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Research article

A Study of Infaunal Abundance, Diversity and Distribution in Chettuva Mangrove, Kerala, India

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Abstract: This study investigates an account on the diversity and abundance of benthic infauna of Chettuva mangrove in Kerala. Marine benthic infaunal species are an important factor in marine ecosystems and play a chief ecological function in the mangrove ecosystem. This research article gives an overview of infaunal diversity associated with eight sites of Chettuva mangrove. The present study revealed that infaunal species are significantly moderate within this mangrove ecosystem.

Keywords: Polychaetes; infauna; mangrove; population density; statistical analysis

1. Introduction

Mangroves are a precise coastal ecosystem contributing as a wealthy store of resident biodiversity. The diversity of the benthic infauna is largely underestimated and must undergo regular revision in order to detect and monitor changes of benthic communities within the area.

The benthic communities constitute a dominant component that supports habitat productivity to a greater extent. Due to this, the species composition may negatively affect the resident community and consequently impact trophic relationships within these communities as a result of any activity exerted, causing a change for sediment features [1,2]. Zainal et al. and Ali et al. pointed out that the macrobenthic faunal diversity around the Huwar islands [3,4] and Bahrain are very important in ecosystem balancing. Other regions, such as Europe [5,6], North America [7,8] and South Africa, have produced monographs for faunal identification [9]. However, most of the benthic faunal communities have not yet been thoroughly explored in India.

Kerala is gifted with a long coastal line and extensive estuaries. Estuarine water contains a rich supply of nutrients. No comprehensive study has been done so far on benthic infaunal biodiversity and abundance in this Chettuva mangrove area.

2. Material and methods

2.1. Collection of water and sediment samples

The present study was designed to characterize the benthic infauna community of eight different sites in Chettuva mangrove, Kerala, as seen in Figure 1. Biological samples from each station, three replicate samples, were collected using benthic grab sampler. The procedure adopted for sampling was following the method of Mackie [10]. After collecting the samples, they were emptied into a plastic tray. The larger organisms were handpicked (extracted) immediately from the sediments and then sieved through 0.5 mm mesh screen. The organisms retained by the sieve were placed in a labelled container and fixed in 5%–7% formalin. Subsequently, the organisms were stained with Rose Bengal solution (0.1 g in 100 ml of distilled water) for greater visibility during sorting. All the species were sorted, enumerated and identified to the advanced possible level with the consultation of available literature. The works of Fauvel and Day and http://www.marinespecies.org/polychaeta/ were referred for identification [11].

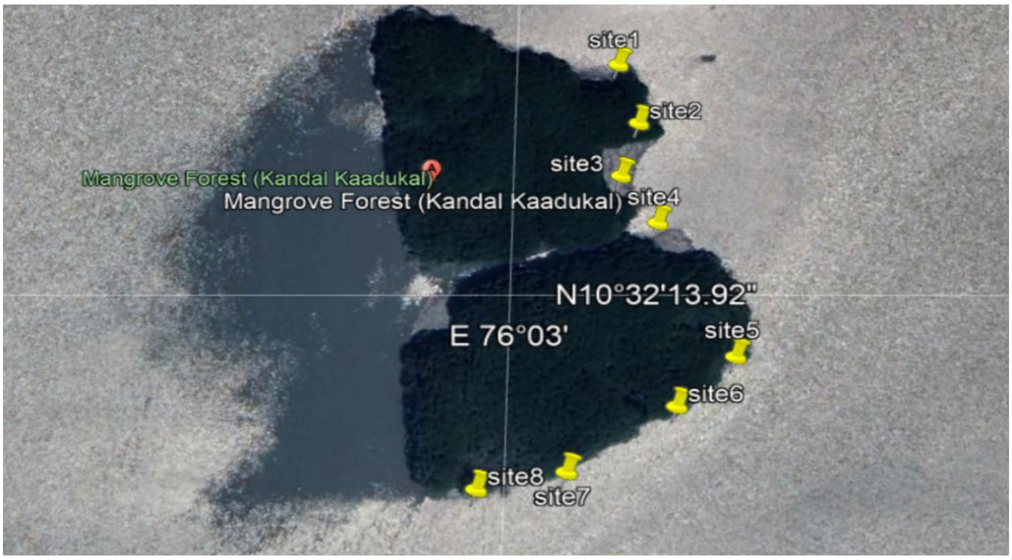

Figure 1. A Chettuva Mangrove map showing eight different sites of collection.

