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# Meiofauna and microalgae associates on the pneumatophores of *Avicennia marina* from the coastal waters of South Andaman, India

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**Abstract**
Meiofauna and associated microalgae assemblage from the pneumatophore roots of *Avicennia marina* was investigated from two different locations of South Andaman during December 2012 to February 2013. Average meiofauna abundance was higher at St.2 ($p > 0.05$; *t*-test) compared to St.1. Dissolved oxygen was the single most key factor that showed wide variation (2.2 - 4.9 mg/L) during the study period and strongly correlated with meiofauna ($r = 0.99$), suggesting the requisite for thriving of meiofauna in the root system. The biotic surface of pneumatophores supported a variety of motile meiofauna which showed a weak/ negative correlation ($r = -1.0$) with the epiphytes exhibiting their feeding relationship. A total of 67 meiofaunal species belonging to 9 different taxonomic groups were recorded. Harpacticoida (17.4 - 43.4%) was the most dominant taxon, followed by Sarcomastigophora (14.4 - 29.4%) and Nematoda (5.1 - 6.2%). The pneumatophores in the present study clearly supported high assemblages of meiofauna along with the microalgae. The present study is the first report on pneumatophore associated meiofauna and epiphytic microalgae from the coastal waters of South Andaman.

**Keywords:** mangrove, pneumatophore, meiofauna, epiphytic microalgae, South Andaman

## 1. Introduction

The Andaman group of islands supports one-fifth of India's extensive mangroves covering an area of 966 km² (Roy *et al*., 2009). Mangroves are the ecotone between the terrestrial and the marine environment. Mangroves are among the most productive ecosystem in marine and estuarine environments; they nourish coastal waters, protect coastlines, and support coastal fisheries (Kathiresan & Bingham, 2001) [19]. Mangrove ecosystem is known for its potential on fisheries and aquaculture development as large quantities of energy from mangrove plants in the form of detritus are exported to open water bodies (Odum & Heald, 1975) [26]. In mangroves, a distinct 'phytal' meiofauna, inhabits hard substrata such as the prop- roots of pneumatophores (Bartsch, 2003) [4]. Considering the importance of mangroves habitats for meiofauna, our knowledge on their ecobiology of associated meiofauna and flora is very much limited (Nagelkerken *et al*., 2008) [25].

Meiofauna are ubiquitous metazoans generally defined as organisms passing through a 1.0 or 0.5 mm sieve but retained on a 63 µm mesh. Their abundance and species composition are controlled by numerous physical factors, including sediment grain size, temperature and salinity, dissolved oxygen and fluxes of organic matter (Giere, 1993) [13]. Meiofauna is generally considered as microbial feeders and/or grazers of microalgae that are likely involved in detritus decomposition (Gee, 1989) [11] and are a potential food source for macrofauna and fishes (Danovaro, 2007) [7].

Mangroves ecosystem supports the growth of ample algal communities providing a rich source of nutrients to the whole ecosystem. They stay in the mangrove forest subsystem as an epiphytic assemblage of algae living on the roots, stems and pneumatophores of mangrove trees and also on the surface of the sediment as epibenthic form and in the nearby aquatic ecosystem as phytoplankton, playing a key role in the total productivity and energy flow of the mangal system (De *et al*., 1987). The pneumatophores of *Avicennia marina* have been found to support a rich flora of microalgae and bacteria (Naidoo *et al*., 2008) [24]. These epiphytes account for a small fraction of total primary production in the mangal ecosystem (Alongi, 1994) [2]. Coull (1999) [6] suggested that the meiofaunal community associated with the mangroves play key roles such as enhancing the nutrient regeneration, supply food for a variety of organisms in higher trophic levels, and also sensible to anthropogenic inputs which makes them highly tolerant organisms to the pollution.

Investigation on meiofauna diversity associated with mangrove roots and vertical distribution has been carried out by Sahoo *et al*. (2013) [30], from Chorao Island, Goa, along the west coast of India but no species list of fauna and flora has reported in their study. Rao *et al*. (2015) report also restricted only up to macrofauna from the mangrove of South Andaman Island. Hence, this study was conducted to understand the distribution and diversity of meiofauna and epiphytic micro algae associated with pneumatophores of *A. marina* from South Andaman Island.

## 2. Material & Methods

### 2.1 Study Area

Present study was carried out from two distinct stations viz. Carbyn's cove and Burmanallah.

Carbyn's Cove (CC / St.1): The sampling site is located at 11°38.428`N, 92°44.652`E (Fig.1). This is a muddy environment and is relatively polluted due to tourism, human settlement and interference. The area is forested by mangroves like *Rhizophora mucronata*, *R. apiculata*, *Sonneratia alba*, *Ceriops tagal* and *Avicennia marina*.

Burmanallah (BN/St.2): The sampling site is located at 11°333.255`N, 092°43.892`E (Fig.1). This area is characterized by muddy substrata and sandy particles. The area is forested by mangroves like *Rhizophora mucronata, Bruguiera gymnorrhiza, Sonneratia alba* and *Avicennia marina*. The area is sparsely polluted despite human settlement and interference.

