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Meiofaunal distribution patterns and trophic structure in response to abiotic conditions in Coringa mangroves on the east coast of India

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Abstract

Meiofauna play essential roles in matter cycling and energy transmission, making them vital to the mangrove environment. In September 2022, sediment and water samples were collected from the bay and creek zones of the Coringa mangroves. We investigated the benthic meiofaunal assemblages and diversity concerning the environmental variables from mangroves. Seven meiofaunal groups including free-living nematodes, benthic harpacticoid copepods, polychaetes, ostracods, kinorhyncha, foraminifera, and amphipods were reported. The meiofauna abundance ranged between 734 ± 75 and 5 741 ± 224 individuals per 10 cm^2 [ind./(10 cm^2)]. Although, nematodes are indicators that measure the ecological state of mangroves on the basis of a range of pressures. Nematoda dominated the creek zone of the mangrove, whereas harpacticoids dominated the bay zone. Eighteen genera from 12 families, including the most prevalent Xyalidae, Desmodoridae, and Linhomoeidae, represented nematodes. The taxa *Monhystera paludicola*, *Daptonema orientale*, and *Terschellingia longicaudata* were prevalent in the silt-dominated zones of mangroves. Several pollution indicator nematode species, including *M. paludicola*, *Sabatieria punctata*, and *D. orientale*, have also been found in the bay zone. In terms of the nematode feeding guilds, epigrowth feeders were dominant, followed by nonselective deposit feeders. Variations in salinity, organic carbon, and sediment texture have a direct impact on the distribution and abundance of meiobenthic organisms, indicating a strong ecological link between habitat conditions and organismal responses. The results highlight the need for more studies on the distribution of meiofauna and their contributions to ecosystem services while offering insights into the dynamics of meiofauna in the Coringa mangrove.

Key words meiofauna, nematode, copepods, mangrove, ecosystem services

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1 Introduction

Mangroves are unique maritime wetland ecosystems in tropical and subtropical parts of the world (Kathiresan and Bingham, 2001). Owing to natural and population stresses, they are among the world's most productive and threatened ecosystems (Kathiresan, 2002; Roy and Krishnan, 2005; Friess et al., 2023). These ecosystems provide habitats for various species, including algae and migratory birds. Mangrove environments support a wide variety of biodiversity and functions. The key biological processes of mangrove ecosystems, including feeding areas, nurseries, blue carbon, sediment, and pollution retention, are significantly damaged (Lee et al., 2015; Duke et al., 1997). Mangrove environments are productive and support a diverse range of faunal species. Benthic organisms, such as bacteria from sediment, microbenthos, and macro- and meiofauna, are essential for the movement of nutrients and energy (Snelgrove, 1999; Austen et al., 2002; Schratzberger et al., 2023).

Benthic organisms are excellent indicators of habitat health because they are exposed to various environmental stresses. In freshwater and marine environments, meiofauna are small metazoans that exhibit significant diversity (Danovaro et al., 2008; Giere, 2009; Zhou et al., 2023; Schratzberger et al., 2023). These organisms improve

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coastal waters and increase marine benthic productivity by recycling nutrients and forming detrital organic matter. Systems for monitoring marine environments and evaluating ecosystems have made considerable use of meiofauna (Zhang et al., 2017; Majdi et al., 2020; Zhao and Liu, 2021). According to Zeppilli et al. (2015), studying the physiological activity and behavior of several meiofauna species may help us understand how these animals adjust to changes in their natural environments and offer early warning signs for human disturbance.

The Coringa mangrove, with a depth of 3−8 m at high tide, has become a significant economic resource for the nation. Coringa mangrove's dense mangroves and vast mud flats, which are interrupted by several estuary gullies and streams that emerge from the Godavari River, one of India's best river systems, are significant features. Bioindicators are among the best methods for monitoring mangrove ecological conditions on the basis of pressure types and levels of degradation, although they differ depending on the environment (Thornton and Johnstone, 2015; Allard et al., 2020). To effectively manage mangrove ecosystems, the bioindicator process has recently highlighted the need for integrated evaluations (Romañach et al., 2018; Cuny et al., 2020; Dirberg et al., 2020). The most important environmental factors affecting meiofauna zonation patterns in mangroves and other ecosystems are salinity, sediment texture, temperature, and tidal incursion (Ansari and Parulekar, 1993; Moens et al., 2000; Alves et al., 2009; Thilagavathi et al., 2011; Pandiya Rajan et al., 2022).

Meiofaunal organisms are widely distributed within sediment and provides the significant food sources for fish, prawns, and shellfish larvae (Moens and Vincx, 1997). Among them free-living marine nematodes constitute the most dominant and ecologically important meiofaunal group. These nematodes were widely distributed, high adaptability to varing environmental conditions, and morphological diversity underscores the significant role in benthic ecosystem functioning (Leduc et al., 2015; Maria et al., 2023). Several earlier studies have reported the spatio - temporal distribution of meiofauna inrelation with environmental variables (Alongi, 1987; Gwyther, 2000; Armenteros et al., 2006; Mokievsky et al., 2011; Abdullah and Lee, 2017). However, relatively few studies were reported from the Indian mangroves patches in relation with meiofaunal community structure (Ansari and Parulekar, 1993; Sarma and Wilsanand, 1994; Goldin et al., 1996; Chinnadurai and Fernando, 2003; Sahoo et al., 2013). Ghosh and Mandal (2019) described the relationship between the meiofaunal distribution and environmental parameters along the east coast of India highlights the vertical distribution of meiofauna in largest mangrove regions. Other than these studies, there is a lack of detailed investigations of meiofaunal community structure in relation with nematode assemblages and their environmental relationships in other mangrove regions of India which results in further reseach in the present study. The objectives of this study are (1) to describe the meiobenthic community assemblages in relation to the abiotic environment, including different habitat zones (bay and creek) of the Coringa mangrove; (2) to focus on diversity patterns at the genus level (richness, composition, dominance); and (3) to examine the distributional patterns of the meiobenthic community in response to specific environmental conditions.

2 Materials and methods

2.1 *Study area*

The Coringa mangroves, India's second largest mangrove ecosystem after the Sundarbans, provide a significant organic load, resulting in high output (Satyanarayana and Krishna, 2017; Raut et al., 2005). The bay is surrounded to the south by dense mangrove forest and vast mudflats, which are punctuated by a network of tidal creeks, estuary gullies, and swamps fed by one of India's largest river systems, the Godavari River. Geographically, the central area is Coringa, after the Corangi River, one of the Gautami Godavari's distributaries, further south. During the southwest monsoon season, plenty of fresh water flows into the Bay zone, along with Gaderu, another Gautami Godavari distributary. At Bhiravapalem, Gautami Godavari enters the sea. The bay zone is bounded east by the mainland and separated from the sea east by a 16-km long sand spit. There are obvious ecological, hydrodynamic, geomorphological, and biological distinctions between the bay (subtidal) and creek (intertidal) zones in the research region, which support the separation of these two ecosystems.

The subtidal (bay) zones of the Coringa mangrove ecosystem are constantly submerged, usually at depths of 1−5 m. These areas experience dynamic hydrological conditions as a result of high tidal currents, river flow, and sporadic wave activity. Plankton and benthic fauna, including fish, bivalves, and polychaetes, are abundant on the typically sandy to silty bottom, which has little vegetation (Rao et al., 2004). The intertidal (creek) zones, on the other hand, are shallower, typically less than 1-m deep, and are frequently exposed by tides. Mangrove species such as *Avicennia marina* and *Rhizophora mucronata* predominate in these zones and are distinguished by fine, organic-rich mud substrates (Satyanarayana and Krishna, 2017; Rao et al., 2004). The vegetation, sediment properties, water dynamics, and biological functions of the two zones are very different. By separating them, we can gain better knowledge of ecosystem services, carbon sequestration mechanisms, and patterns of biodiversity. To manage ecosystem services and develop research on hydrology, carbon stocks, or biodiversity, it is essential to comprehend these distinctions.

2.2 *Sampling and sample processing*

Water and sediment samples were collected from the

Coringa mangrove and bay zones (Fig.1) in September 2022 to analyse the various physicochemical including salinity, dissolved oxygen (DO), sedimentary organic carbon (SOC), sediment texture (sand; silt; clay composition). A Van Veen grab sampler (surface area: 0.01 m^2; penetration depth: about 10 cm) was used for collecting the bottom sediment samples. Surfacial layer of sediment (about 5−7 cm) were mostly biologically active where majority of meiofaunal organism were reported from the earlier study (De Troch et al., 2013; Ghosh and Mandal, 2019). To collect triplicate samples at each sampling site, the grab was deployed three times. Subsamples in triplicate were taken with an acrylic cylindrical core (10 cm^2) from the upper 3 cm of the sediment. A conventional density-gradient centrifugation technique, often employed in meiofaunal research, was utilized to recover meiofaunal species from mangrove soil samples (Giere, 2009). A colloidal silica solution (LUDOX HS-40) with a specific gravity was used to perform density separation on the retained sediment. The sediment-LUDOX mixture was centrifuged at 3 000 r/min for 10 min. This procedure was repeated 3−4 times (Burgess, 2001). The supernatant, which included the separated meiofauna, was decanted through a 0.045 μm filter following centrifugation. After that, the extracted organisms were kept and fixed in 70% ethanol and stained with Rose Bengal (0.5 g/L), which improved the visibility of soft-bodied species, including copepods and nematodes. A stereomicroscope was then used to examine the preserved samples to identify and count the