2.2. Statistical analyses

Statistical software was used to analyze the data obtained from different sites [12]. This was done using various statistical methods, such as univariate, multivariate and graphical/distributional methods. Biodiversity indices were calculated for the infaunal community, which included diversity index (H') using the method of Shannon-Wiener's [13] formula, species richness (d) using the Margalef [14] formula and species evenness (J') using the Pielou [15] formula. Similarities (or dissimilarities) between sites were obtained showing the interrelationships of all through an MDS plot (non-metric Multi-Dimensional Scaling) [16,17]. Cluster analysis was also done to calculate the similarities. All the various statistical methodologies and calculations were obtained through the software PRIMER V7 (Plymouth Routines in Multivariate Ecological Research) developed by Plymouth Marine Laboratory.

3. Results

3.1. Species Composition in Chettuva Mangrove

A total of 339 organisms were identified from eight samples, spanning 40 taxa from four phyla (Tables 1 & 2), representing an average of 42 specimens per sample. The species composition by phylum within the Chettuva Mangrove area was predominated by annelids with 72.27% (Figure 2). Arthropods formed the second most important group, represented by 15.93%. Mollusca constituted 9.73%, and the fourth important group was the Echinodermata, which comprised of 2.06%. Annelids composed the majority of the infaunal species composition (Table 1).

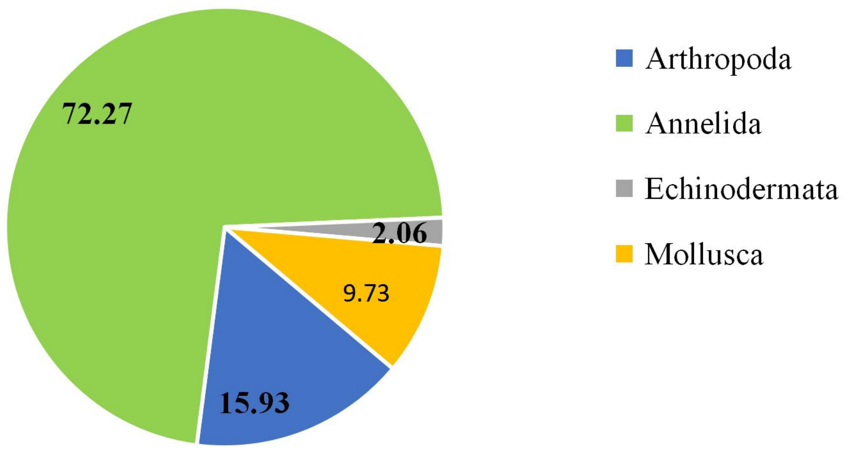

Figure 2. Infauna species composition by phylum level in the Chettuva Mangrove area.