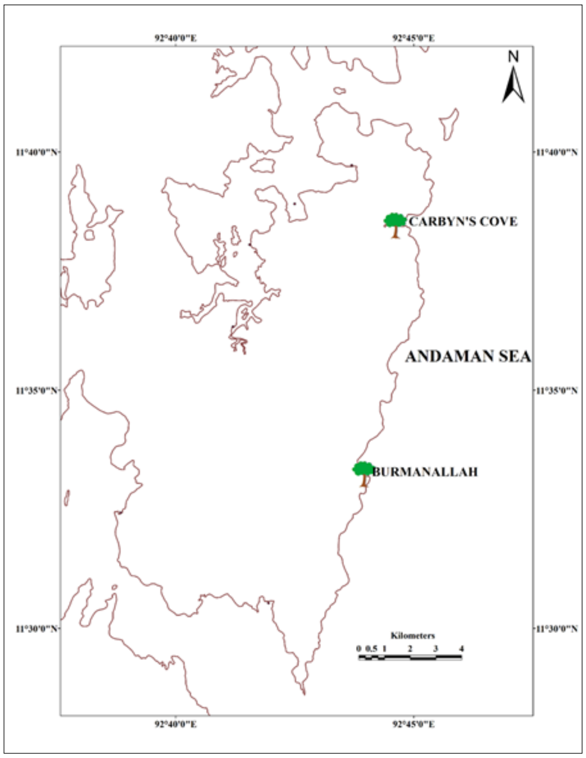



**Fig 1:** Map showing sampling stations. Inset: Study site is indicated by the trees.

### 2.2 Sampling

Mangrove root associated meiofauna and epiphytes of *Avicennia marina* was collected from the study area during low tide by collecting exposed algal and sediment covered pneumatophores from December 2012 to February 2013. Pneumatophores were sampled from the near low water mark where mangroves were dense and also the abundance of algal epiphytes on pneumatophore. Three quadrats of 50 x 50 cm at an interval of 2m were laid through the mangrove area (Gwyther, 2002) [14]. From each section, ten uniform roots of ~10 cm were collected and were kept in separate polythene bags. Meiofauna samples were stained with Rose Bengal (1 g/1 L of filtered sea water) and preserved in 4% formalin solution while epiphytic micro algae were stained with 1% Lugol's Iodine solution.

### 2.3 Laboratory analysis

In laboratory, pneumatophore root surface were gently scraped by using a paintbrush in filtered seawater and each root was then transferred to a measuring cylinder with a stopper which was decanted over 10 times and sieved through 1mm mesh size followed by 63 µm. The fauna that were retained on the 63µm sieve were collected and preserved in 4% formalin (Gwyther, 2002) [14]. Meiofauna were sorted out under the stereomicroscope (SMZ 1500) were counted and identified to the species level for some taxa such as Harpacticoida, Sarcomastigophora, Tanaidacea and Halacaroidea while for other taxa, the lowest possible taxonomic level following identification keys (Wells & Rao, 1987; Warwick *et al*., 1998; Higgins & Thiel, 1988; Loeblich & Tappan, 1988) [33, 16, 21]. Epiphytic microalgae was isolated by using brush in filtered sea water and sieved through 1 mm followed by 63 µm and 20 µm meshes. The algal cells retained on the 20 µm sieve were collected with care and preserved in 1% of Lugol's Iodine solution. 1 ml of the sample was taken on the Sedgwick Rafter Counting Chamber under the Nikon Trinocular Inverted Microscope and then cells were enumerated for lowest possible taxon level using identification keys (Desikachary, 1987; Lopez *et al*., 2010) [10, 22].

Univariate (richness, diversity and equitability) analysis were performed to determine the meiofaunal and microalgal community by using statistical software PRIMER (version 5). Bray-Curtis similarity matrix was performed on square root transform abundance data.

## 3. Results

### 3.1 Physico-chemical parameters

Temperature ranged from 26°C - 30°C, salinity (26 - 30 psu), dissolved oxygen ( 2.2 - 4.9 mg/L) and pH varied from 7.4 – 8.4 in the study area. Maximum temperature (30°C) was recorded during Feb'13, maximum salinity (30 psu) during Dec' 12 at St 2. Maximum dissolved oxygen (4.9 mg/L) was recorded during Jan'13 at St.2 and very low D.O (2.2 mg/L) was recorded at St. 1 during Dec'12. pH didn't show much variation during the study period. A strong positive correlation (r =0.99) was found between meiofauna and dissolved oxygen in the study area (Table 1).

**Table 1:** Spearmann rank correlation coefficients (r) between various environmental parameters and meiofauna in the study area

| St. 1 | Meiofauna | Temperature | pH | Salinity | D.O | Epiphytes |
|---|---|---|---|---|---|---|
| Meiofauna | 0 | 0.55 | 0.79 | 0.42 | 0.10 | 0.03 |
| Temperature | 0.65 | 0 | 0.67 | 0.12 | 0.65 | 0.51 |
| pH | -0.33 | 0.5 | 0 | 0.79 | 0.69 | 0.82 |
| Salinity | 0.79 | 0.98 | 0.33 | 0 | 0.53 | 0.39 |
| D.O | 0.99 | 0.53 | -0.47 | 0.68 | 0 | 0.14 |
| Epiphytes | -1.00 | -0.69 | 0.28 | -0.82 | -0.98 | 0 |

| St.2 | Meiofauna | Temp | pH | Salinity | D.O | Epiphytes |
|---|---|---|---|---|---|---|
| Meiofauna | 0 | 0.91 | 0.42 | 0.09 | 0.08 | 0.83 |
| Temp | -0.14 | 0 | 0.67 | 1.00 | 0.83 | 0.25 |
| pH | 0.79 | 0.50 | 0 | 0.33 | 0.50 | 0.41 |
| Salinity | -0.99 | 0 | -0.87 | 0 | 0.17 | 0.75 |
| D.O | 0.99 | -0.26 | 0.71 | -0.97 | 0 | 0.91 |
| Epiphytes | 0.26 | 0.92 | 0.80 | -0.39 | 0.14 | 0 |

### 3.2 Meiofauna composition

Average meiofauna abundance was higher at St.2 ($p > 0.05$; *t*-test) compared to St.1 (Fig.2). In the present study, a total of 10 different groups such as Harpacticoida Sarcomastigophora, Nematoda, Tanaidacea, Halacaroidea, Polychaeta, Gastrotricha, Tardigrada, Ostracoda and Insecta were identified. Overall abundance ranged from 27 to 141 ind./10cm$^2$ (71±0.05 ind./10cm$^2$). At St.1, Harpacticoida contributed the highest (43.4%) to the total meiofauna population followed by Sarcomastigophora (14.4%), Tanaidacea (8.9%), Insecta (7.6%) and Nematoda (6.2 %). At St.2 groups such as Sarcomastigophora (29.4%), Insecta (18.7%), and Harpacticoida (17.4%) made larger contribution to the total meiofauna (Fig 3). While few groups such as Invertebrate eggs, copepodids and copepod nauplii formed a minor component of the meiofauna (< 1%) during the study period.

