3 in mangrove sediments in Transkei, Southern Africa.

The results of meiofaunal densities in Khe Nhan mudflat seem not to differ too much from the results of Netto and Gallucci (2003) in a mangrove area from the Island of Santa Catarina, South Brazil, with the densities ranging from 77-1589 inds/10 cm^2. Alongi (1989) recorded very high meiofaunal densities (mean = 2130/10 cm^2) in surface sediments of Kondalarao with a dominance of nematodes. He also mentioned that previous investigation of tropical mangroves had revealed in general low densities (<500/ 10 cm^2) compared to abundance found in subtropical and temperate mangroves. Furthermore, he noted that the total densities range from 200-6000 inds/10 cm^2 was recorded in subtidal adjacent area to mangrove in India.

Along the mudflat transect, a significant decrease in meiofaunal densities is observed from the low water line towards the mangrove forest edge. This is similar to the data of Dye (1983), who found the greatest concentration of meiofauna in the mid-intertidal zone, whereas meiofaunal densities generally decreased with topographic height in temperature in a tropical mangrove in South Africa (Alongi 1989). In the mudflat transect, densities of Polychaeta and Copepoda intend to increase towards the low water line but densities of Nematoda and Sarcomastigophora were not significantly different. Comparing with the study of Ólafsson (1995), densities of nematodes, harpacticoids, polychaetes and turbellarians were significantly higher at low water stations compared with mid and high water stations.

The composition of the meiofaunal community in Khe Nhan mudflat, Can Gio mangrove forest consists of some main taxa as Nematoda, Copepoda, Sarcomastigophora, Polychaeta, Ostracoda, Oligochaeta, Bivalvia larvae, Gastropoda, Tunicata and Nauplius. The abundance of the Nematoda was much higher than the other taxa in the group of meiofauna (84.6 %). This percentage is however lower than the value found by Kondalarao (1984) in India (86 %) and Ólafsson (1995) in Eastern Africa (64-99 %) but quite high compared with the data published by Sultan Ali *et al.* (1983) (50-67 %), Dye (1983) (80 %) and Lalara-Rueda *et al.* (1986) (54 %). Vanhove *et al.* (1992) showed that nematodes accounted for up to 95 % of total densities; other common taxa were copepods, turbellarians, oligochaetes, polychaetes, ostracods and rotifers. Nematoda is numerically dominant at all sites, at densities generally within the range recorded from other littoral sediments without mangrove (Platt and Warwick 1980). Nematode is also the most species-rich taxon and the dominance at each site of only a few species is also typical (Heip and Decraemer 1974; Platt 1981).

An interesting difference between meiofauna of Australia, the Indian and the South African fauna is the numerical dominance of Turbellaria in tropical Australian mangroves (Alongi 1989); this was also very different from Can Gio mudflat where Turbellaria were only occasionally found (0.03 % in total) in the low water line station.

The data concerning the composition of the meiofauna at different places are difficult to compare because of the different methods used by the different authors, however, all results showed that Nematoda, Copepoda and Polychaeta

Table 5. Data from literature on meiofauna densities from mangrove areas all over the world