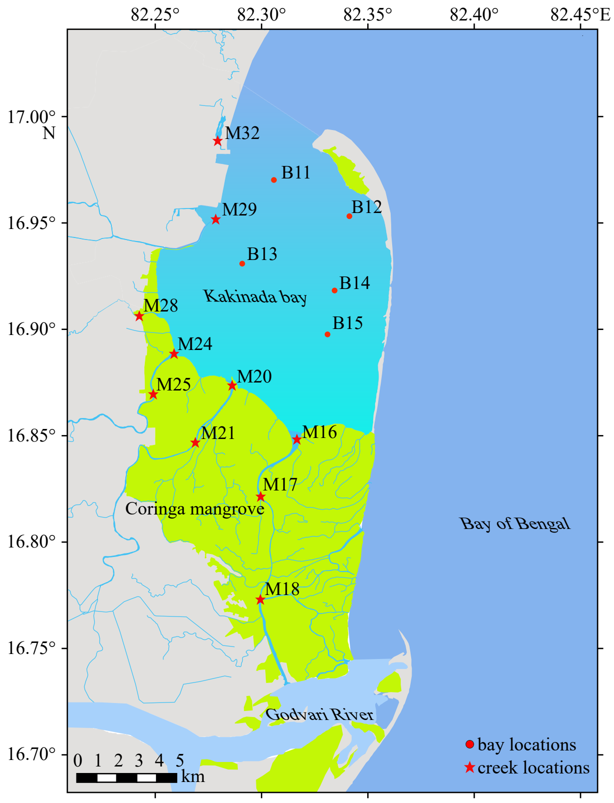

Fig. 1. Map showing the sampling locations in the Coringa mangrove ecosystem.

meiofaunal species. According to Zeppilli et al. (2015), this technique is thought to be successful in distinguishing living and preserved meiofauna from mangrove sediments that have a high organic content and fine-grained textures. The sediments were collected separately for sediment grain size analysis via a sieve shaker and laser diffraction particle size analyzer (McCave and Syvitski, 1991). SOC was estimated via the Walkley and Black (1934) method.

2.3 *Meiofaunal analysis*

Preserved meiofaunal samples were examined in the laboratory to identify nematodes. Using a stereomicroscope, meiofaunal organisms were picked, identified and classified into major taxa. The abundance per 10 cm^2 was used to recalculate all of the obtained values. For taxonomical and functional identification, nematodes were collected, preserved in a 10% formaldehyde solution, and then placed on temporary mounted slides (Seinhorst, 1959; Danovaro et al., 2008). Using the taxonomical guidelines of Platt et al. (1985), Warwick et al. (2002a, 2002b), Warwick et al. (1998), and Zullini et al. (2001), as well as the original species descriptions found on the Nemys website (Nemys, 2025), genus-level identification was completed via light optical microscopy (nikon). Other meiobenthic taxa were identified via keys (Conway et al., 2003; Higgins and Theil, 1988; Fauchald and Jumars, 1979; Day, 1968; Kasturirangan, 1963; Fauvel, 1953). The taxonomic status of the genera was checked and updated from the World Register of Marine Species (WoRMS) website. Nematodes were classified into feeding group, according to Wieser (1953), as selective (1A) and nonselective (1B) deposit feeders, epi-growth (diatoms) feeders (2A), and predators/omnivores (2B) .

2.4 *Statistical analysis*

Both univariate and multivariate approaches were used to analyze the meiofaunal community assemblages to assess diversity, distribution, and ecological interactions. Univariate analysis to assess the abundance ind./10 cm^2, number of taxa, and diversity indices (Shannon-Wiener index and Pielou's evenness). The PRIMER v7.1 software package was used for all the univariate and multivariate procedures and diversity calculations (Clarke and Gorley, 2015). A similarity profile (SIMPROF) permutation test (999 permutations) was also performed to identify significant assemblages of stations (P < 0.05) (Clarke and Gorley, 2015). One way analysis of variance (ANOVA) was performed on the environmental parameters to test for significant differences between the habitats (bay and creek) (Zar, 2010). The interrelationship between the biological and environmental variables was evaluated via redundancy analysis (RDA) (CANOCO 4.5). The biological variables were centered and log-transformed before analysis. The ordination significance was tested with a Monte Carlo (499 unrestricted permutations) test (P <

0.05). The results of the RDA are presented as Triplots with stations as points and the species and environmental parameters are represented by arrows (Lepš and Šmilauer, 2003).

3 Results

3.1 *Environmental parameters*

The environmental characteristics of the creek and bay zones are presented in Table 1. Salinity ranged from 0–30, whereas the creek zone were dominated by oligohaline/mesohaline conditions (0–18), and the bay was dominated by conditions ranging from 14–30, whereas upper mesohaline (14–18) and polyhaline (18–30) conditions had maximum limits barely above the euhaline threshold (30). DO in the bottom waters ranged between 1.96 mg/L and 5.64 mg/L. In contrast, the DO was lower in the creek zone than in the bay zones. The nutrient level in the water column was greater in the creek zone than in the Coringa mangrove bay zone. The sediment texture at the bay zone of the Coringa mangrove was dominated by silty sand. In contrast, the creek zones was dominated by the higher proportions of silt and clay compared to the bay zones (Fig. 2).

One-way ANOVA indicated that several environmental parameters differed significantly between bay and creek zones of Coringa mangroves (Table 2). Salinity (P = 0.001) and SOC (P = 0.000) showed highly significant differences, while DO (P = 0.029) exhibited a significant variation between zones. Clay particles (P = 0.056) showed a marginal difference, whereas silt (P = 0.367) and sand (P = 0.090) did not show the varied significantly among zones. These results indicate that variations in salinity, organic carbon, and DO levels play a major role in distinguishing the environmental characteristics of the bay and creek zones.

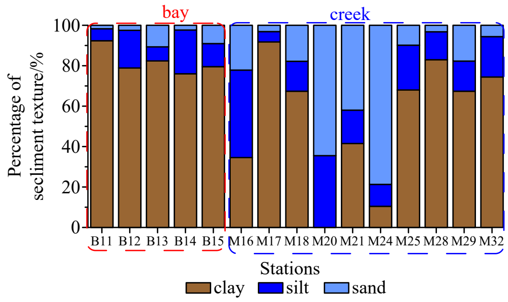

Fig. 2. Percentage of sediment texture (%) in the creek and bay zones of the Coringa mangrove ecosystem.

Table 2. Significant one way analysis of variance (ANOVA) results of spatial patterns in environmental data

One way ANOVA			
Parameters	*F*	*P-value*	S
Salinity	20.690	0.001	***
DO	5.987	0.029	*
Clay	4.413	0.056	†
Silt	0.875	0.367	ns
Sand	3.358	0.090	ns
SOC	158.597	0.000	***

Note: Significance levels denoted as P value, *** represents $P < 0.001$; * represents $P < 0.05$; † represents $P < 0.10$; ns represents not significant.

3.2 *Meiobenthic community*

Meiofaunal organisms belonging to seven meiofaunal groups, which include nematodes, copepods, polychaetes, ostracods, Kinorhyncha, Foraminifera, and amphipods, were recorded in the present study. Meiofaunal abundance and diversity, indices are presented in Table 3. Forty-four species of meiofaunal organisms dominated, with nematode assemblages represented by 32 species.

Table 1. Environmental and sediment characteristics of Coringa mangrove and bay regions during September 2022

Stations	Salinity	DO/(mg·L^{-1})	Clay/%	Silt/%	Sand/%	SOC/%
B11	30	4.75	92.35	5.93	1.72	1.1
B12	23	5.11	78.88	18.62	2.5	1.04
B13	18	5.06	82.37	6.96	10.67	1.01
B14	20	5.65	76.02	21.64	2.34	0.98
B15	14	2.38	79.54	11.41	9.05	1.5
M16	2	4.50	34.56	43.28	22.16	2.07
M17	0	3.41	91.76	5.13	3.11	2.21
M18	0	2.79	67.39	14.80	17.81	2.10
M20	6	1.97	0	35.51	64.49	2.11
M21	0	2.77	41.51	16.51	41.99	2.13
M24	0	2.07	10.45	0.85	88.70	2.18
M25	15	3.68	67.99	22.17	9.84	2.37
M28	7	3.93	82.97	13.81	3.22	2.1
M29	1	2.22	67.39	14.90	17.71	2.1
M32	18	4.39	74.41	19.99	5.60	1.98

Note: DO represents dissolved oxygen; SOC represents sedimentary organic carbon.

Table 3. Biological variables in the Coringa mangrove during September 2022

Biological variables	Meiofaunal abundance/[ind.·(10 cm^2)$^{-1}$]	Pielou evenness (J')	Shannon-Wiener diversity (H)
B11	749 ± 80	0.959	3.006
B12	836 ± 117	0.961	3.235
B13	1 000 ± 67	0.898	2.777
B14	734 ± 76	0.960	2.826
B15	1 753 ± 125	0.837	2.694
M16	1 002 ± 143	0.882	2.327
M17	5 234 ± 398	0.842	2.919
M18	2 944 ± 167	0.796	2.461
M20	4 174 ± 190	0.880	2.592
M21	3 128 ± 241	0.838	2.422
M24	2 501 ± 167	0.850	2.408
M25	1 449 ± 79	0.880	2.592
M28	1 843 ± 95	0.832	2.306
M29	3 669 ± 211	0.864	2.670
M32	5 741 ± 224	0.758	2.497

The meiofaunal abundance ranged between (734 ± 76) ind./(10 cm^2) and (5 741 ± 224) ind./(10 cm^2). In contrast, the abundance was greater in the creek zone than in the bay zone (Fig. 3). *Oithona* sp., *Arenosetella* sp., *Stenhelia* sp., *Pontella* sp., *and Calanus* sp. are among the copepods reported from the bay. *Ammonia* sp., *Elphidium* sp., *and Bolivina* sp., which are foraminifera, were also reported in this study. Some of the larvae belong to the polychaete, bivalve, and gastropod groups, which were also observed in the creek zone of the mangroves. The Shannon diversity index was greater at the bay zone station (B12) than at creek, and a low diversity index was observed at creek (M28). Pielou's evenness was greater in the bay zone location (B12) than in creek, and there was low evenness in creek (M32).