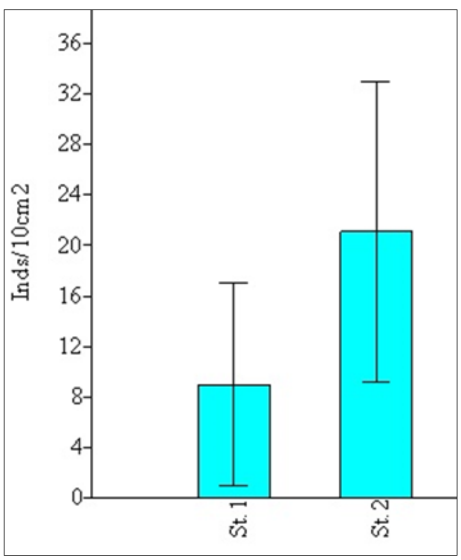



**Fig 2:** Average meiofauna abundance in the study area

### 3.3 Species Composition of meiofauna in pneumatophore

A total of 67 species of meiofauna belonged to 9 genera were identified in the study area (Table 2). Harpacticoida were the most dominant group in the study area. Maximum density of harpacticoida (33 ind/10 cm$^2$) was found during Jan'13 at St. 2 when low temperature (26°C) and high dissolved oxygen (4.9 mg/L) was recorded. Minimum density (6 ind./10 cm$^2$) was recorded during Feb'13 at St. 2 when both temperature (30°C) and dissolved oxygen (4.5 mg/L) were high.

A total of 21 species of harpacticoida viz. *Parastenhelia hornelli, Stenhelia (Delavalia) indica, S. oblonga, Typhlamphiascus ovale, Robertsonia robusta, R. propinqua, R. adduensis, Scottolana longipes, S. rostrata, Helmutkunzia variabilis, Ameira parvula, Halophytophilus simplex, Raowellsia maculatus Metamphiascopsis nicobaricus, Diathrodes dissimilis, D. brevipes, Afrolaophonte ensiger, Bradya sp., Noodtiella ornamentallis, Ectinosoma melaniceps* and *Apodopsyllus madrasensis* belonging to 16 genera were identified in this region. Harpacticoid species such as *H. variabilis, S.rostrata, A. parvula, M. nicobaricus* and *A. madrasensis* were recorded only at St. 1. While eight species such as *A. ensiger, D. dissimilis, D. brevipes, S. oblonga, Bradya* sp., *N. ornamentalis, E. melaniceps* and *R. adduensis* recorded only at St. 2. Among these, species such as *P. hornelli, M. nicobaricus, S. (Delavalia) indica, S. oblonga* and *R. robusta* were the most abundant, while species such as *A. madrasensis, R. adduensis, E. melaniceps, H. simplex* and *S. rostrata* were rare in the samples.

Sarcomastigophora was the second dominant group of organisms. Maximum density of sarcomastigophora (65 ind./10 cm$^2$) was observed during Feb'13 at St 2 when high temperature (30°C) and high dissolved oxygen (4.5 mg/L) was recorded. Minimum density (2 ind./10 cm$^2$) was observed during Dec'13 at St.1 when low D.O (2.2 mg/L) was recorded. A total of 23 species of Sarcomastigophora viz. *Allogromia* sp., *Saccamminidae* sp., *Elphidium* sp., *Spiroloculina* sp., *Endothyra* sp., *Spirolina cylindaracea*, *Gyroidina soldanii*, *Planorbulina* sp., *Quinqueloculina* sp., *Spirillana vivpara*, *Globorotalia tumida*, *Planispira* sp., *Opthalmidium* sp., *Bradyina* sp., *Allomorphina* sp., *Rotorbis* sp., *Globobulimina* sp., *Valvulineria* sp. *Tretomphalus* sp., *Anomalina* sp., *Flosculina* sp., *Globigerina* sp. and *Rosalina* sp. were identified from this region. Among these species such as *Allogromia* sp., *Elphidium* sp., *Spiroloculina* sp. and *Quinqueloculina* sp. were the most abundant while species such as *Globorotalia tumida*, *Planispira* sp., *Anomalina* sp. and *Rosalina* sp. were rare in the pneumatophore sample.

Nematoda ranked next in the order of abundance from this region. Maximum density of Nematoda (13 ind./10 cm$^2$) was observed during Jan'13 at St 2 when low temperature (26°C) and high dissolved oxygen (4.9 mg/L) was recorded. Minimum density (1 ind./10 cm$^2$) was observed during Dec'12 at St. 2 when high salinity (30 psu) and low D.O (3.4 mg/L) was recorded.

A total of 12 species of Nematoda viz. *Thoracostoma* sp., *Bolbolaimus* sp., *Cobbia* sp., *Microlaimus* sp., *Camacolaimus* sp. *Odontophora longisetosa*, *Adoncholaimus* sp., *Halailamus* sp., *Procmacolaimus* sp., *Dracograllus* sp., *Apodotrocha* sp. and *Acaromantis subasper* were identified in this region. Among these species, *Cobbia* sp. and *Camacolaimus* sp. were the most abundant while species like *Adoncholaimus* sp., *Dracograllus* sp. and *Acaromantis subasper* were rare in the sample.