Author	Area	Habitat	Composition	Densities (Min-Max)
Present study	Can Gio mangrove, Vietnam	Mangrove mudflat	Nematodes 84.58%, Copepods, Sarcomastigophores and Polychaetes dominant	From 1156 inds/10 cm^2 to 2032 inds/10cm^2
Sultan Ali *et al*. (1983)	Bay of Bengal, India	Mangrove	Nematodes 50 -67%	35-280 inds/10 cm^2
Dye (1983)	Transkei, Southern Africa	Mangrove sediment	Nematodes 80%, Ciliates, Oligochaetes, Gastrotrichs, Polychaetes, Copepods, Kinorhynchs, Crustacea larva	Highest densities is 1000 ind/ 100 cm^3
Kondalarao (1984)	Godavari River, India	Mangrove	Nematodes 86%	2131 inds/10 cm^2
Lalara-Rueda *et al*. (1986)	South Cuba	Mangrove	Nematodes 54%	36-245 ind/10 cm^2
Alongi (1987)	Cape York peninsula, Australia	Mangrove estuarine	Turberllarian 70% (summer) and 46% (winter)	217-2454 inds/10 cm^2
Alongi (1990)	Hinchinbrook island, Australia	Tropical mangrove estuarine	Nematodes, Polychaetes, Harpacticoids, Nauplii, Tardigrades, Gastrotrichs, Isopods, Bivalves, Kinorhynchs, Amphipods, Oligocheates, Foraminiferans, Hydrozoa, Archiannelida, Cumacea	From 14±8 inds/10 cm^2 to 1840± 2517 ind/10 cm^2
Vanhove *et al* (1992)	Gazi Bay, Kenya	Five mangrove vegetation types	Nematodes 95%, Copepods, Turbellarians, Oligochaetes, Polychaetes, Ostracods and Rotifers	*Bruguiera* (6707 inds/10 cm^2), *Rhizophora* (3998 inds/10 cm^2), *Avicennia* (3442 inds/10 cm^2), *Sonneratia* (2889 inds/10 cm^2) *Ceriops* (1976 inds/10 cm^2)
Ólafsson (1995)	Eastern Africa	Mangrove	17 major taxa; nematodes dominated (64-99%), Harpacticoid copepods was second	205-5263 inds/10 cm^2, average 1493 inds/10 cm^2
Netto and Gallucci (2003)	Santa Catarina, South Brazil	Mangrove	Nematodes, Polychaetes, Copepods, Halocarides Kinorhynchs, Insect larvae, Ostracods, Turbellaria, Oligochaetes	77-1589 inds/10 cm^2

were presented as dominant taxa (Table 5).

Considering meiofauna diversity in mangrove mudflat, all publications included taxa richness instead of calculation of the biodiversity indices. However, in this study, meiofauna communities were studied in detail. Diversity of meiofauna in Khe Nhan mudflat was computed in d (Margalef index), H' (Shannon-Wiener diversity index) and Pielous's evenness. H' value ranged from 0.67 to 0.78. However, there was no significant difference between the stations for most of these biodiversity indices. Only taxa richness had significant variation between station 4 and station 3.

The nematode communities in Khe Nhan mudflat, Can Gio mangrove forest

Nematode community composition

The nematode community composition in the Khe Nhan mudflat is quite diverse with 80 genera in total. *Paracomesoma, Theristus, Hopperia, Neochromadora* and *Halalaimus* were found dominantly. However, the community per sampling station is different based on ecological adaptation. Composition and number of genera occurring in each station are not much different along the transect (the similarity Cluster Bray-Curtis amounted almost more than 60 %) but clearly showed a difference in genera composition in station 4 at the low water line.

Multivariate analysis by MDS showed that *Theristus* and *Neochromadora* were better adapted to conditions at the low water line than to those of higher located stations. Some genera, typical for mangrove mudflats, such as *Paracomesoma, Sphaerolaimus, Daptonema* and *Viscosia* were also present in the Can Gio mangrove forest. The number of individuals and genera belonging to the family Comesomatidae, Xyalidae, Oxystominidae and Desmodoridae reach a high percentage in the nematode community. Moreover, SIMPER analysis also reported that *Paracomesoma, Hopperia* and *Theristus* were the main cause for the similarity in 4 stations and that *Parodontophora, Desmoscolex, Halalaimus, Paracomesoma, Theristus* and *Neochromadora* were responsible for the dissimilarity in the mudflat transect.

The body of nematodes living in the specific environment of the mudflat is often adapted to the narrow interstitial spaces between the sediment grains by having a smooth cuticle and a long tail. The number of nematodes with slender long tail (such as species of the genera *Paracomesoma, Hopperia* and *Halalaimus*) is dominant. Their densities are higher than those of the nematodes with a short stout body.

In intertidal mangrove and temperature mudflats all over the world, such as in Australia, Vietnam, Brazil, France and Zanzibar (present as five continental nematode assemblages), following dominant genera are present: *Daptonema, Metachromadora, Metalinhomoeus, Paramonhystera, Ptycholaimellus, Viscosia, Anoplostoma, Halalaimus, Oxystomina, Parodontophora, Sabatieria, Sphaerolaimus* and *Terschellingia.*

According to Gwyther (2003), *Diplolaimella* and *Diplolaimelloides* are common genera in Malaysia, Hong Kong, India, America and Australia. The distribution of these genera is effected by the decay of leaf litter of *Avicennia.*