Cluster analysis revealed dominant meiobenthic assemblages in two zones of Coringa mangroves on the basis of Bray-Curtis similarity (Fig. 4). Table 4 describes the assemblages of the dominant meiobenthic taxa in the bay and creek zones of Coringa mangroves. The important representatives and common taxa formed two zones: the bay zone, with an average abundance of 324 ind./(10 cm^2), and the creek zone, with an average abundance of 479 ind./(10 cm^2). The average similarity in the bay zone was 47.92%. The dominant meiofauna in the bay zone are *Thalassoalaimus* sp., *Desmoscolex* sp., *Sabatieria punctata, Halalaimus longicaudatus*, and *Chromadorita* sp., accounts for 71% of the cumulative similarity. The average similarity in the creek zone was 40.92%. The dominant meiofauna in the creek zone are *Ammonia tepida*, *Oncholaimus siddiqii*, *Thalassolaimus* sp., *S. punctata*, *Arenosetella* sp., and *Desmoscolex* sp. *Thalassolaimus* sp. shows 50% cumulative similarity.

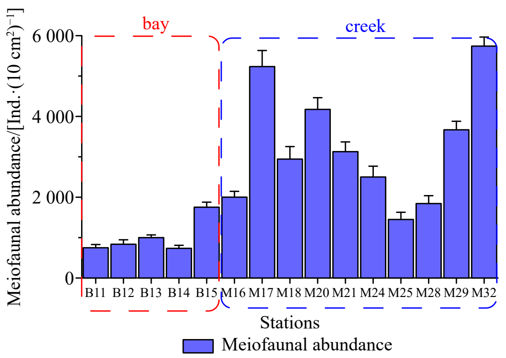

Fig. 3. Meiobenthic abundances in the Coringa mangrove ecosystem.

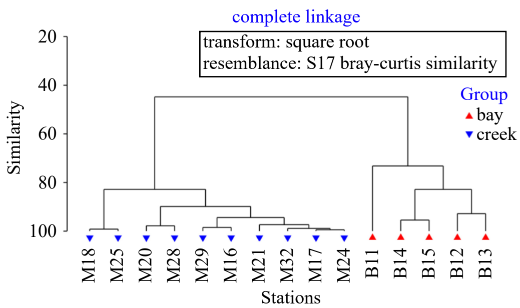

Fig. 4. Cluster analysis represents the variations of the meiofauna group at the creek and bay zones of the Coringa mangrove ecosystem.

3.2.1 *Nematode community and feeding guilds*

Overall, 32 species of free-living nematodes belonging to 12 families were recorded in the present study. Free-living nematodes were present in both zones of mangroves. The most spatially widespread species were *Anoplostoma macrospiculum*, *Quadricoma* sp., *Ascolaimus* sp., *Piranchulus* sp., *Oncholaimus siddiqii, Daptonema orientale*, *S. punctata*, *Thalassoalaimus* sp., *Diplolaimella* sp., *H. longicaudatus*, *Dorylaimopsis* sp., *Mononchus bastian*, *Tricoma* sp., and *Mesorhabditis capitata*. This species was the dominant nematode recorded in the present study. Diversity indices and evenness are greater along creek than in the bay zone. Some pollution-indicating nematodes, such as *Monhystera paludicola*, *S. punctata*, and *D. orientale*, have also been recorded from the bay zones of Coringa mangroves.

The proportion of nematodes gathered per trophic guild is presented in Fig. 5. At bay zone of coringa mangrove, selective feeders (1A) was dominant feeding type followed by the non selective deposit feeders (1B) represented average proportions of 53% and 29%, respectively. Epi-growth feeder (2A) guild and omnivorous carnivores (2B), accounted for smaller proportions was about 9% each. In contrast, creek zones was dominated by epi-growth feeders (2A) and omnivorous carnivores feeders (2B) with mean proportions of 44% and 40.5%, respectively, which were inversely proportional to 1A and 1B about proportions 7% and 8.5% in the creek zones. The variations between the bay and creek zone of coringa mangrove staticsally significant ($P < 0.05$) feeding behaviour of the nematodes.

3.3 *Redundancy analysis*

The interrelationships between the environmental parameters (salinity, temperature, SOC, and sediment grain size) and the biological parameters (meiobenthic group abundance) are presented in Fig. 6. Arrows in the same direction indicate a high positive correlation between those variables. In contrast, variables with negative correlations are represented by arrows oriented in opposite directions. Copepods, nematodes, and foraminifera have different ecological affinities. Nematodes and foraminifera are associated with greater SOC and clay contents, indicating a preference for organically enriched, fine-textured sediments found in creek zones. Polychaetes and other groups are closely related to sandy sands and increased silt content, and they predominate in the bay zone. Copepods are negatively related to salinity and are found in low-salinity settings (Locations-B14, B12). Locations such as M27 and M28 are heavily influenced by sand and silt, separating them from the main cluster, implying localized envi-

Table 4. Characterization of the two species assemblages defined by cluster analysis, showing average “within group” similarity based on one way SIMPER analysis of fourth-root transformed abundance data. Species accounting for 90% cumulative contributing of the “within group” similarity are listed along with their contribution (Contrib%)

Bay region						Creek region					
Average similarity: 47.92						Average similarity: 40.92					
Species	Av. Abun	Av. Sim	Sim/SD	Contr./%	Cum./%	Species	Av.Abun	Av.Sim	Sim/SD	Contr./%	Cum./%
Thalassoalaimus sp.	46.68	4.12	9.38	8.6	8.6	*Ammonia tepida* sp.	83.39	2.71	1.2	6.62	6.62
Desmoscolex sp.	38.32	3.08	1.16	6.42	22.66	*Enoplolaimus* sp.	73.71	2.6	1.2	6.36	12.98
Sabatieria punctata	33.20	2.6	1.15	5.42	28.08	*Viscosia* sp.	67.32	2.29	1.23	5.6	18.58
Halalaimus longicaudatus	32.72	2.35	1.15	4.9	32.98	*Bolivina* sp.	58.64	2.2	0.86	5.38	23.96
Acartia tonsa	32.83	2.3	1.16	4.8	37.78	*Microlaimus* sp.	43.41	2	0.91	4.9	28.86
Eucalanus sp.	29.06	2.26	1.15	4.71	42.49	*Sabatieria punctata*	32.37	1.95	1.19	4.76	33.62
Calanus sp.	28.99	2.17	1.15	4.53	47.01	*Acartia* sp.	28.04	1.93	0.89	4.71	38.33
Elphidium sp.	21.50	2.07	1.13	4.32	51.34	*Desmoscolex* sp.	22.89	1.68	0.88	4.1	42.43
Daptonema sp.	20.49	2.02	1.13	4.21	55.55	*Arenosetella* sp.	22.7	1.55	0.68	3.8	46.23
Chromadorita sp.	20.02	1.27	0.62	2.64	67.05	*Monhysterida paludicola*	22.58	1.41	0.67	3.45	48.68
Axonolaimus sp.	19.87	1.12	0.61	2.33	71.41	*Thalassoalaimus* sp.	22.41	1.36	0.68	3.33	50.01

Note: Av. Abun -average abundance; Av. Sim - average similarity; Sim/SD - similarity to standard deviation ratio; Contr./% - percentage contribution (%); Cum./% - cumulative percentage (%).

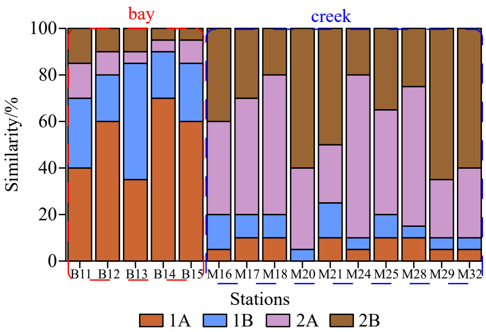

Fig. 5. Trophic structure of nematode assemblages at the Coringa mangrove region. 1A (selective deposit feeders); 1B (non selective deposit feeders); 2A (epi-growth feeders); 2B (predators/omnivores).

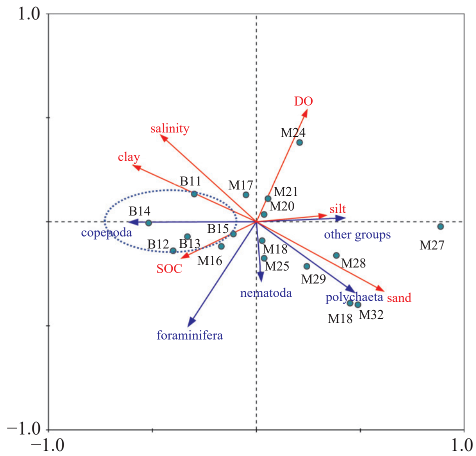

Fig. 6. RDA triplots showing the distribution of environmental (salinity, turbidity, DO, sediment texture) and biological parameters (meiobenthic group abundance & total abundance) and their interrelation at Coringa mangrove & Bay region. Red arrows indicate the environmental variables, and blue colored arrows represent the biological variables.

ronmental variability and its impact on community composition. The RDA triplot revealed that nematode was always high in the bay and creek zone at the mesohaline salinity level.