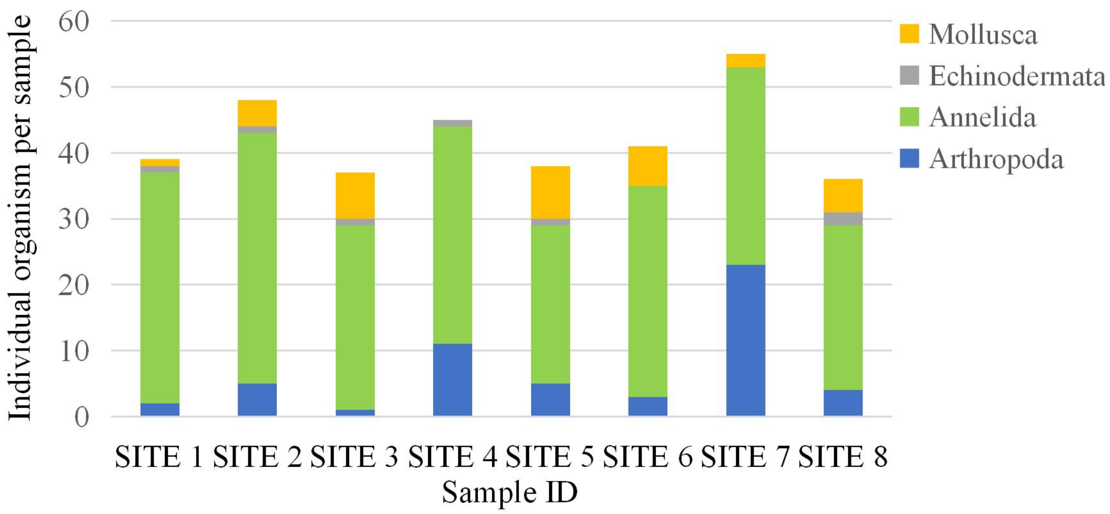

Figure 3: Total number of individuals per site.

Among all the eight stations, Site 7 is the most abundant and diverse, with 55 individuals across 19 taxa. Capitellidae was the most numerous family, indicating a clear dominance. Samples with common abundant taxa are presented in Figure 3. Within the polychaetes, Capitellidae, Opheliidae, Spionidae and Terebellidae were found to be the most recurring species in the samples collected within this mangrove ecosystem. With respect to arthropods, *Anoplodactylus* sp. and Apseudidae were the most abundant species.

Table 1. Taxonomic breakdown of infauna in the Chettuva Mangrove area.

Phylum	Number of Taxa	Relative abundance (%)
Annelida	22	72.27
Arthropoda	13	15.93
Mollusca	4	9.73
Echinodermata	1	2.06
Total	40	100

Figure 4. *Branchiostoma lanceolatum*, Terebellidae, Capitellidae, *Anoplodactylus* sp., Sabellidae, and Lumbrineridae.

3.2. Dominance

Figure 5 represents the k-dominance curves for each station at each area. These plots illustrate the cumulative abundance of infauna plotted against the species rank. The curves are formulated from both a richness measure (species rank) and an evenness measure (% cumulative dominance).

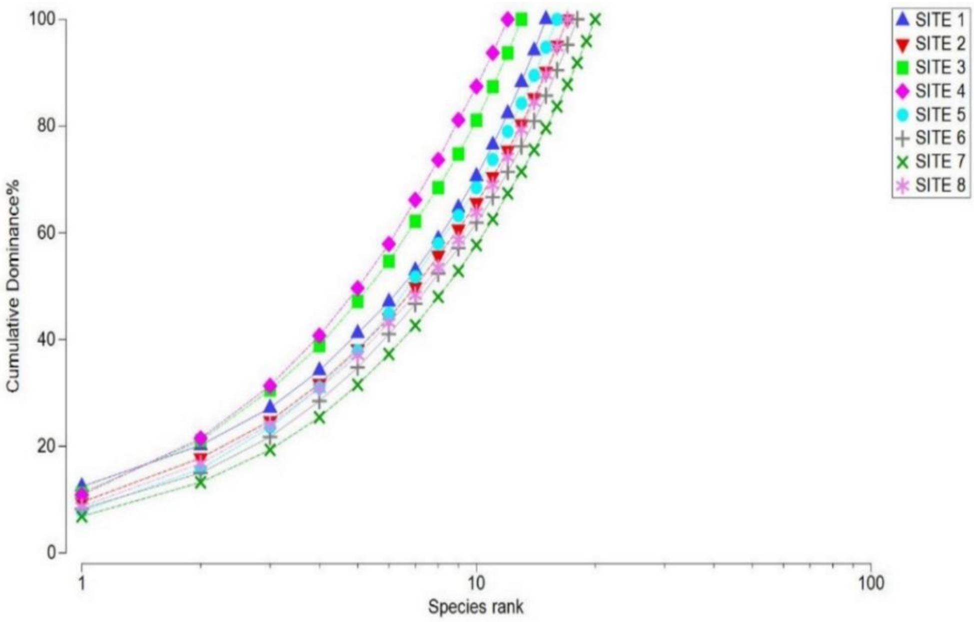

Figure 5. Dominance plots of benthic Infaunal taxa in the Chettuva Mangrove area.