Tanaidacea followed next in the order of abundance in this region. Maximum density (7 ind./10 $cm^2$) was observed during Dec'12 at St 1 when high pH (8.4) and low dissolved oxygen (2.2 mg/L) was recorded. Minimum density (1 ind./10 $cm^2$) was recorded during Dec'12 at St. 2 when high salinity (30 psu) and low D.O (3.4 mg/L) was recorded. Four species of tanaidacea viz. *Heterotanais oerstedi, Synapseudes idios, Leptognathia* sp. and *Mirandotanais vorax* were identified from this region. Among these species, *Heterotanais oerstedi* and *Synapseudes idios* occurred more while one species viz. *Mirandotanais vorax* was rare in the pneumatophore sample.

**Table 2:** Occurrence of meiofauna at St. 1 & St.2 during the study period.

| Sl. No | Species Occurrence | St. 1 | | | St. 2 | | |
|---|---|---|---|---|---|---|---|
| | | Dec'12 | Jan'13 | Feb'13 | Dec'12 | Jan'13 | Feb'13 |
| | Harpacticoida | | | | | | |
| 1 | *Parastenhelia hornelli* Thompson & A. Scott, 1903 | + | + | + | - | + | - |
| 2 | *Stenhelia (Delavalia) indica* Krishnaswamy, 1957 | + | + | - | + | + | - |
| 3 | *S. (D.) oblonga* Lang, 1965 | - | - | - | + | + | + |
| 4 | *Typhlamphiascus ovale* Wells & Rao, 1987 | + | + | - | + | + | + |
| 5 | *Robertsonia robusta* Wells & Rao, 1987 | + | + | + | + | + | + |
| 6 | *R. propinqua* T. Scott, 1894 | + | - | - | - | + | - |
| 7 | *R. adduensis* Sewell, 1940 | - | - | - | - | - | + |
| 8 | *Scottolana longipes* Wells &Rao, 1987 | + | - | - | - | + | - |
| 9 | *S. rostrata* Wells & Rao, 1987 | + | - | - | - | - | - |
| 10 | *Helmutkunzia variabilis* Wells &Rao, 1987 | + | + | + | - | - | - |
| 11 | *Ameira parvula* Claus, 1866 | + | + | + | - | - | - |
| 12 | *Halophytophilus simplex* Wells & Rao, 1987 | + | - | - | + | + | + |
| 13 | *Raowellsia maculatus* Wells &Rao,1987 | - | + | + | + | + | + |
| 14 | *Metamphiascopsis nicobaricus* Sewell, 1940 | - | + | + | - | - | - |
| 15 | *Diathrodes dissimilis* Lang, 1965 | - | - | - | + | + | - |
| 16 | *D. brevipes* Wells & Rao, 1987 | - | - | - | + | + | - |
| 17 | *Bradya* sp. Boeck, 1873 | - | - | - | + | + | - |
| 18 | *Afrolaophonte ensiger* Wells & Rao, 1987 | - | - | - | + | - | - |
| 19 | *Noodtiella ornamentallis* Wells & Rao, 1987 | - | - | - | - | + | - |
| 20 | *Ectinosoma melaniceps* Boeck, 1864 | - | - | - | - | + | - |
| 21 | *Apodopsyllus madrasensis* Krishnaswamy | + | + | - | - | - | - |
| | Nematoda | | | | | | |
| 22 | *Thoracostoma* sp. Marion, 1870 | + | - | - | - | + | - |
| 23 | *Bolbolaimus* sp. Cobb, 1920 | - | - | - | - | + | - |
| 24 | *Cobbia* sp. de Man, 1907 | - | + | - | - | + | + |
| 25 | *Microlaimus* sp. de Man, 1880 | - | + | - | - | + | - |
| 26 | *Camacolaimus* sp. de Man, 1889 | - | + | - | - | + | - |
| 27 | *Odontophora longisetosa* Allgen, 1928 | - | - | - | + | - | - |
| 28 | *Adoncholaimus* sp. Cobb, 1930 | - | - | - | - | + | - |
| 29 | *Halailamus* sp. | - | - | - | - | + | + |
| 30 | *Procamacolaimus* sp. Gerlach, 1954 | - | - | - | - | + | - |
| 31 | *Dracograllus* sp. Allen & Noffsinger, 1978 | - | - | - | - | + | - |
| 32 | *Apodotrocha* sp. Westheide & Riser, 1983 | - | - | - | + | + | - |
| 33 | *Acaromantis subasper* Bartsch, 1977 | - | - | - | - | + | - |
| | Tanaidacea | | | | | | |
| 34 | *Heterotanais oerstedi* KrØyer, 1842 | + | + | + | - | + | + |
| 35 | *Synapseudes idios* Gardiner, 1973 | + | + | - | + | + | - |
| 36 | *Leptognathia* sp. Sars, 1882 | - | + | + | - | + | + |
| 37 | *Mirandotanais vorax* Kussakin & Tzareva, | - | + | - | - | - | - |
| | Sarcomastigophora | | | | | | |
| 38 | *Allogromia* sp. Rhumbler, 1904 | + | + | + | - | - | - |
| 39 | *Saccamminidae* sp. Sars, 1869 | - | + | + | - | + | - |
| 40 | *Elphidium* sp. Montfort, 1808 | - | + | - | + | + | + |
| 41 | *Spiroloculina* sp. d'Orbigny, 1826 | - | - | - | + | + | + |
| 42 | *Endothyra* sp. Phillips, 1846 | - | - | - | - | + | + |
| 43 | *Spirolina cylindaracea* | - | - | - | + | + | + |
| 44 | *Gyroidina soldanii* d'Orbigny, 1826 | - | - | - | - | + | + |
| 45 | *Planorbulina* sp. | - | - | - | - | + | - |
| 46 | *Quinqueloculina* sp. d'Orbigny, 1826 | - | - | - | - | + | + |
| 47 | *Spirillana vivpara* Ehrenberg, 1843 | - | - | - | - | - | + |
| 48 | *Globorotalia tumida* Brady, 1877 | - | - | - | - | - | + |
| 49 | *Planispira* sp. Beck, 1837 | - | - | - | - | - | + |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 50 | *Opthalmidium* sp. KÜbler & Zwingli, 1870 | - | - | - | - | - | + |
| 51 | *Bradyina* sp. Möller, 1878 | - | - | - | - | - | + |
| 52 | *Allomorphina* sp. Reuss, 1849 | - | - | - | - | - | + |
| 53 | *Rotorbis* sp. d'Orbigny, 1839 | - | - | - | - | - | + |
| 54 | *Globobulimina* sp. Cushman, 1927 | - | - | - | - | - | + |
| 55 | *Valvulineria* sp. d'Orbigny, 1826 | - | - | - | - | - | + |
| 56 | *Tretomphalus* sp.Möbius, 1880 | - | - | - | - | - | + |
| 57 | *Anomalina* sp. d'Orbigny, 1826 | - | - | - | - | - | + |
| 58 | *Flosculina* sp. Stache, 1880 | - | - | - | - | - | + |
| 59 | *Globigerina* sp. d'Orbigny, 1826 | - | - | - | - | - | + |
| 60 | *Rosalina* sp. d'Orbigny, 1826 | - | - | - | - | - | + |
| | Tardigrada | | | | | | |
| 61 | *Tanarctus* sp.Lindgren, 1971 | - | + | - | - | - | - |
| | Halacaroidea | | | | | | |
| 62 | *Soldanellonyx* sp. Walter, 1917 | - | - | - | + | + | - |
| 63 | *Halacarellus* sp. Viets, 1927 | - | - | - | + | - | - |
| | Polychaeta | | | | | | |
| 64 | *Typosyllis* sp. Langerhans, 1879 | - | - | - | + | + | + |
| 65 | *Nereis* sp. Linnaeus, 1758 | - | - | - | - | + | + |
| 66 | Ostracoda | - | - | - | - | + | + |
| 67 | Gastrotricha | + - - | | | - - - | | |
| 68 | Gastropod veliger larva | - | + | + | - | + | + |
| 69 | Bivalve veliger larva | - | - | - | - | + | - |
| | Insecta | | | | | | |
| 70 | Diptera larva | + | + | + | + | + | + |
| 71 | Polychaete larva | - | - | - | - | + | - |
| 72 | Invertebrate egg | + | + | + | + | + | + |
| 73 | Cyclopoid copepodid | + | - | - | - | - | - |
| 74 | Copepod nauplii | - | - | - | - | + | - |