4 Discussion

4.1 *Meiobenthic community composition*

Chinnadurai and Fernando (2007) reported that 234–890 ind./(10 cm^2) was slightly greater than that reported in earlier studies on the southeastern coast of India. In the early 1980s, meiofaunal densities were approximately 2 130 ind./(10 cm^2) in the Gautami-Godavari estuarine system (Kondalarao, 1984). In the present study, the meiofaunal abundance of the Coringa mangroves was relatively high compared with that reported in earlier studies (Kondalarao, 1984). In numerous studies of various geographical locations worldwide, temporal changes linked to nematode dominance in meiobenthic communities have been noted (Semprucci et al., 2016; Landers et al., 2012; Harguinteguy et al., 2012; Hongayo et al., 2013). Nematodes are the most prevalent meiofauna species in Indian mangroves (Sultan-Ali et al.,1983; Krishnamurthy et al., 1984; Kondalarao and Ramanamurty,1988; Ansari and Parulekar, 1993; Sarma and Wilsanand, 1994). Similar results are observed in the present study. In contrast, nematodes were more abundant in the creek zone of coringa mangroves. According to the present study, nematodes are more abundant and exhibit extraordinary richness and variety in the creek zone of mangroves. Nematodes dominate surface sediment, which has the most extensive variety of meiofauna (Schmidt and Arbizu, 2015). Free-living nematodes represents the one of the dominant and ecologically significant groups of the meiobenthic organisms. These organisms are found between sediment particles in interstitial spaces, mainly in aquatic ecosystems (Heip et al., 1985).

Nematode communities include many genera but few dominant genera, as observed in other estuaries (Steyaert et al., 2003; Ferrero et al., 2008). Seasonally, the density and diversity of nematodes fluctuate substantially. Nematode diversity was greater in the creek compared to bay zone. In contrast, the creek zone was deposited with more organic matter due to anthropogenic inputs and various sources of pollutants. Nematodes are possible biomarkers of anthropogenic disturbance in aquatic environments (Coull and Chandler, 1992; Moreno et al., 2008). Because they are less harmed and recover faster, meiofauna, particularly nematodes, are thought to be more resistant to physical disturbance than are more significant organisms (Leduc and Pilditch, 2013). The low meiofaunal abundance in the mangroves adjacent to the Bay of Bengal, 35−280 ind./(10 cm^2), subsequently occurred (Sultan-Ali et al., 1983). Harpacticoid copepods are among the most common meiofaunal taxa in terms of occurrence. Nevertheless, they are present at much lower abundances than are nematodes in the mangrove bay zone. Copepods are more related to coarse or sandy sediments in tropical areas (Semprucci et al., 2016), mangrove ecosystems (Chinnadurai and Fernando, 2007) or many European mudflats (Rzeznik-Orignac et al., 2003). In this study, copepods was more abundant in the bay zone because of seawater intrusion into the Bay zone of Coringa mangroves. Benthic foraminifera are sensitive to slight environmental changes in an ecosystem and serve as indicators of its health. *Ammonia tepida*, a foraminifera species, is a bioindicator of contaminants because of its high contamination tolerance (Samir, 2000). *Ammonia tepida*, *Elphidium* sp., *Rosalina* sp., and other foraminifera species have been described from Sundarbans mangroves (Ghosh et al., 2018). The present investigation revealed *A. tepida* and *Elphidium* sp. in the bay sections of Coringa mangroves.

4.1.1 *Nematode assemblages*

According to earlier studies, nematode diversity is greater in mangrove regions worldwide. Nevertheless, the current study revealed fewer nematode species, which could have various anthropogenic impacts (Pinto et al., 2013). *Anoplostoma macrospiculum*, *Quadricoma* sp., *Ascolaimus* sp., *Piranchulus* sp., *Oncholaimus siddiquii*., *D. orientale*, *S. punctata*, *Thalassoalaimus* sp., *Diplolaimella* sp., and *H. longicaudatus* are some of the dominant nematode species reported from our study, and a very low number of nematode species (32) were reported from our study. Some of the dominant nematode genera in various mangrove forests around the world were compared with our results. The common genera include *Terschellingia longicaudata* (Netto and Gallucci, 2003; Moreno et al., 2008; Sawangarreruks et al., 2011). *Sabatieria punctata* (Moreno et al., 2008; Sawangarreruks et al., 2011) and other genera, such as *Anoplostoma* sp., were also found to be dominant in tropical mangrove areas (Netto and Gallucci, 2003). These common genera were also present at relatively high abundances in our study area. *Hopperia* sp. is predominant in mangrove forests in Thailand (Sawangarreruks et al., 2011). *Haliplectus* sp. is abundant in mangroves in southern Brazil (Netto and Gallucci, 2003). Furthermore, *Haliplectus* sp. and *Dichromadora* sp. are abundant nematode in the leaves of the red mangrove *Rhizophora mangle* (Torres-Pratts and Schizas, 2007), which indicates that the dominant genera in Xiatanwei and Zhanjiang mangrove region (Fu et al., 2021). *Monhystera paludicola*, *S. punctata*, and *D. orientale* are some the indicator species shows their high tolerance to organic enrichment conditions in polluted or disturbed environments (Essink and Keidel, 1998; Alves et al., 2013).

The dominance of nematodes in both the bay and creek zone corresponds to earlier research on their ecological resilience and adaptability in estuarine sediments (Bhadury et al., 2015; Semprucci et al., 2019). Increased food availability and niche stability are suggested by the greater number of species in creek, which is linked with higher sediment organic carbon and finer sediments (Santos et al., 2019). In contrast, the high diversity and evenness of the bay zone may be related to broader salinity ranges and improved oxygenation, which promote a more balanced faunal assemblage (Somerfield et al., 2005). The variations in meiofaunal density across mangroves are similar to those reported in previous studies conducted globally. The results of this preliminary investigation of mangrove–meiofauna interactions revealed typical aspects of the mangrove–meiofaunal distribution, as described elsewhere. As previously mentioned, nematodes were the most prevalent and species-rich group during the study (Netto and Gallucci, 2003; Abdullah and Lee, 2017).

4.1.2 *Trophic guilds and environmental drivers*

Trophic guild analysis revealed that epigrowth feeders (2A) dominated, indicating the presence of diatom-rich biofilms on fine sediments, whereas nonselective deposit feeders (1B) predominated in coarser, more disturbed habitats. RDA analysis revealed that sediment texture and SOC were the key drivers of community patterns, which was similar to previous findings in mangrove and estuarine ecosystems (Zeppilli et al., 2015). These results provide important baseline data for long-term monitoring of Indian mangrove ecosystems and support the ecological significance of meiofauna as sensitive markers of environmental fluctuations. According to Pusceddu et al. (2014), the diversity and abundance of taxa are generally reduced in contaminated and pushed environments due to the disappearance of other delicate groups (such as ostracods, gastrotrichs, hydrozoans, and tardigrades), leaving an array that is overpowered by nematodes and other organic organisms with a broad mindset. The "FORAM" (Foraminifera in Reef Assessment and Monitoring) index (FI) evaluates the need for coral reefs and the suitability of benthic circumstances for networks overrun by peaceful algae organisms (Hallock et al., 2003). Ostracods respond to natural changes caused by pollution by exhibiting a strong aversion to heavy metal contamination, oil spills, and anoxic conditions (Ruiz et al., 2005). Certain ostracod species might overpopulate in polluted environments because they are acclimated to hypoxic environments (Yasuhara et al., 2003). Nematoda and copepods are more abundant than other meiofaunal groups; hence, future studies will help us identify the anthropogenic impacts with their ratios.

The meiofaunal assemblage patterns found in the current research on the Coringa mangrove ecosystem are consistent with findings from other tropical mangrove ecosystems across the world (Table 5). Nematodes are the dominant group in all situations and frequently exhibit the highest diversity, highlighting their ecological ubiquity in mangrove sediments. These worldwide comparisons confirm that mangrove systems continuously sustain high nematode diversity characterized by sediment texture, organic matter, and salinity regimes, even while site-specific environmental factors influence meiofaunal assemblages. As a result, the Coringa mangrove reflects the functional patterns of benthic ecosystems worldwide and substantially contributes to regional biodiversity.

4.2 *Meiobenthic organism and environmental interactions*

The present study emphasizes how abiotic variables such as salinity, sediment grain size, and organic content affect the meiofaunal community composition and trophic structure in the Coringa mangrove environment, resulting in significant geographic variation. In a marine environment, changes in hydrographical characteristics can impact benthic biota and degrade water quality (Shao et al., 2023). A significant amount of freshwater is released into the Bay of Bengal annually by the Godavari River (Ranga Rao et al., 2003; Satyanarayana and Krishna 2017). This enormous volume of silt- and sediment-filled freshwater enters the Godavari delta through several distributaries (Narasimha Rao and Rangaiah, 2010). The diurnal fluctuations in physical-chemical properties and primary production in connected marine, mangrove, and freshwater biotopes along the Kakinada coast in Andhra Pradesh were examined by Selvam et al. (1992). Freshwater from the Godavari River and Gautami River flows through the mangrove regions.

These findings reveal unique meiofaunal community structures in bay and creek habitats, which are most likely influenced by differences in environmental factors such as sediment type and organic content. Meiofaunal abundance was high in the creek zones, mainly because the high SOC results in the bottom substratum, which is related to food availability. However, diversity and evenness were higher in the bay zones, primarily associated with variations in salinity distribution and high bottom DO levels. In contrast, the bay zone experiences polyhaline conditions due to regular seawater intrusion from the Bay of Bengal. The water quality of the Gautami Godavari mangrove estuary ecosystem in Andhra Pradesh was evaluated by Tripathy et al. (2005). The environmental characteristics, such as salinity, were oligohaline across the mangrove sections. However, the average salinity of the estuarine and mangrove systems (3.28−3.86) was relatively lower than the high value (21.1) in bay zone, which is adjacent to the coastal environment. Similar results were observed in our study, which indicates that the creek zone experienced oligohaline conditions.