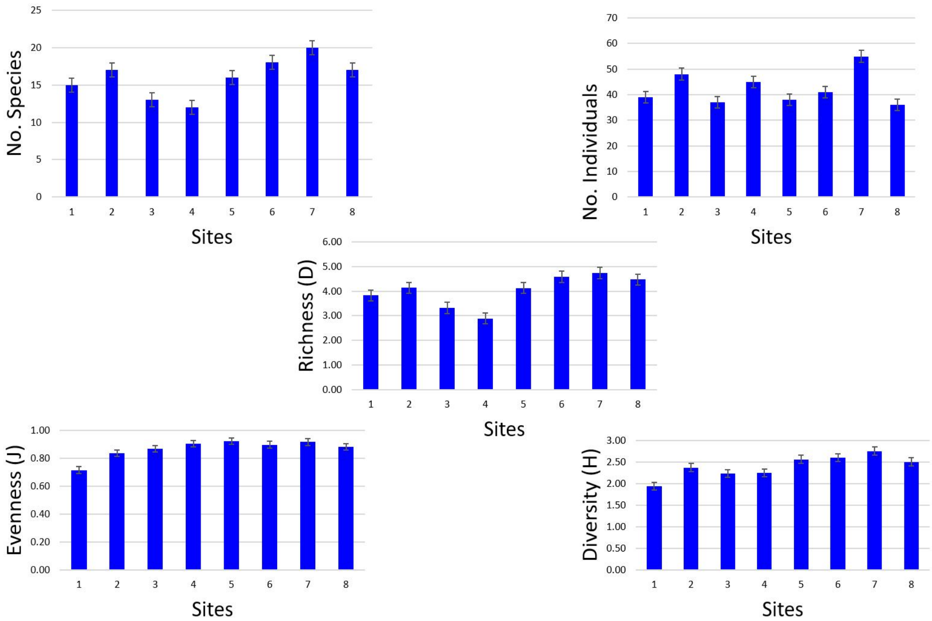

Figure 6. Biodiversity indices of infaunal benthic community in the Chettuva Mangrove area.