Nematode diversity

Worldwide, Decraemer and Coomans (1978) were the first to examine species diversity of nematodes at different sampling sites in a mangrove, and they utilized multivariate techniques to establish the degree of affinity in species composition among sites. They found the lowest species richness in the high intertidal mangrove. A low degree of

Table 6. Data on nematode diversity in mangrove areas from different places in the world

Author	Area	Habitat	Common (dominant) nematode genera/species	Diversity
Present study	Can Gio, Vietnam	Mangrove mudflat	*Paracomesoma, Hopperia, Halalaimus, Theristus, Neochromadora, Daptonema, Metachromadora, Parodontophora*	H'=3.6-4.2 (80 genera)
Gwyther (2003)	Victoria, SE Australia	*Avicennia* (only)	*Tripyloides, Metachromadora, Daptonema*	H'=0.558±0.084 (21 genera)
Somerfield *et al*. (1998)	Merbok, Malaysia	*Rhizophora, Brugiera*	*Diplolaimella, Diplolaimelloides, Atrochromadora, Theristus*	77 genera
Gee and Somerfield (1997)	Merbok, Malaysia	*Rhizophora, Brugiera*	*Atrochromadora, Daptonema, Dichromadora, Diplolaimelloides, Haliplectus, Halalaimus, Perspiria, Terschellingia, Theristus*	H' = 2.0 - 3.2
Decraemer and Coomans (1978)	Great Barrier Reef, Australia	Mangrove swamp	*Microlaimus, Onyx, Dichromadora, Atrochromadora, Xyzzors, Paradesmodora, Axonolaimus, Prochromadorella, Enoploides, Monhystera (*), Prodorylaimus*	68 species
Krishnamurthy *et al*. (1984)	Bay of Bengal, SE India	*Rhizophora*, others not specified	*Viscosia, Adoncholaimus, Oncholaimus, Anoplostoma, Desmodora, Halichoanolaimus*	18 species
Zhou (2001)	Hong Kong	*Kandelia*	*Diplolaimella, Diplolaimelloides, Theristus, Haliplectus, Megasdesmolaimus, Anoplostoma, Desmodora,Dichromadora, Chromaspirina, Paracanthonchus*	NA
Hopper *et al*. (1973)	Florida, USA	*Rhizophora*, others not specified	*Rhabditis marina, Diplolaimelloides, Diplolaimella ocellata, Oncholaimus sp. Haliplectus dorsalis*	NA
Rzeznik – Orignac *et al*. (2003)	Marennes-Oléron, France	Temperate intertidal mudflat	*Metachromadoroides remanei, Terschellingia longicaudata, Ptycholaimellus jacobi, Chromadora macrolaima, Sabatieria pulchra, Daptonema oxycerca, Sabatieria punctata, Axonolaimus paraspinosus, Metalinhomoeus filiformis, Desmolaimus zeelandicus, Sphaerolaimus gracilis*	H'=2.7-3.5
Netto and Gallucci (2003)	Santa Catarina, South Brazil	Mangrove	*Haliplectus, Trissonchulus, Terschellingia, Halalaimus, Sphaerolaimus, Anoplostoma*	H'=2.5-3.5
Alongi (1987)	Cape York peninsula, Australia	Mangrove estuarine	*Spirina, Oxystomina, Terschellingia, Neochromadora, Sabatieria, Metalinhomoeus, Trissonchulus, Anoplostoma, Paracomesoma, Pseudochromadora*	H'= 2.02-2.91
Tietjen and Alongi (1990)	Queensland, NE Australia	*Rhizophora, Avicennia,*	*Monhystera, Chromadorina*	NA
Nicholas *et al*. (1991)	New South Wales, Australia	Mangrove mudflat	*Ptycholaimellus, Desmodora, Microlaimus, Sphaerolaimus, Terschellingia, Parodontophora, Onyx, Daptonema, Sabatieria*	NA
Hodda and Nicholas (1985)	Hunter river and Fullerton, Australia	Mangrove	*Ptycholaimellus, Parodontophora, Terschellingia, Sphaerolaimus, Halalaimus, Oncholaimus, Molgolaimus, Sabatieria, Anoplostoma, Theristus*	H'=1.28-2.76

**become Thalassomonhystera, NA=not available* affinity among sites was observed by Alongi (1989). The results of Netto and Gallucci (2003) showed that nematodes are very diverse within mangrove sediments.