Tidal wash-out, which releases interstitial fluids from

Table 5. Comparison of the meiofauna diversity, abundance, and key environmental factors in different mangrove ecosystems across the globe

Serial No.	Location	Meiobenthic groups	Species richness (Taxa)	Dominant group	Abundance/ [ind.·(10 cm^2)$^{-1}$]	Key environmental factors	References
1	Sundarbans, India	11	about 79 species nematodes	nematoda	405−2 978	sediment organic matter & DO	Ghosh and Mandal, 2021
2	Pichavaram, India	4	62 species (12 species nematodes)	foraminifera	270−434	sediment texture & organic matter	Punniyamoorthy et al., 2021
3	Island of Santa Catarina, South Brazil	9	(94 species nematodes)	nematoda	77−1 589	high organic matter (OM), sediment texture	Netto & Gallucci, 2003
4	Charao Island, Goa	12	−	nematoda	166−520	sediment texture	Sahoo et al., 2013
5	Can Gio Mangrove, Vietnam	18	80 nematodes	nematoda	1 156−2 082	silt−clay substrate	Xuan et al., 2007
6	Longhai Mangrove, Xiamen, China	7	about 35 species	nematoda	735−5 831	seasonal variations, Sediment texture	Hultman., 2017
7	Coringa, India	7	44 species (32 nematodes)	nematoda, copepoda, foraminifera	734−5 174	high SOC in creek, clayey silt, salinity variation	present study

Note: − represents no data.

surficial mangrove sediments, is the leading cause of nutrient concentrations in the water column. This suggests that tidal mixing and flooding remove these nutrients from the mangrove area. The mangrove ecology and sediment properties in the Godavari estuary on the east coast of India were studied by Bhaskara Rao et al. (1992). Organic carbon input into estuary sediments is influenced by primary production, sediment structure, and the amount of terrestrial material available (Nair and Ramachandran, 2002). High meiofaunal densities are generally supported by mangrove sediment, which overpowers detritus (Heip et al., 1985; Coull, 1988). The surface sediments were more diverse and plentiful in meiofauna than were the subterranean communities. Because surface sediments are more exposed to disturbance, physical disturbance significantly impacts these populations. Because of their remarkable resilience, meiobenthic organisms recover quickly from disturbances (Alongi, 1990). Meiofauna diversity decreases, but its abundance increases in sediments when detritus and clay concentrations increase (Heip et al., 1985).

The sediment organic carbon content was relatively high in the creek zone of the mangrove area because of the high organic load from mangrove litter and limited sea water intrusion and relatively low organic carbon content in the bay zone may be attributed to seawater intrusion and dilution effects. Sediment particle size was positively correlated with meiofaunal species and diversity. Our study revealed similar results, whereas the Nematode prefers clayey sediments for their proliferation. Organic matter flux from the soil surface is one of the main factors influencing meiofauna abundance (Lambshead et al., 2002; Soltwedel, 2000). According to Kennish (1994), suspended silts, clays, and organic particles sink to the bottom substratum in estuaries. Meiofaunal abundance and food availability in sediment are mostly correlated, with high food concentrations connected to large numbers of individuals (Ingels et al., 2009; Leduc et al., 2014). The concentration of SOC also affects the spatial variation of meiofauna (Dal Zotto et al., 2016). The study area concentration of SOC was greater at creek than at bay since the creek zone receives a massive amount of nutrient load from Kakinada town and the freshwater flow from numerous tributaries of the Godavari River. In connection with this, nematodes also prefer the higher SOC zone in creek than in bay.

4.2.1 *Role of meiobenthic organism in ecosystem services*

In terms of ecosystem services, these tiny metazoans play essential roles in changes in sediment properties (physical/biogeochemical), changes in trophic levels (energy flow), and changes in ecological processes (intra/interspecific relationships), which affect subsequent ecosystem services (sediment stability, biochemical cycling, waste removal, and food web dynamics). Meiofauna-mediated effects on marine sediments, which can be direct or indirect, positive or negative, and at various spatial and temporal scales, can modulate the delivery of some ecosystem services (Fig. 7). The present study provides initial assessment of meiofaunal diversity as proxy for study the ecosystem services. The future research mainly

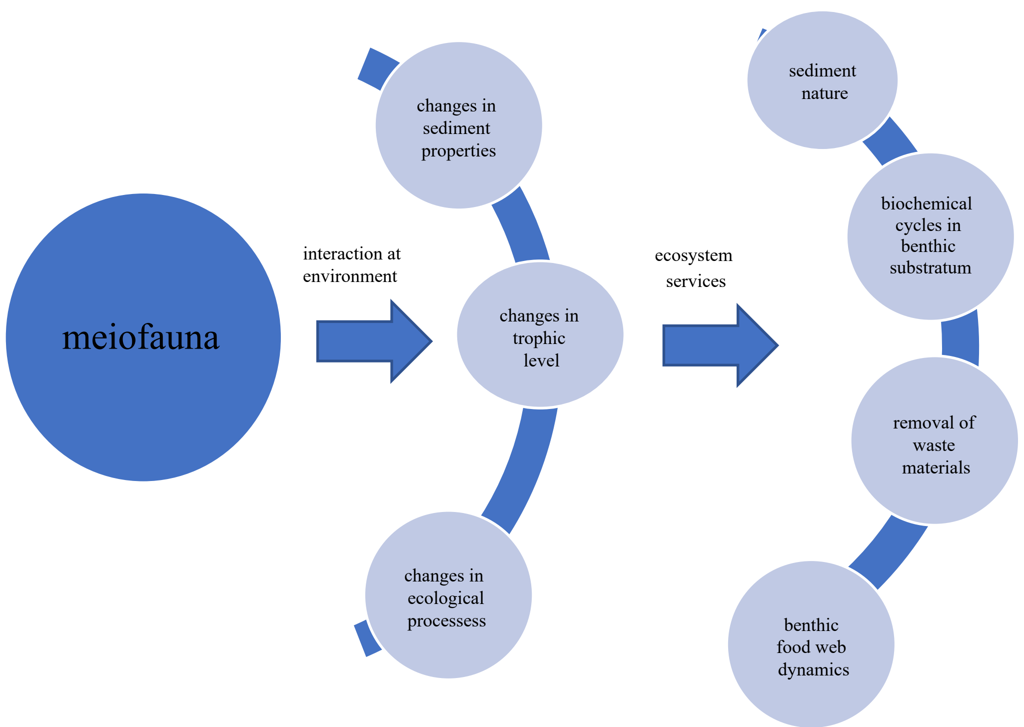

Fig. 7. Schematic diagram representing meiofauna role in the ecosystem processes and ecosystem services in the mangrove-associated ecosystem.

based on the meiofaunal community structure with the experimental and biogeochemical measurements to their role in nutrient cycling and other ecosystem services. In the present study, meiofauna play a vital role, as they act as nutrient sources for higher organisms in mangrove habitats, and disturbances in their abundance affect some of the monetary value of ecosystem services for Coringa mangroves. Research on meiofauna in the Coringa mangrove is essential for identifying and quantifying the ecosystem services associated with sediment distribution and energy flow from lower trophic levels to higher levels. It also plays a vital role in ecological processes.

The resulting surge of anthropogenic inputs, such as heavy metals and nutrient pollutants, indicates the growth of fallow land, agricultural and aquaculture activities, and industrial pollution. Especially with respect to coastal mangrove ecosystem degradation, various case studies highlight past changes and present trends in human activities through industrialization and urbanization. In physically harsh environments, the abundance and species diversity of benthic organisms are significantly reduced, and this group sometimes disappears. Integrated management planning should also ensure that all products, services, and values are addressed. The planning process should thus incorporate periodic environmental impact assessments, and actual management should be checked regularly through environmental auditing. We have periodically evaluated the impact of anthropogenic inputs on mangrove ecosystems with an approach to emphasize the crucial role of mangroves, both in terms of quality and quantity and the absolute need to conserve their future. These results are consistent with earlier research highlighting the susceptibility of meiofaunal communities to modest changes in sedimentary and physicochemical conditions (dos Santos et al., 2023). Overall, the findings illustrate how local abiotic factors influence meiofaunal structure and function, emphasizing their importance as ecosystem health indicators in mangrove ecosystems.

5 Conclusions

The present study on the meiofaunal distribution at the Coringa mangroves was detailed study along the southeast coast of India which revealed the nematodes as the dominant at creek and copepods at bay region of the mangrove. The study mainly focused towards the meiofaunal interaction with environmental variables. The linkages between community composition and environmental variables are one of the first kind in the Coringa mangrove. It is necessary to improve our scientific focus to understand how this meiofaunal organism responds towards the heavy metals concentrations and other pollutants disbursed from rivers which results in anthropogenic impacts. The physiological limitations of species and altered biological interactions are frequently cited as the primary reasons for changes in meiofauna distribution patterns under various human disturbance regimes, although they are seldom examined directly. The present study is baseline for the ecosystem-based management and conservation strategies and future research should focus on meiofauna distributions and ecosystem services. The future research mainly focused on the vertical distribution of meiofauna community assemblages and their contributions the ecosystem services.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request through the Director, National Centre for Coastal Research, Chennai.