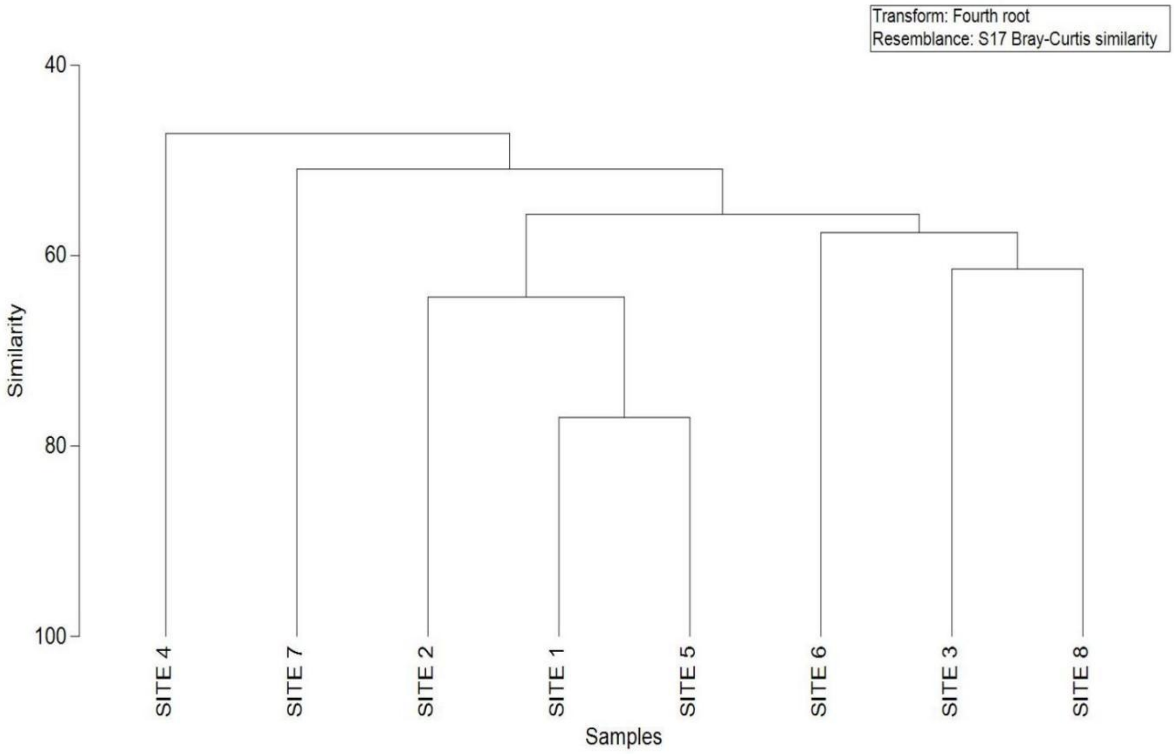

Figure 7. Dendrogram of benthic infaunal communities by site, based on Bray-Curtis similarity.

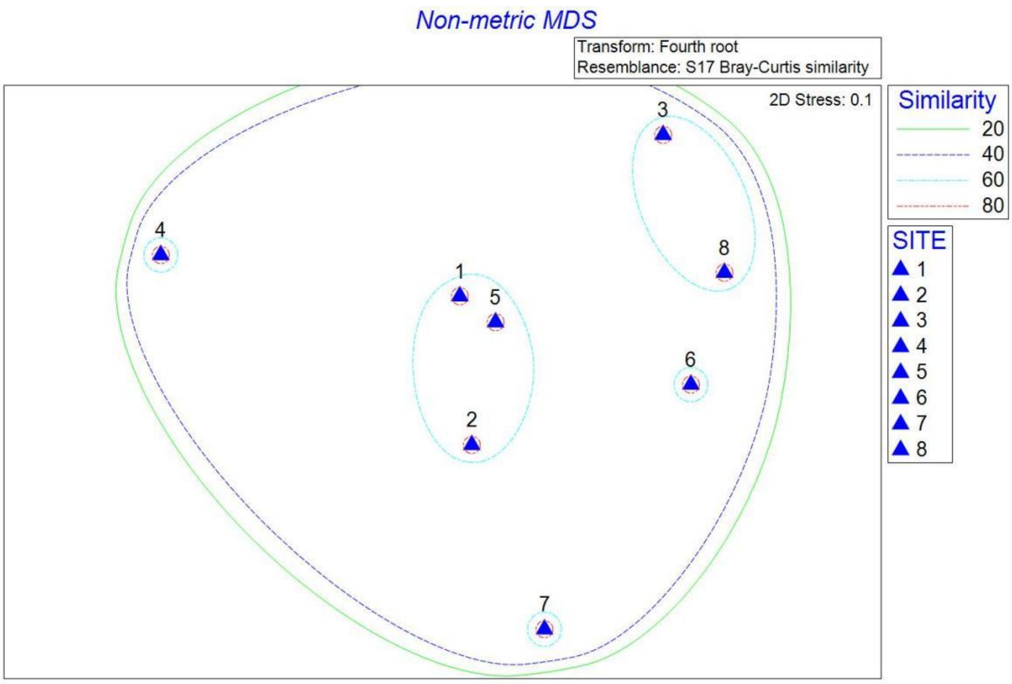

Figure 8: MDS Plot of benthic infaunal communities by site, based on Bray-Curtis similarity.