The biodiversity of nematodes in the mangrove mudflat is hardly investigated, especially in South Vietnam. The diversity index of nematodes in the Khe Nhan mudflat was expressed as Shannon – Wiener index with values ranging from 3.6 to 4.2 on the average per station. However, the parametric test and non-parametric tests showed no significant differences between stations along the transect for the Shannon – Wiener, the Pielou as well as the Hill indices. The only significant difference in diversity based on the Margalef index indicated that the diversity of the nematode assemblages was getting poorer towards to the low water line. The densities of the nematode assemblages increase while the number of nematode genera decreases towards the low water line. According to Rzeznik – Orignac *et al*. (2003), the diversity of nematode communities on the high mudflat is higher than on the low mudflat.

Although the purposes of different studies were quite different and not completely similar methods were used, the results in Khe Nhan mudflat can be compared to some other studies in the world (Decraemer and Coomans 1978; Krishnamurthy *et al*. 1984; Hodda and Nicholas 1985; Alongi 1987; Somerfield *et al.* 1998; Rzeznik – Orignac *et al.* 2003; Netto and Gallucci 2003; Gwyther 2003). The species richness and diversity of the nematode assemblages in Khe Nhan mudflat, Can Gio mangrove forest, were higher than in a temperature intertidal mudflat in France as well as intertidal tropical mangrove mudflats in Brazil and Australia (Table 6). This supports the statement that Viet Nam is one of the 10 centres of highest biodiversity in the world (Ryan 2005).

5. Conclusion

The meiofauna at the Khe Nhan mudflat of Can Gio mangrove is characterized by high densities and rich meiofaunal communities (18 taxa) dominated by nematodes. In a total of 80 nematode genera belonging to 24 families, 7 orders were found over the 4 stations, illustrating the high diversity.

Diversity of meiofauna did not change along the transect from the low water line to the mangrove edge. The species richness and diversity of the nematode assemblages are high compared to some other researches. Densities of meiofauna and nematode communities increased from the mangrove edge towards the low water line. Nematode composition at the low water line is very different from 3 other stations on the higher mudflat.

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Appendix

Table 1. Composition, feeding types and number of nematodes per replicate in stations 1 and 2, expressed as number per subsample of 200 nematodes.

Taxa	Feeding type	Station 1									Station 2								
		Rep.1			*Rep.2*			*Rep.3*			*Rep.1*			*Rep.2*			*Rep.3*		
		J	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*
Adoncholaimus	2B	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Aegialoalaimus	1A	0	0	0	0	0	0	1	0	0	0	0	1	2	1	0	0	0	0
Amphimonhystrella	1B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Anoplostoma	1B	0	1	1	0	1	0	0	0	1	4	1	0	0	1	0	0	0	0
Anticyathus	1B	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Antomicron	1A	0	0	0	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0
Araeolaimus	1A	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Astomonema	1A	0	0	0	0	0	0	1	1	0	6	0	1	1	1	0	1	2	0
Camacolaimus	2A	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cervonema	1A	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cobbia	2A	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Comesomatidae	1B	0	0	0	3	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Comesomoides	1B	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Cyartonema	1A	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0
Cyatholaimidae	2A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Daptonema	1B	5	0	2	4	0	0	3	1	0	7	3	0	7	1	3	12	2	2
Desmoscolex	1A	2	5	7	4	5	8	5	3	3	3	0	0	1	0	5	8	2	5
Desmolaimus	1B	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Desmodora	2A	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Doliolaimus	2B	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorylaimopsis	2A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Enchelidiidae	2B	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Elzalia	1B	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Eurystomina	2B	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halalaimus	1A	3	5	2	2	2	2	2	0	1	0	3	0	3	4	5	10	2	1
Halichoanolaimus	2B	1	1	0	1	1	1	2	0	0	2	0	0	0	0	0	0	0	0
Haliplectus	1A	1	1	0	3	0	0	1	0	0	0	0	0	2	0	0	4	2	3
Hopperia	2A	17	6	5	16	7	6	10	6	5	11	4	2	8	5	4	17	5	11
Laimella	2A	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Leptolaimidae	1A	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0
Leptolaimoides	1A	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Leptolaimus	1A	1	3	2	1	0	1	1	0	2	2	0	1	0	0	2	1	0	1
Linhystera	1A	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0
Litinium	1A	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0
Longicyatholaimus	2A	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marylynia	2A	0	3	1	2	2	1	2	0	0	3	1	1	5	0	2	2	0	0
Megadesmolaimus	1B	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Metachromadora	2B	10	8	4	6	2	1	5	0	0	4	1	1	2	2	0	2	0	1
Metalinhomoeus	1B	0	0	1	0	0	0	3	0	1	2	3	0	1	0	2	0	1	0
Metasphaerolaimus	2B	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	1	0	0
Minolaimus	1A	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Mongolaimus	1A	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Table 1. (continued)