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References

Abdullah M M, Lee S Y. 2017. Structure of mangrove meiofaunal assemblages associated with local sediment conditions in subtropical eastern Australia. Estuarine, Coastal and Shelf Science, 198: 438–449, doi: 10.1016/j.ecss.2016.10.039

Adão H, Alves A S, Patrício J, et al. 2009. Spatial distribution of subtidal nematoda communities along the salinity gradient in southern European estuaries. Acta Oecologica, 35(2): 287–300, doi: 10.1016/j.actao.2008.11.007

Allard S M, Costa M T, Bulseco A N, et al. 2020. Introducing the mangrove microbiome initiative: identifying microbial research priorities and approaches to better understand, protect, and rehabilitate mangrove ecosystems. mSystems, 5(5): e00658–20, doi: 10.1128/msystems.00658-20

Alongi D M. 1987. The influence of mangrove-derived tannins on intertidal meiobenthos in tropical estuaries. Oecologia, 71(4): 537–540, doi: 10.1007/BF00379293

Alongi D M. 1990. Abundances of benthic microfauna in relation to outwelling of mangrove detritus in a tropical coastal region. Marine Ecology Progress Series, 53–63.

Alves A S, Adão H, Ferrero T J, et al. 2013. Benthic meiofauna as indicator of ecological changes in estuarine ecosystems: the use of nematodes in ecological quality assessment. Ecological Indicators, 24: 462–475, doi: 10.1016/j.ecolind.2012.07.013

Alves A S, Adão H, Patrício J, et al. 2009. Spatial distribution of subtidal meiobenthos along estuarine gradients in two southern European estuaries (Portugal). Journal of the Marine Biological Association of the United Kingdom, 89(8): 1529–1540, doi: 10.1017/S0025315409000691

Ansari Z A, Parulekar A H. 1993. Distribution, abundance and ecology of the meiofauna in a tropical estuary along the west coast of India. Hydrobiologia, 262(2): 115–126, doi: 10.1007/BF00007512

Armenteros M, Martín I, Williams J P, et al. 2006. Spatial and temporal variations of meiofaunal communities from the western sector of the Gulf of Batabanó, Cuba. Ⅰ. Mangrove systems. Estuaries and Coasts, 29(1): 124–132, doi: 10.1007/BF02784704

Austen M C, Lambshead P J D, Hutchings P A, et al. 2002. Biodiversity links above and below the marine sediment–water interface that may influence community stability. Biodiversity & Conservation, 11(1): 113–136, doi: 10.1023/A:1014098917535

Bhadury P, Mondal N, Ansari K G M T, et al. 2015. Checklist of free-living marine nematodes from intertidal sites along the central west coast of India. Check List, 11(2): 1605, doi: 10.15560/11.2.1605

Bhaskara Rao V, Narasimha Rao G M, Sarma G V S, et al. 1992. Mangrove environment and its sediment characters in Godavari estuary, east coast of India. Indian Journal of Marine Sciences, 21(1): 64–66

Burgess R. 2001. An improved protocol for separating meiofauna from sediments using colloidal silica sols. Marine Ecology Progress Series, 214: 161–165, doi: 10.3354/meps214161

Chinnadurai G, Fernando O J. 2003. Meiofauna of Pitchavaram mangroves along southeast coast of India. Journal of the Marine Biological Association of India, 45(2): 158–165

Chinnadurai G, Fernando O J. 2007. Meiofauna of mangroves of the southeast coast of India with special reference to the free-living marine nematode assemblage. Estuarine, Coastal and Shelf Science, 72(1–2): 329–336, doi: 10.1016/j.ecss.2006.11.004

Clarke K R, Gorley R N. 2015. PRIMER v7: User Manual/Tutorial. PRIMER-E, Plymouth, 296

Coull B C. 1988. Ecology of the marine meiofauna. In: Higgins R P, Thiel H, eds. Introduction to the Study of Meiofauna. Washington: Smithsonian Institution Press, 18–38

Coull B C. 1999. Role of meiofauna in estuarine soft-bottom habitats. Australian Journal of Ecology, 24(4): 327–343

Coull B C, Chandler G T. 1992. Pollution and meiofauna: field, laboratory, and mesocosm studies. Oceanography and Marine Biology: An Annual Review, 30: 191–271

Conway D V P, White R G, Hugues-Dit-Ciles J. et al. 2003. Guide to the coastal and surface zooplankton of the southwestern Indian Ocean. Occasional Publication of the Marine Biological Association 15

Cuny P, Jezequel R, Michaud E, et al. 2020. Oil spill response in mangroves: Why a specific ecosystem-based management is required? The case of French Guiana-A mini-review. Vie et Milieu/Life & Environment, 70(3–4): 69–76

Dal Zotto M, Santulli A, et al. 2016. Organic enrichment effects on a marine meiofauna community, with focus on Kinorhyncha. Zoologischer Anzeiger-A Journal of Comparative Zoology, 265: 127–140

Danovaro R, Gambi C, Croce N D. 2002. Meiofauna hotspot in the Atacama Trench, eastern South Pacific Ocean. Deep-Sea Research Part Ⅰ: Oceanographic Research Papers, 49(5): 843–857, doi: 10.1016/S0967-0637(01)00084-X

Danovaro R, Gambi C, Dell'Anno A, et al. 2008. Exponential decline of deep-sea ecosystem functioning linked to benthic biodiversity loss. Current Biology, 18(1): 1–8, doi: 10.1016/j.cub.2007.11.056

Day J H. 1968. A Monograph on the Polychaeta of Southern Africa Part 1, Errantia: Part 2, Sedentaria Published by the Trustees of the British Museum (Natural History), London, 1967 Publication no. 656. Pp. viii 878. Price£ 15. Journal of the Marine Biological Association of the United Kingdom, 48(3): 836

Della Patrona L, Marchand C, Hubas C, et al. 2016. Meiofauna distribution in a mangrove forest exposed to shrimp farm effluents (New Caledonia). Marine Environmental Research, 119: 100–113, doi: 10.1016/j.marenvres.2016.05.028

De Troch M, Roelofs M, Riedel B, et al. 2013. Structural and functional responses of harpacticoid copepods to anoxia in the Northern Adriatic: an experimental approach. Biogeosciences, 10(6): 4259–4272, doi: 10.5194/bg-10-4259-2013

dos Santos T B L, Baia E, & Venekey V. 2023. Effect of sediment on meiofauna and Nematoda structure in different freshwater Amazon environments under the influence of mesotides. Journal of the Marine Biological Association of the United Kingdom, 103, e75

Dirberg G, Barnaud G, Brivois O, et al. 2020. Towards the development of ecosystem-based indicators of mangroves functioning state in the context of the EU water framework directive. Vie et Milieu/Life & Environment, 70(3–4): 303–310

Dissanayake N, Chandrasekara U. 2014. Effects of mangrove zonation and the physicochemical parameters of soil on the distribution of macrobenthic fauna in Kadolkele mangrove forest, a tropical mangrove forest in Sri Lanka. Advances in Ecology, 2014: 564056, doi: 10.1155/2014/564056

Duke N C, Pinzón M Z S, Prada T M C. 1997. Large-scale damage to mangrove forests following two large oil spills in Panama. BioTropica, 29(1): 2–14, doi: 10.1111/j.1744-7429.1997.tb00001.x

Essink K, Keidel H. 1998. Changes in estuarine nematode communities following a decrease of organic pollution. Aquatic Ecology, 32(3): 195–202, doi: 10.1023/A:1009901207217

Fauchald K, Jumars P A. 1979. The diet of worms: a study of polychaete feeding guilds. Oceanography and Marine Biology: An Annual Review, 17: 193–284

Fauvel P. 1953. The fauna of India including Pakistan, Ceylon, Burma, Malaya. Annelida Polychaeta. Indian Press, Allahabad. 12, 507

Ferrero T J, Debenham N J, Lambshead P J D. 2008. The nematodes of the Thames estuary: assemblage structure and biodiversity, with a test of Attrill's linear model. Estuarine, Coastal and Shelf Science, 79(3): 409–418, doi: 10.1016/j.ecss.2008.04.014

Friess D A, Gatt Y M, Fung TK, et al. 2023. Blue carbon science, management and policy across a tropical urban landscape. Landscape and Urban Planning, 230, 104610

Fu Sujing, Rao Yiyong, Chen Xinwei, et al. 2021. Comparison of benthic nematode assemblages in native mangrove forest and exotic mangrove plantations (Sonneratia apetala Buch-Ham) along the South China Coast. Marine Pollution Bulletin, 166: 112249, doi: 10.1016/j.marpolbul.2021.112249

Ghosh M, Mandal S. 2019. Does vertical distribution of meiobenthic community structure differ among various mangrove habitats of Sundarban Estuarine System?. Regional Studies in Marine Science, 31: 100778, doi: 10.1016/j.rsma.2019.100778

Ghosh M, Mandal S, Chatterjee M. 2018. Impact of unusual monsoonal rainfall in structuring meiobenthic assemblages at Sundarban estuarine system, India. Ecological Indicators, 94: 139–150, doi: 10.1016/j.ecolind.2018.06.067

Ghosh M, Mandal S. 2021. Disentangling the effect of seasonal dynamics on meiobenthic community structure from River Matla of Sundarbans Estuarine System, India. Frontiers in Marine Science, 8, 671372

Giere O. 2009. Meiobenthology: The Microscopic Motile Fauna of Aquatic Sediments. 2nd ed. Berlin: Springer-Verlag

Goldin Q, Mishra V, Ullal V, et al. 1996. Meiobenthos of mangrove mudflats from shallow region of Thane creek, central west coast of India. Indian Journal of Marine Sciences, 25(2): 137–141

Gwyther J. 2000. Meiofauna in phytal-based and sedimentary habitats of a temperate mangrove ecosystem-A preliminary survey. Proceedings of the Royal Society of Victoria, 112(2): 137–151

Hallock P, Lidz B H, Cockey-Burkhard E M, et al. 2003. Foraminifera as bioindicators in coral reef assessment and monitoring: The FORAM index. Environmental Monitoring and Assessment, 81(1): 221–238, doi: 10.1023/A:1021337310386