The results of the dendrogram show that species from these eight sites were grouped to two major categories (Figure 7). Among these sites, site 4, site 6, and site 7 form a separate group while all other sites are branched to from a major group.

Table 2. Infaunal taxa and its distribution in the Chettuva Mangrove area.

Taxon	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7	SITE 8
Golfingia sp.	-	4	1	-	-	-	1	4
Sipunculidae	-	1	-	2	-	1	-	-
Phascolosoma sp.	-	1	1	-	1	-	-	-
Phyllodocidae	1	-	1	-	-	1	-	-
Nephtyidae	-	-	-	-	-	1	3	-
Syllidae	1	2	-	-	3	-	5	-
Nereididae	-	-	2	-	-	4	-	1
Sigalionidae	-	2	-	3	-	-	-	-
Polynoidae	1	-	-	-	1	-	-	-
Glyceridae	2	-	-	1	3	-	-	-
Maldanidae	-	1	-	-	-	-	-	-
Lumbrineridae	2	1	-	5	1	1	3	2
Opheliidae	1	2	3	1	5	9	2	1
Spionidae	1	-	10	9	2	1	-	1
Capitellidae	20	14	5	6	5	4	8	6
Magelonidae	-	-	-	-	-	-	-	1
Orbiniidae	1	8	-	-	1	3	5	-
Terebellidae	1	1	3	2	1	4	2	8
Flabelligeridae	-	-	-	-	-	-	-	-
Cirratulidae	1	-	-	-	-	1	-	-
Amphinomidae	-	-	2	-	-	-	-	-
Sabellidae	3	1	-	4	1	2	1	1
Anoplodactylus sp.	2	4	1	-	5	1	6	1
Hyalidae	-	1	-	-	-	-	1	-
Melitidae	-	-	-	3	-	-	4	-
Isaeidae	-	-	-	-	-	-	-	1
Ampeliscidae	-	-	-	-	-	-	1	1
Urothoe brevicornis	-	-	-	-	-	-	2	-
Leptanthuridae	-	-	-	-	-	-	-	1
Accalathura borradailei	-	-	-	-	-	1	-	-
Cirolanidae	-	-	-	-	-	-	-	-
Bodotriidae	-	-	-	-	-	-	2	-
Paranebalia sp.	-	-	-	-	-	-	1	-
Apseudidae	-	-	-	8	-	1	5	-
Paratanaidae	-	-	-	-	-	-	1	-
Amphiuridae	1	1	1	1	1	-	-	2
Ancillariidae	-	1	1	-	4	2	1	3
Pteriidae	-	-	-	-	1	-	-	-
Veneridae	-	-	-	-	-	3	-	1
Tellinidae	1	3	6	-	3	1	1	1

Table 3 shows the total abundance per site, number of species and their diversity indices; Margalef species richness, Pielou species evenness and the Shannon-Weiner diversity index. Graphs of the biodiversity indices by site can be seen in Figure 6.

The three indices provide an indication of the diversity of each of the samples based on the number of species, number of individuals and the distribution of individuals between species. A more settled community will generally have a greater number of species with individuals spread more evenly between them, while a stressed or recovering community will tend to be numerically dominated by a small number of species and have fewer species overall.

Margalef species richness index (d) is heavily influenced by the overall number of species measured, though it makes a slight allowance for the number of individuals. Higher values indicate a greater number of species per individual. Margalef species richness index (d), values are ranged between 2.89 and 4.74 showing reasonably moderate to high richness. Pielou's species evenness index (J') reflects the level of spread of the individuals between the species and lies between 0 (uneven) and 1 (even). The Shannon-Weiner diversity index (H') lies between 1.94 to 2.75, indicating an average diversity. The total number of species and individuals present was influenced by salinity regimes, sediment types, organic content food availability [18]. etc. Overall, the range of species present in all samples combined suggests a moderately high level of diversity [19–22].