Taxa	Feeding type	Station 1									Station 2								
		Rep.1			*Rep.2*			*Rep.3*			*Rep.1*			*Rep.2*			*Rep.3*		
		J	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*
Monhystera	1B	0	0	0	0	0	0	2	1	2	0	0	0	0	0	0	1	1	0
Neochromadora	2A	0	0	1	0	2	6	0	3	2	2	7	2	0	5	2	0	1	4
Nemanema	1A	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Oncholaimidae	2B	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Oxystominiidae	1A	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Oxystomina	1A	3	0	1	0	0	0	1	1	0	0	0	1	0	0	1	1	1	0
Paracomesoma	2A	35	10	16	25	16	9	24	7	8	35	3	3	29	5	7	44	12	15
Paralinhomoeus	1B	1	0	0	1	0	2	0	0	0	1	2	0	1	0	0	0	0	0
Paramesonchium	2A	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paramonohystera	1B	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Parasphaerolaimus	2B	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	2
Parodontophora	1B	0	0	0	0	0	0	0	1	1	2	2	8	8	2	2	8	0	4
Pierrickia	1A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pomponema	2B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Prooncholaimus	2B	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Pseudochromadora	1B	0	3	0	4	2	3	2	0	3	2	0	2	4	3	2	1	0	1
Pseudolella	2A	1	0	2	2	2	0	0	0	1	0	0	1	1	1	0	1	0	3
Ptycholaimellus	2A	4	0	0	1	1	2	1	3	2	2	0	0	0	0	0	2	1	0
Quadricoma	1A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sabatieria	1B	0	0	1	1	0	0	0	2	4	2	0	2	7	0	1	2	1	0
Siphonolaimus	2B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Southerniella	1A	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Sphaerolaimus	2B	3	0	2	6	0	0	3	0	0	1	1	1	2	0	0	4	1	2
Spilophorella	2A	1	5	0	2	2	2	3	3	2	0	1	1	0	1	1	0	0	0
Synonchiella	2B	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Terschellingia	1A	0	0	0	3	0	0	1	2	1	2	2	1	1	0	0	0	2	0
Thalassoalaimus	1A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Thalassomonhystera	1B	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Theristus	1B	3	0	1	1	1	0	3	2	0	3	0	0	7	2	0	1	3	1
Tricoma	1A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Trissonchulus	2B	1	0	0	1	1	0	2	0	0	2	0	0	5	3	0	2	0	1
Tubolaimoides	1A	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Unidentified specimen	-	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Vasostoma	2A	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
Viscosia	2B	0	0	0	4	0	1	1	0	1	1	0	0	1	0	0	1	0	0
Wieseria	1A	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Total		95	54	52	101	49	45	97	47	46	105	35	30	111	42	48	128	43	59

(J = Juvenile; F = Female; M = Male; 1A = selective deposit-feeders; 1B = non-selective deposit-feeders; 2A = epistratum (epigrowth) feeders; 2B = predators or omnivores)

Table 2. Composition, feeding types and number of nematodes per replicate in stations 3 and 4 expressed as numbers per subsample of 200 nematodes.