Harguinteguy C A, Cofré M N, De Ward C T P. 2012. Change in the meiofauna community structure of sandy beaches of the Nuevo Gulf (Chubut, Argentina). Papéis Avulsos de Zoologia, 52(34): 411–422, doi: 10.1590/S0031-10492012021400001

Heip C, Vincx M, Vranken G. 1985. The ecology of marine nematodes. Oceanography and Marine Biology: An Annual Review, 23: 399–489

Higgins R P, Thiel H. 1988. Introduction to the Study of Meiofauna. Washington: Smithsonian Institution Press

Hongayo M C, Abad L A A, Acuesta T R, et al. 2013. Marine meiofauna in Songculan Lagoon, Songculan, Dauis, Bohol Philippines. Journal of Entomology and Zoology Studies, 1(3): 47–51

Hourston M, Potter I C, Warwick R M, et al. 2011. The characteristics of the nematode faunas in subtidal sediments of a large microtidal estuary and nearshore coastal waters differ markedly. Estuarine, Coastal and Shelf Science, 94(1): 68–76, doi: 10.1016/j.ecss.2011.05.022

Hultman M. 2017. Distribution of Meiofaunal biodiversity and abundance in relation to development stage of the Mangrove Forest [dissertation]. Lund: Lund University

Ingels J, Kiriakoulakis K, Wolff G A, et al. 2009. Nematode diversity and its relation to the quantity and quality of sedimentary organic matter in the deep Nazaré Canyon, Western Iberian Margin. Deep-Sea Research Part Ⅰ: Oceanographic Research Papers, 56(9): 1521–1539, doi: 10.1016/j.dsr.2009.04.010

Kasturirangan L R. 1963. A Key for the Identification of the More Common Planktonic Copepoda of Indian Coastal Waters. New Delhi: Council of Scientific and Industrial Research

Kathiresan K. 2002. Greening the blue mud!. Revista de Biologia Tropical, 50(3–4): 869–874

Kathiresan K, Bingham B L. 2001. Biology of mangroves and mangrove ecosystems. Advances in Marine Biology, 40: 81–251, doi: 10.1016/S0065-2881(01)40003-4

Kennish M J. 1994. The Ecology of Estuaries: Anthropogenic Effects. Boca Raton: CRC Press

Kondalarao B. 1984. Distribution of meiobenthic harpacticoid copepods in Gautami-Godavari estuarine system. Indian Journal of Marine Sciences, 13: 80–84

Kondalarao B, Murty K V R. 1988. Ecology of intertidal meiofauna of the Kakinada Bay (Gautami-Godavari estuarine system), east coast of India. Indian Journal of Marine Sciences, 17(1): 40–47

Krishnamurthy K, Sultan Ali M A, Jeyaseelan M J P. 1984. Structure, dynamics of the aquatic food web community with special reference to nematodes in mangrove ecosystem. In: Soepadmo E, Rao A N, MacIntosh D J, eds. Proceedings of the Asian Symposium on Mangrove Environment: Research, Management. 429–452

Lambshead P J D, Brown C J, Ferrero T J, et al. 2002. Latitudinal diversity patterns of deep-sea marine nematodes and organic fluxes: a test from the central equatorial Pacific. Marine Ecology Progress Series, 236: 129–135, doi: 10.3354/MEPS236129

Landers S C, Romano F A, Stewart P M, et al. 2012. A multiyear survey of meiofaunal abundance from the northern Gulf of Mexico continental shelf and slope. Gulf of Mexico Science, 30(1): 20–29, doi: 10.18785/goms.3001.04

Leduc D, Pilditch C A. 2013. Effect of a physical disturbance event on deep-sea nematode community structure and ecosystem function. Journal of Experimental Marine Biology and Ecology, 440: 35–41, doi: 10.1016/J.JEMBE.2012.11.015

Leduc D, Rowden A A, Nodder S D, et al. 2014. Unusually high food availability in Kaikoura Canyon linked to distinct deep-sea nematode community. Deep-Sea Research

Part Ⅱ: Topical Studies in Oceanography, 104: 310–318, doi: 10.1016/j.dsr2.2013.06.003

Leduc D, Brown J C, Bury S J, & Lörz A N. 2015. High intraspecific variability in the diet of a deep-sea nematode: stable isotope and fatty acid analyses of Deontostoma tridentum on Chatham Rise, Southwest Pacific. Deep Sea Research Part Ⅰ: Oceanographic Research Papers, 97: 10−18

Lee Z, Marra J, Perry M J, et al. 2015. Estimating oceanic primary productivity from ocean color remote sensing: a strategic assessment. Journal of Marine Systems, 149: 50–59, doi: 10.1016/j.jmarsys.2014.11.015

Lepš J, Šmilauer P. 2003. Multivariate Analysis of Ecological Data Using CANOCO. Cambridge: Cambridge University Press

Lima dos Santos T B, Baia E, Venekey V. 2023. Effect of sediment on meiofauna and Nematoda structure in different freshwater Amazon environments under the influence of mesotides. Journal of the Marine Biological Association of the United Kingdom, 103: e75, doi: 10.1017/S0025315423000656

Majdi N, Colls M, Weiss L, et al. 2020. Duration and frequency of non-flow periods affect the abundance and diversity of stream meiofauna. Freshwater Biology, 65(11): 1906–1922, doi: 10.1111/fwb.13587

Maria T, Esteves A, Garraffoni A, et al. 2023. Meiofauna biodiversity. In: Amaral A C Z, Checon H H, Corte G N, eds. Brazilian Sandy Beaches. Cham: Springer, 57–90, doi: 10.1007/978-3-031-30746-1_3

McCave I N, Syvitski J P M. 1991. Principles and methods of geological particle size analysis. In: Syvitski J P M, ed. Principles, Methods and Application of Particle Size Analysis. Cambridge: Cambridge University Press, 3–21

McIntyre A D. 1969. Ecology of marine meiobenthos. Biological Reviews, 44(2): 245–288, doi: 10.1111/j.1469-185X.1969.tb00828.x

Moens T, Herman P, Verbeeck L, et al. 2000. Predation rates and prey selectivity in two predacious estuarine nematode species. Marine Ecology Progress Series, 205: 185–193, doi: 10.3354/MEPS205185

Moens T, Vincx M. 1997. Observations on the feeding ecology of estuarine nematodes. Journal of the Marine Biological Association of the United Kingdom, 77(1): 211–227, doi: 10.1017/S0025315400033889

Mokievsky V O, Tchesunov A V, Udalov A A, et al. 2011. Quantitative distribution of meiobenthos and the structure of the free-living nematode community of the mangrove intertidal zone in Nha Trang Bay (Vietnam) in the South China Sea. Russian Journal of Marine Biology, 37(4): 272–283, doi: 10.1134/S1063074011040109

Moreno M, Vezzulli L, Marin V, et al. 2008. The use of meiofauna diversity as an indicator of pollution in harbours. ICES Journal of Marine Science, 65(8): 1428–1435, doi: 10.1093/ICESJMS/FSN116

Nair M N M, Ramachandran K K. 2002. Textural and trace elemental distribution in sediments of the Beypore estuary (SW coast of India) and adjoining innershelf. Indian Journal of Marine Sciences, 31(4): 295–304

Narasimha Rao G M, Rangaiah G S. 2010. Distribution of mangroves and associated flora of the Pandi back waters of Gautami Godavari estuary. ANU Journal of Natural Sciences, 1(1): 22–26

Nemys. 2025. Nemys: World Database of Nematodes. doi: 10.14284/366

Netto S A, Gallucci F. 2003. Meiofauna and macrofauna communities in a mangrove from the Island of Santa Catarina, South Brazil. Hydrobiologia, 505(1–3): 159–170, doi: 10.1023/B:HYDR.0000007304.22992.b2

Pandiya Rajan R S, Gera A, Ramu K, et al. 2022. Influence of salinity on the meiofaunal distribution in a hypersaline lake along the southeast coast of India. Environmental Monitoring and Assessment, 194(3): 199, doi: 10.1007/s10661-022-09829-5

Pinto T K, Austen M C, Warwick R M, et al. 2013. Nematode diversity in different microhabitats in a mangrove region. Marine Ecology, 34(3): 257–268, doi: 10.1111/maec.12011

Platt H M, Warwick R M, Furstenberg J P. 1985. Free-living marine nematodes. Part 1 British Enoplids. South African Journal of Zoology, 20(3): 177, doi: 10.1080/02541858.1985.11447932

Pusceddu A, Gambi C, Corinaldesi C, et al. 2014. Relationships between meiofaunal biodiversity and prokaryotic heterotrophic production in different tropical habitats and oceanic regions. PLoS One, 9(3): e91056, doi: 10.1371/journal.pone.0091056

Punniyamoorthy R, Murugesan P, Mahadevan G, Sanchez, A. 2021. Benthic meiofaunal diversity in four zones of Pichavaram Mangrove Forest, India. Journal of Foraminiferal Research, 51(4): 294−307

Ranga Rao V, Reddy B S R, Raman A V, et al. 2003. Oceanographic features of the Bay-mangrove waterways of Coringa, east coast of India. Proceedings of AP Akademi of Sciences, 7(2): 135–142

Rao V V, Anjaneyulu M, Nagulu V, et al. 2004. Water fowl status at Coringa Wildlife Sanctuary, Andhra Pradesh. ENVIS Newsletter, 10(4): 7–12

Raut D, Ganesh T, Murty N V S S, et al. 2005. Macrobenthos of Kakinada Bay in the Godavari delta, East coast of India: comparing decadal changes. Estuarine, Coastal and Shelf Science, 62(4): 609–620, doi: 10.1016/j.ecss.2004.09.029