+ = Present; - = Absent

### 3.4 Species Diversity of meiofauna in pneumatophore

The no. of species (S) and diversity indices in the study area are given in fig. 4. The no. of species recorded were high at St.2 (S=49) compared to St.1 (S=31). Species diversity (H´= 2.8) was comparatively higher at St. 1 compared to St.2 (H´= 2.6). Relatively high species richness (d=6.3) and low evenness in meiofaunal species distribution (J= 0.5) at St. 2 could be due to the dominance of few species such as *Quinqueloculina* sp., *Elphidium* sp. and *Parastenhelia hornelli*.

### 3.5 Cluster Analysis of meiofauna in pneumatophore

The pattern of association of common meiofaunal species in this region showed high degree of correlation with dissolved oxygen content. On the basis of clustering, the different meiofaunal species formed one major clusters over time and showed 93% similarity. Cluster 1 represented a group of species that formed depending on the type of distribution and abundance during Jan'13 and Feb'13 while in Dec' 12, the low dense population with low dissolved oxygen content showed 57 % similarity separately and joined with the cluster (Fig. 5)

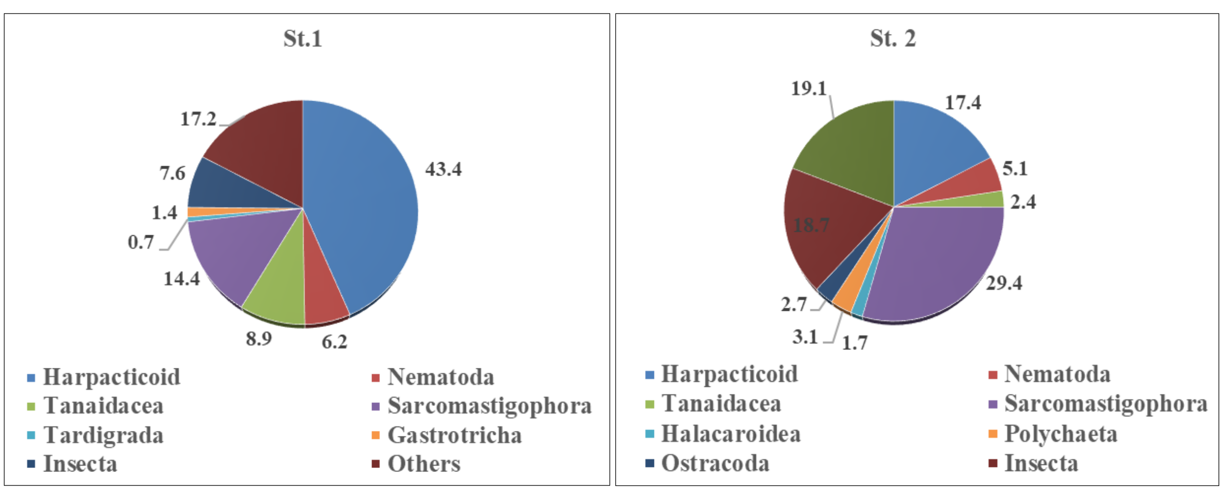



**Fig 3:** Percentage composition of meiofauna in the study area

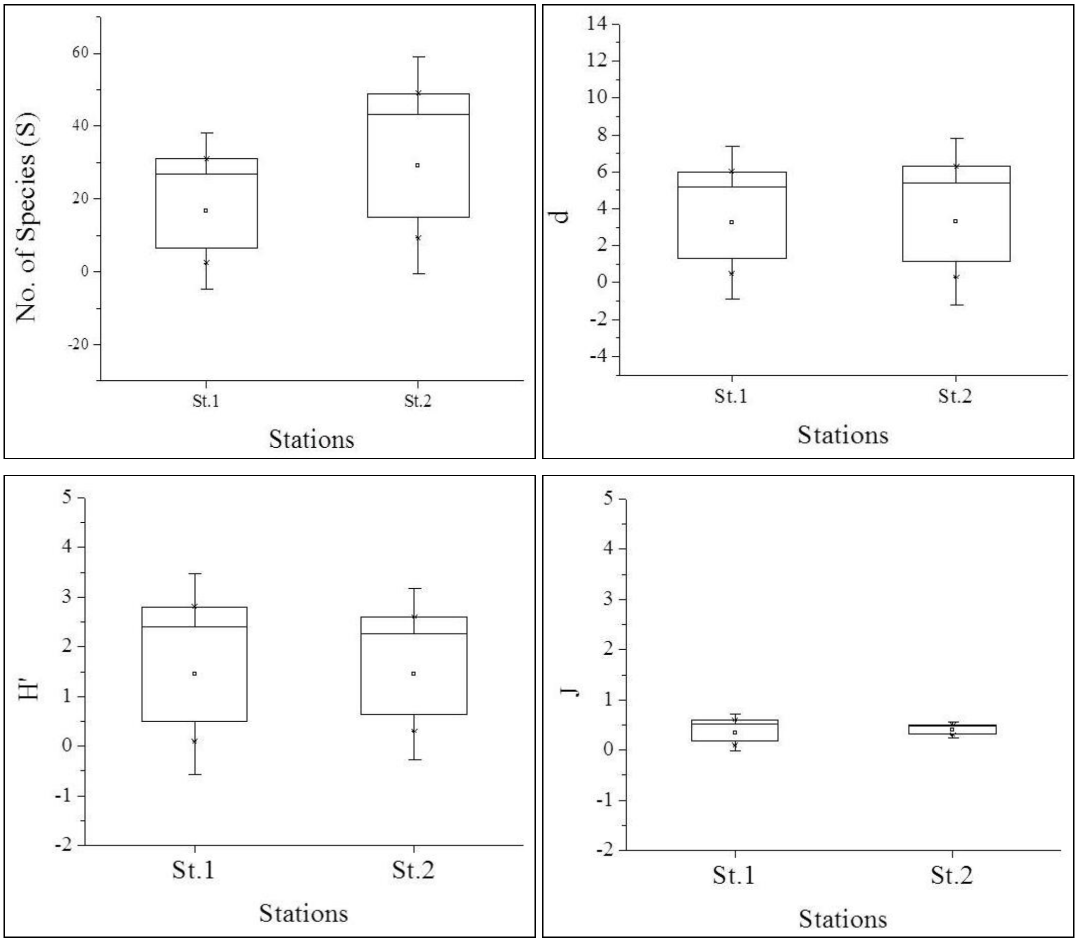



**Fig 4:** Diversity indices of meiofauna species from pneumatophores of *A. marina* in the present study

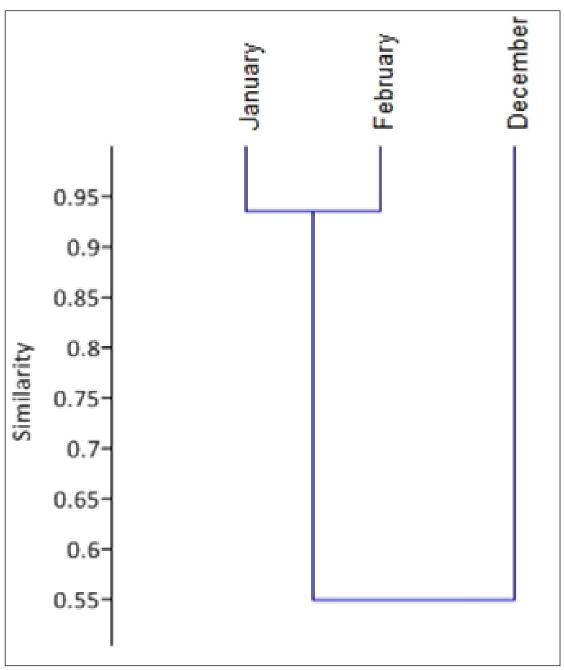



**Fig 5:** Bray-Curtis similarity showing the formation of groups of meiofaunal community in the study area

**3.6 Epiphytic microalgae:** In the present study, a total of 32 epiphytic micro algal species belonged to 4 groups viz. Centric Diatom (7 sp.), Pennate Diatom (23 sp.), Cyanobacteria (1 sp.) and Dinoflagellate (1 sp.) were identified from the pneumatophores of *A. marina* (Table 3). Overall, abundance ranged from 60 to 122 cells/10cm$^2$

in the study area (51±4.1 cells/10cm$^2$at St.1; 64±4.3 cell /10cm$^2$at St.2). Pennate diatoms contributed the maximum (46.39%) to the total phytoplankton population followed by Cyanobacteria (26.23%), Centric Diatom (26.01%) and Dinoflagellates (1.68 %; Plate 2)