Taxa	Feeding type	Station 3									Station 4								
		Rep.1			*Rep.2*			*Rep.3*			*Rep.1*			*Rep.2*			*Rep.3*		
		J	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*
Aegialoalaimus	1A	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Amphimonhystrella	1B	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Anoplostoma	1B	12	3	3	1	0	0	0	1	0	3	2	0	0	0	0	1	1	0
Antomicron	1A	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Astomonema	1A	0	2	0	0	0	0	9	2	3	1	0	0	1	0	0	0	0	1
Campylaimus	1B	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Comesomatidae	1B	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Cyartonema	1A	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Daptonema	1B	3	0	0	5	2	1	7	1	2	7	2	1	17	1	0	10	1	0
Desmoscolex	1A	0	1	0	0	2	1	1	0	0	0	0	0	3	0	0	3	1	1
Diplolaimella	1B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Doliolaimus	2B	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorylaimopsis	2A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gomphionema	2B	0	0	0	0	0	0	0	0	0	4	0	0	9	2	0	5	0	0
Halalaimus	1A	3	4	5	10	3	7	3	4	8	2	2	5	4	1	0	4	3	3
Halichoanolaimus	2B	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Haliplectus	1A	0	0	3	0	0	0	4	0	0	0	0	0	1	0	0	0	1	1
Hopperia	2A	10	4	2	8	5	7	19	4	3	2	0	0	8	2	5	0	2	0
Laimella	2A	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Leptolaimoides	1A	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Leptolaimus	1A	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Linhomoeidae	1B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Linhystera	1A	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Litinium	1A	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Longicyatholaimus	2A	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marylynia	2A	4	1	0	2	2	0	0	1	0	0	1	0	1	0	0	1	2	0
Megadesmolaimus	1B	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metachromadora	2B	3	0	0	2	0	1	5	5	5	0	1	0	1	0	0	7	0	0
Metalinhomoeus	1B	3	1	0	1	2	1	5	1	1	1	2	1	0	0	0	0	0	0
Metasphaerolaimus	2B	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Microlaimus	2A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Monhystera	1B	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nanolaimus	1A	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Neochromadora	2A	2	4	0	2	5	5	1	0	0	4	10	6	3	6	4	0	14	1
Oncholaimidae	2B	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Oxystomina	1A	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Paracomesoma	2A	44	8	7	50	21	17	35	12	13	16	6	1	8	2	5	16	4	0
Paralinhomoeus	1B	2	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Parasphaerolaimus	2B	0	1	1	0	0	0	2	1	0	1	0	0	2	0	0	0	1	0
Pareudesmocolex	1A	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Parodontophora	1B	1	1	1	2	0	1	2	0	2	1	1	1	10	2	1	4	0	1
Pierrickia	1A	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procamacolaimus	2A	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Promonhystera	1B	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table 2. (continued)

Taxa	Feeding type	Station 3									Station 4								
		Rep.1			*Rep.2*			*Rep.3*			*Rep.1*			*Rep.2*			*Rep.3*		
		J	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*	*J*	*F*	*M*
Pseudochromadora	1B	0	1	2	4	0	1	1	1	1	1	2	0	0	0	0	2	0	0
Pseudolella	2A	2	2	2	0	0	2	2	0	0	4	0	4	5	3	1	3	2	2
Ptycholaimellus	2A	2	0	3	1	0	0	2	1	2	3	1	2	1	0	1	2	0	1
Quadricoma	1A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Retrotheristus	1B	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Sabatieria	1B	0	0	0	0	0	0	0	1	0	2	1	0	10	10	6	5	3	1
Sphaerolaimidae	2B	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	16	4	0
Sphaerolaimus	2B	5	0	0	2	1	0	3	0	0	2	0	1	1	3	0	1	0	2
Spilophorella	2A	3	3	4	1	3	2	0	0	2	0	1	0	0	0	0	0	0	1
Subsphaerolaimus	1B	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0
Terschellingia	1A	1	0	1	0	0	0	1	0	3	1	2	0	1	1	1	1	0	1
Thalassomonhystera	1B	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Theristus	1B	10	1	1	4	0	0	6	1	1	70	5	1	52	7	7	56	3	2
Tricoma	1A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Trissonchulus	2B	2	0	0	4	0	0	0	0	1	0	0	0	1	0	0	3	0	0
Unidentified specimen	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Vasostoma	2A	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Viscosia	2B	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		116	40	40	106	48	48	114	39	47	129	43	28	146	42	32	147	43	21

(J = Juvenile; F = Female; M = Male; 1A = selective deposit-feeders; 1B = non-selective deposit-feeders; 2A = epistratum (epigrowth) feeders; 2B = predators or omnivores)