Romañach S S, DeAngelis D L, Koh H L, et al. 2018. Conservation and restoration of mangroves: Global status, perspectives, and prognosis. Ocean and Coastal Management, 154: 72–82, doi: 10.1016/j.ocecoaman.2018.01.009

Roy S D, Krishnan P. 2005. Mangrove stands of Andamans vis-à-vis tsunami. Current Science, 89(11): 1800–1804

Ruiz F, Abad M, Bodergat A M. et al. 2005. Marine and brackish-water ostracods as sentinels of anthropogenic impacts. Earth-Science Reviews, 72(1–2): 89–111

Rzeznik-Orignac J, Fichet D, Boucher G. 2003. Spatio-temporal structure of the nematode assemblages of the Brouage mudflat (Marennes Oléron, France). Estuarine, Coastal and Shelf Science, 58(1): 77–88, doi: 10.1016/S0272-7714(03)00061-1

Sahoo G, Suchiang S R, Ansari Z A. 2013. Meiofauna-Mangrove interaction: a pilot study from a tropical mangrove habitat. Cahiers de Biologie Marine, 54(3): 349–358

Sanders H L. 1958. Benthic studies in Buzzards Bay. 1. Animal-sediment relationships. Limnology and Oceanography, 3(3): 245–258

Santos R, Duque-Núñez N, De Los santos C B, et al. 2019. Superficial sedimentary stocks and sources of carbon and nitrogen in coastal vegetated assemblages along a flow gradient. Scientific Reports, 9(1): 610, doi: 10.1038/s41598-018-37031-6

Sarma A L N, Wilsanand V. 1994. Littoral meiofauna of Bhitarkanika mangroves of river Mahanadi system, east coast of India. Indian Journal of Marine Sciences, 23: 221–224

Satyanarayana J E, Krishna P V. 2017. Assessment of water quality in terms of physico-chemical parameters of East Godavari mangrove ecosystem (Coringa Wildlife Sanctuary) East Godavari, Andhra Pradesh, India. International Journal of Advanced Research, 5(1): 782–788, doi: 10.21474/IJAR01/2814

Sawangarreruks S, Yaowasooth P, Poovachiranon S. 2011. Nematode diversity at Thachin River mouth, Samut Sakhon, Thailand. Publications of the Seto Marine Biological Laboratory, 41: 25–34

Schmidt C, Arbizu P M. 2015. Unexpectedly higher metazoan meiofauna abundances in the Kuril-Kamchatka trench compared to the adjacent abyssal plains. Deep-Sea Research Part Ⅱ: Topical Studies in Oceanography, 111: 60–75, doi: 10.1016/j.dsr2.2014.08.019

Samir A M. 2000. The response of benthic foraminifera and ostracods to various pollution sources: a study from two lagoons in Egypt. The Journal of Foraminiferal Research, 30(2): 83–98

Schratzberger M, Danovaro R, Ingels J, et al. 2023. Hidden players-meiofauna mediate ecosystem effects of anthropogenic disturbances in the ocean. In: Giere O, Schratzberger M, eds. New Horizons in Meiobenthos Research: Profiles, Patterns and Potentials. Cham: Springer, 175–255, doi: 10.1007/978-3-031-21622-0_7

Seinhorst J W. 1959. A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. Nematologica, 4(1): 67–69, doi: 10.1163/187529259x00381

Selvam V, Azariah J, Azariah H. 1992. Diurnal variation in physical-chemical properties and primary production in the interconnected marine, mangrove and freshwater biotopes of Kakinada coast, Andhra Pradesh, India. Hydrobiologia, 247(1): 181–186, doi: 10.1007/978-94-017-3288-8_19

Semprucci F, Balsamo M, Sandulli R. 2016. Assessment of the ecological quality (EcoQ) of the Venice lagoon using the structure and biodiversity of the meiofaunal assemblages. Ecological Indicators, 67: 451–457, doi: 10.1016/j.ecolind.2016.03.014

Semprucci F, Gravina M F, Magni P. 2019. Meiofaunal dynamics and heterogeneity along salinity and trophic gradients in a Mediterranean transitional system. Water, 11(7): 1488, doi: 10.3390/w11071488

Shao Wenhua, Chen Zhongli, Shao Ying. 2023. Intergrading water quality parameters, benthic fauna and acute toxicity test for risk assessment on an urban-rural river. Sustainability, 15(8): 6423, doi: 10.3390/su15086423

Snelgrove P V R. 1999. Getting to the bottom of marine biodiversity: Sedimentary habitats: Ocean bottoms are the most widespread habitat on Earth and support high biodiversity and key ecosystem services. BioScience, 49(2): 129–138

Soltwedel T. 2000. Metazoan meiobenthos along continental margins: a review. Progress in Oceanography, 46(1): 59–84, doi: 10.1016/S0079-6611(00)00030-6

Somerfield P J, Gee J M, Aryuthaka C. 1998. Meiofaunal communities in a Malaysian mangrove forest. Journal of the Marine Biological Association of the United Kingdom, 78(3): 717–732, doi: 10.1017/S0025315400044738

Somerfield P J, Warwick R M, Moens T. 2005. Meiofauna techniques. In: Eleftheriou A, McIntyre A, eds. Methods for the Study of Marine Benthos. 3rd ed. Oxford: Blackwell, 229–272

Steyaert M, Vanaverbeke J, Vanreusel A, et al. 2003. The importance of fine-scale, vertical profiles in characterising nematode community structure. Estuarine, Coastal and Shelf Science, 58(2): 353–366

Sultan-Ali M A, Krishnamurthy K, Jeyaseelan M J. 1983. Energy flow through the benthic ecosystem of the mangroves with special reference to nematodes. Mahasagar, 16(3): 317–325

Thilagavathi B, Das B, Saravanakumar A, et al. 2011. Benthic meiofaunal composition and community structure in the Sethukuda mangrove area and adjacent open sea, east coast of India. Ocean Science Journal, 46(2): 63–72, doi: 10.1007/s12601-011-0006-y

Thornton S R, Johnstone R W. 2015. Mangrove rehabilitation in high erosion areas: assessment using bioindicators. Estuarine, Coastal and Shelf Science, 165: 176–184, doi: 10.1016/j.ecss.2015.05.013

Torres-Pratts H, Schizas N V. 2007. Meiofaunal colonization of decaying leaves of the red mangrove *Rhizophora mangle*, in southwestern Puerto Rico. Caribbean Journal of Science, 43(1): 127–137, doi: 10.18475/cjos.v43i1.a12

Tripathy S C, Ray A K, Patra S, et al. 2005. Water quality assessment of Gautami-Godavari mangrove estuarine ecosystem of Andhra Pradesh, India during September 2001. Journal of Earth System Science, 114(2): 185–190, doi: 10.1007/BF02702020

Walkley A, Black I A. 1934. An examination of the degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science, 37(1): 29–38, doi: 10.1097/00010694-193401000-00003

Warwick R M, Dexter D M, Kuperman B. 2002a. Freeliving nematodes from the Salton Sea. Hydrobiologia, 473(1–3):

121–128, doi: 10.1023/A:1016533801827

Warwick R M, Dexter D M, Kuperman B. 2002b. Freeliving nematodes from the Salton Sea-Part Ⅱ. Hydrobiologia, 473

Warwick R M, Platt H M, Somerfield P J. 1998. Free-living marine nematodes. Part Ⅲ: British monhysterids. Synopses of the British Fauna (New Series) No. 53. Shrewsbury: Field Studies Council, 296

Wieser W. 1953. Die Beziehung zwischen Mundhohlengestalt, Ernahrungsweise und Vorkommen bei freilebenden marinen Nematoden: eine ökologisch-morphologische Studie. Arkiv för Zoologi, 4(2): 439–484

Wieser W. 1960. Benthic studies in Buzzards Bay. Ⅱ. The meiofauna. Limnology and Oceanography, 5(2): 121–137

Xuan Q N, Vanreusel A, Thanh N V. et al. 2007. Biodiversity of meiofauna in the intertidal Khe Nhan mudflat, Can Gio mangrove forest, Vietnam with special emphasis on free living nematodes. Ocean Science Journal, 42(3): 135–152

Yasuhara M, Yamazaki H, Irizuki T, et al. 2003. Temporal changes of ostracode assemblages and anthropogenic pollution during the last 100 years, in sediment cores from Hiroshima Bay, Japan. The Holocene, 13(4): 527–536, doi: 10.1191/0959683603hl643rp

Zar J H. 2010. Biostatistical Analysis. 5th ed. Englewood Cliffs, NJ: Prentice-Hall

Zeppilli D, Sarrazin J, Leduc D, et al. 2015. Is the meiofauna a good indicator for climate change and anthropogenic impacts?. Marine Biodiversity, 45(3): 505–535, doi: 10.1007/s12526-015-0359-z

Zhang Zhinan, Zhou Hong, Hua Er, et al. 2017. Meiofauna study for the forty years in China–Progress and prospect. Oceanologia et Limnologia Sinica (in Chinese), 48(4): 657–671, doi: 10.11693/hyhz20170100022

Zhao Meihong, Liu Xiaoshou. 2021. Taxa composition and distribution patterns of meiofauna in the intertidal zones of Shandong Peninsula. Journal of Liaocheng University (Natural Science Edition) (in Chinese), 34(5): 100–110, doi: 10.19728/j.issn1672-6634.2021.05.013

Zhou Hong, Abdul K M, Yu Qing, et al. 2023. Detection of global change with meiofauna and its benthic environment in a shelf sea cold water mass ecosystem. Regional Studies in Marine Science, 62, 102918

Zullini A, Loof P A A, Bongers T. 2001. Standardizing nematode morphometrics. Nematologia Mediterranea, 29(1): 11–12