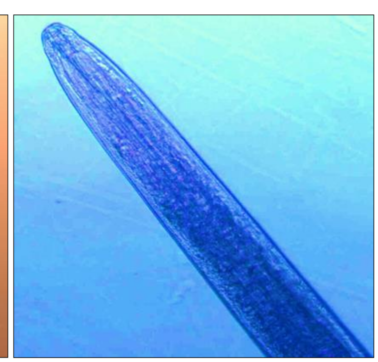
**Table 3:** Occurrence of epiphytic species in St. 1 & St. 2 during the study period.

| Sl. No | Species Occurred | St. 1 | | | St. 2 | | |
|---|---|---|---|---|---|---|---|
| | | Dec'12 | Jan'13 | Feb'13 | Dec'12 | Jan'13 | Feb'13 |
| | Centric diatom | | | | | | |
| 1 | *Melosira nummuloides* C. Agardh, 1824 | - | + | + | + | + | + |
| 2 | *Rhizosolenia* sp. Brightwell, 1858 | + | - | - | - | - | - |
| 3 | *Biddulphia* sp. S.F. Gray, 1821 | - | - | + | + | + | - |
| 4 | *Thalassiosira* sp. P.T. Cleve, 1873 | - | - | + | + | - | - |
| 5 | *Thalassiosira oestrupii* (Ostenfeld) Hasle, 1972 | - | - | - | - | - | + |
| 6 | *Odontella aurita* C. Agardh, 1832 | - | - | - | - | - | + |
| 7 | *Biddulphia pulchella* S. F. Gray, 1821 | - | - | - | - | - | + |
| | Pennate diatom | | | | | | |
| 8 | *Cymbella* sp. C. Agardh, 1830 | + | + | + | + | - | + |
| 9 | *Achnanthes brevipes* C. Agardh, 1824 | + | + | + | + | + | + |
| 10 | *Amphora cf. turgida* W. Gregory, 1857 | - | - | - | - | - | + |
| 11 | *Amphora* sp. C. G. Ehrenberg ex F.T. KÜtzing, 1844 | - | + | + | + | - | + |
| 12 | *Campylodiscus* sp. C. G. Ehrenberg ex F.T. KÜtzing, 1844 | - | - | - | - | - | + |
| 13 | *Climacosphenia elongate* Mereschkowsky | - | - | - | - | - | + |
| 14 | *Cocconeis scutellum* Ehrenberg, 1838 | - | + | + | + | + | + |
| 15 | *Cylindrotheca closterium* (Ehrenberg) Reimann & J.C. Lewin, 1964 | - | - | - | - | - | + |
| 16 | *Diploneis* sp. P.T. Cleve, 1894 | - | - | + | + | - | - |
| 17 | *Diploneis crabro* Ehrenberg, 1854 | - | - | - | - | + | + |
| 18 | *Licmophora ehrenbergii* Grunow, 1867 | - | - | + | - | + | + |
| 19 | *L. remulus* | - | - | | | | + |
| 20 | *Navicula* sp. J.B.M Bory de Saint-Vincent, 1822 | - | - | + | + | - | + |
| 21 | *Nitzschia closterium* (Ehrenberg) W. Smith, 1853 | - | + | + | + | - | - |
| 22 | *N. sigma* | + | + | - | - | - | - |
| 23 | *Nitzschia* sp. | + | + | + | + | + | - |
| 24 | *Pleurosigma angulatum* W. Smith, 1852 | + | - | + | + | - | - |
| 25 | *P. strigosum* W. Smith, 1852 | + | - | - | - | - | - |
| 26 | *Pleurosigma* sp. W. Smith, 1852 | + | - | + | + | + | + |
| 27 | *Podacystis spathulata* | - | - | - | - | - | + |
| 28 | *Striatella unipunctata* C. Agardh, 1832 | - | - | - | - | - | + |
| 29 | *Surirella fastuosa.* P.J.F. Turpin, 1828 | - | + | - | - | - | - |
| 30 | *Tryblionella acuminata* W. Smith, 1853 | - | - | - | - | - | + |
| | Dinoflagellates | | | | | | |
| 31 | *Prorocentrum micans* Ehrenberg, 1834 | - | + | + | + | - | - |
| | Cyanobacteria | | | | | | |
| 32 | *Oscillatoria* sp. Vaucher ex Gomont, 1892 | + | + | + | + | + | + |

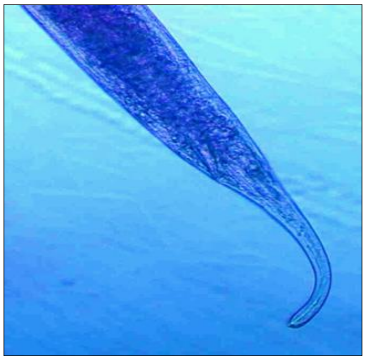
+ = Present; - = Absent

*Helmutkunzia variabilis*

*Scottolana longipes*



*Adoncholaimus sp. (Head)*

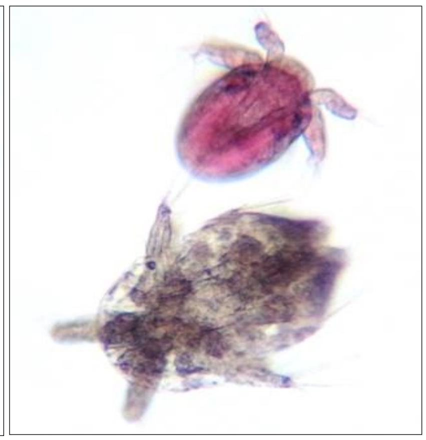

Adoncholaimus sp. (Tail)