Multivariate analyses were conducted to investigate resemblances in the infaunal assemblages between sites across the study area (Clarke and Gorley). A Bray-Curtis (BC) similarity matrix was used to calculate the percentage similarity between all infaunal sites based on all the species present and their abundances. The samples from each site were summed so that the focus of the analysis was on similarities and differences between locations. To ensure better representation for presence/absence of taxa rather than the analysis being dominated by the most numerous species, a fourth-root transformation was applied.

Table 3. Infaunal abundance and univariate diversity indices of all sites.

Site ID	No. of Taxa (s)	No. of Individuals (n)	Margalef Species Richness (d)	Pielou Species Evenness (J')	Shannon-Weiner Diversity (loge)(H')
SITE 1	15	39	3.82	0.72	1.94
SITE 2	17	48	4.13	0.84	2.37
SITE 3	13	37	3.32	0.87	2.23
SITE 4	12	45	2.89	0.91	2.25
SITE 5	16	38	4.12	0.92	2.56
SITE 6	18	41	4.58	0.90	2.60
SITE 7	20	55	4.74	0.92	2.75
SITE 8	17	36	4.47	0.88	2.50
Average by site	16	42	4.01	0.87	2.40

To assist with visualizing relationships between sites, the BC values have been displayed as a dendrogram (group average), in which sites where the communities are more comparable (i.e., have a higher percentage similarity value) split from one another further down the diagram.

Table 4: Similarity Percentage of sites

	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7	SITE 8
SITE 1	-	-	-	-	-	-	-	-
SITE 2	59.601	-	-	-	-	-	-	-
SITE 3	51.726	55.286	-	-	-	-	-	-
SITE 4	55.143	48.329	40.422	-	-	-	-	-
SITE 5	76.999	69.116	59.144	49.716	-	-	-	-
SITE 6	61.097	52.862	55.576	47.677	55.462	-	-	-
SITE 7	48.443	62.275	38.993	43.931	52.765	53.200	-	-
SITE 8	53.663	55.334	61.420	45.064	56.319	59.580	49.866	-

The BC values are also used to create Multi-Dimensional Scaling plots (MDS), where sites which have similar assemblages are plotted closer together, while those that are more dissimilar are plotted further apart. Fig. 8 shows an MDS plot for the Bray-Curtis matrix (fourth rooted data), with colored symbols indicating the transect type and a line added to show the 25% similarity level to assist with interpretation.

4. Discussion and conclusions

In this study, polychaetes were found to be the predominating phylum, playing a very important role in the recycling of organic materials within the mangroves. Their biomass creates the energy needed for the survival of this ecosystem, fueling aquatic benthic feeders. Bandekar et al. [23] stated that families like Nereidae, Nephthydae, Onuphidae, Eunicidae, Spoinidae, Maladanidae, Sabellidae, etc. are the major biomass producing annelids which form as an important food source for fishes and prawns. Similarly, bivalves provide stability to soil inhabitants and their diversity and species abundance.

The infaunal species found in all the sites occupy varied benthic habitats, such as, sandy, muddy and even seagrasses, indicating an adaptive feature for survival, especially among polychaetes. However, not many studies have been conducted within the Chettuva mangroves regarding infaunal diversity to impose an assertive conclusion on this.

Although that may be the case, similar studies in other mangrove fields like Bandekar et al. in Karwar Mangrove and Sarkar et al. [24] in Sunderban Biosphere Reserve Mangroves, have concluded that polychaetes carry certain features that help in the adaptation for survival. They are known to secrete mucus protecting themselves within peculiar habitats.

Several factors play a role causing a change in infaunal diversity and abundance, like competition with epifauna, predation by epifauna, poor quality of food and chemical defense by mangroves [25–27]. Seasons affect the diversity and density mostly due to salinity, water and sediment quality, inundation and waterlogging [28].

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Conflict of interest

The authors declare no conflict of interest.

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