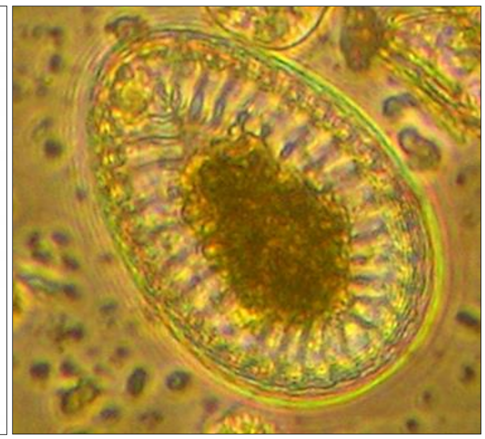

*Heterotanais oerstedi*

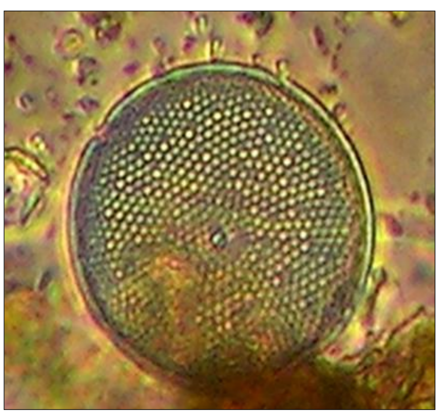

Diptera Larva

**Plate 1**


*Elphidium sp.*


Copepod nauplius


*Surirella fastuosa*


*Thalassiosira* sp.


*Tryblionella acuminate*

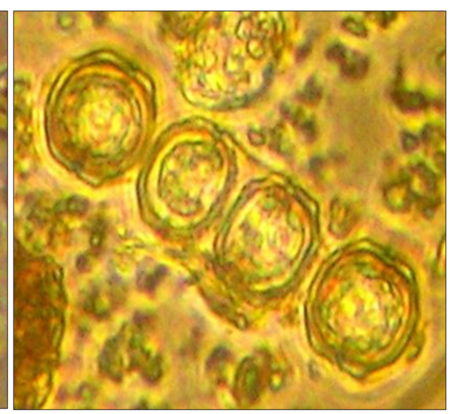

*Melosira nummuloides*

**Plate 2**

## 4. Discussion

Dissolved oxygen, the single most important physico-chemical parameter showed wide variation (2.2-4.9 mg/L) during the study period and strongly correlated with meiofauna (r= 0.99) suggesting its requirement for thriving the meiofauna in the root system. Further, the presence of lenticels on the pneumatophore roots that are capable of gaseous exchange (Scholander, 1955) plus associated microalgae which contribute D.O through photosynthesis.

The biotic covering surface of pneumatophores supported a variety of motile meiofauna as found in this study has been reported earlier (Proches *et al*., 2001). The meiofuanal assemblages on the pneumatophore roots of *Avicennia marina* comprised 23 species of Sarcomastigophora, 21 species of Harpacticoida followed by 12 species of Nematoda, 4 species of Tanaidacea and 32 species of epiphytic microalgae suggest that mangrove pneumatophore provides an ideal surface area for the attachment of epiphytic algae and other associated meiofaunal communities.

The root system in this study area is dominated by some true phytal-dwelling harpacticoid families such as Diosaccidae and Thalestridae. Earlier reports from mangrove ecosystem (Gwyther, 2002; Naidoo *et al*., 2008) [24], from seaweeds (Cacabelos *et al*., 2010) [14] and seagrass (Jayabarathi *et al*., 2012) also confirms that harpacticoida dominates in the phytal substrata in the meiofaunal community. In sheltered environments like mangrove, the phytal surface may acquire a layer of sediment (Hicks, 1986) which points out that under reduced silt-clay or detrital load harpacticoids dominated the root surfaces in this area and resulted in a low abundance of nematodes. The abundance of harpacticoids in the pneumatophore roots of *A. marina* can be explained by their physical morphology since the presence of their appendages help them for the attachment to the substrata plus the availability of epiphytic algae (diatoms) on the pneumatophore roots reflects the provision of extra food resources for them as well as other associated fauna. In this study, meiofauna showed a weak/ negative correlation with epiphytes (Table 1) evincing their feeding relationship between them and epiphytes. In the present study at St.2, dense algal covered pneumatophores with high abundance microalgae and meiofauna was recorded while at St.1 less dense algae cover and more of silt resulted in less abundance of both microalgae and meiofauna. Further, meiofauna in this study generally aggregated in areas where potential food such as bacteria and diatoms concentrated and provided more refuge against desiccation during low tide (Gerlach, 1977; Hogue & Miller, 1981).

The presence of gastropod veliger larvae on the pneumatophore root in the present study suggests that gastropods occupy a wide range of ecological niches in the mangrove ecosystem (Nagelkerken *et al*., 2008) [25]. Abundance of diptera larvae on the algal covered pneumatophore roots (at St.2) indicate a preferable habitat for these larvae to nurture as found in this study has been reported elsewhere (Gwyther, 2002) [14].

Pneumatophore roots of *A. marina* in the present study showed abundance of associated flora such as diatoms, dinoflagellates and cyanobacteria. Blue-green algae which fix atmospheric nitrogen (Toledo *et al*., 1995; Kyaruzi, 2003) and facilitate the supply of nitrogen source to the mangroves (Mann & Steinke, 1993) suggest a mutualistic relationship between the mangroves and epiphytic microalgae in this area. The epiphytes clearly derive benefit from having a substratum for their attachment and protection from the mangrove of this area, and also could derive nutritional benefits from this association (Naidoo *et al*., 2008) [24]. The habitats offered by the pneumatophores in the present study clearly supported high assemblages of meiofauna along with the microalgae.

## 5. Conclusion

In this study, mangrove pneumatophore provided an ideal surface for the attachment of epiphytic microalgae and a variety of associated meiofaunal communities which conclude that pneumatophore roots of *Avicennia marina* is not a simple root; but a complex niche. There is a continuous need to monitor the two distinct habitats viz. roots of mangrove and its adjacent sediment, to understand the pattern of meiofauna and microalgae assemblages that they aid.

## 6. Acknowledgment

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