Available online at: www.mbai.org.in doi:10.6024/jmbai.2022.64.2.2164-08

A comparative analysis of the epibiotic community on pneumatophore and artificial substratum in a mangrove ecosystem, south-west coast of India

Annie Koshy*, K. Bindu and R. Sunil Kumar
Catholicate College, Pathanamthitta-689 645, Kerala, India.

*Correspondence e-mail: anniekoshy301@gmail.com

Received: 25 Mar 2021 Revised: 05 June 2022
Accepted: 06 July 2022 Published: 03 Oct 2022

Original Article

Abstract

The occurrence and diversity of epibionts on pneumatophore and an artificial substratum were evaluated simultaneously for 120 days at the Ayiramthengu mangrove area of the Kerala coast. A total of 46 genera were recorded, including ciliates, flagellates, algae, diatoms, rotifers, nematodes and copepods. Among these forms, 14 genera were specific to the pneumatophore whereas, ten genera were confined to the artificial substratum. The major groups recorded in terms of diversity and abundance were diatoms belonging to 21 genera. *Cocconeis, Pleurosigma, Navicula, Nitzschia, Gyrosigma, Biddulphia, Cymbella* and *Melosira* were the common genus recorded from both the substrate. *Coscinodiscus, Cyclotella, Campylodiscus, Bacillaria, Diploneis, Licmophora, Striatella* and *Amphora* were recorded only from pneumatophores, whereas *Cyclostephanus, Puncticulata, Pinnularia, Lindavia, Encyonopsis* were found only on the artificial substratum. The ciliates and rotifers also showed a similar type of substrate specificity. Out of the total 11 Ciliates, *Vorticella, Pyxicola, Vaginicola, Zoothamnium, Thuricola* and *Cothurnia* were common and found on both substrata. The ciliates *Stentor, Epistylis* and *Tetrahymina* were recorded only from pneumatophores while *Frontonia* and *Ephelota* were found on the artificial substratum. In general, the density of epibionts on pneumatophore varied from 65 to 615 no./cm^2 while the density of epibionts on artificial substratum ranged from 25 to 805 no./ cm^2. The Shannon diversity index, species richness and evenness varied from 2.018 to 2.077, 0.141 to 0.125 and 0.940 to 0.997, respectively and the values were always higher on pneumatophore than on the artificial substratum. It was duly evident that the most dominant genera were *Vorticella* followed by *Cocconeis*, *Pleurosigma* and *Navicula*. The study revealed substratum preference of the epibionts.

Keywords*: Epibionts, pneumatophore, artificial substratum, substratum preference, mangrove*

Introduction

Mangrove wetlands are the most productive ecosystem and diverse groups of organisms inhabit that area. Mangrove wetlands along the tropical estuaries are intended as intertidal and ecotones of marine and freshwater biological communities which have a major role in the biochemical process, and nutrient cycling (Alongi, 2009; Vishal *et al*., 2015). Ayiramthengu, bordering the Kayamkulam estuary, is one of the richest habitats of naturally growing mangroves. Wetlands provide habitats for diverse aquatic flora and fauna. The roots, leaves, and litters of mangrove trees form an important habitat for many mangrove epibiont species. The mangrove substratum supports a variety of epibenthic, infaunal and meiofaunal invertebrates. Most of the organisms in mangroves possess interaction with other species for survival, and this interaction may be temporary or last for their entire lifetime.

An epibiont is, by definition, harmless to its host and in this sense, the interaction between the two organisms can be considered natural or commensal. Wahl (1989) opined that more intense water flow with greater nutritional supply also enhances the dispersion of epibionts. The organism on which the epibiont settled was referred to as a basibiont, which provides the attachment surface and is generally larger than the epibiont (Gregorio Fernandez, 2013). This phenomenon is very common in the aquatic ecosystem, where very few hard substrates was available for sessile organisms (Wahl, 1989; Gill and Tomilinson, 1997). Epibionts are organisms that colonize and grow on any living, non-living solid or exposed surface of the aquatic ecosystem. They are a good source of fish culture and also act as a good indicator of pollution. Studies made in several geographic regions have reported that pneumatophores are encrusted with

epibionts (Sasekumar, 1994). Therefore, the present compared the occurrence of epibionts on pneumatophores of *Avicennia* sp. and an artificial substratum in the mangrove ecosystem of Ayiramthengu, Kerala.

Material and methods

Study area

The study area was Ayiramthengu Mangrove (latitude 9 62'to 9 8'N: 76 28'to 76 29'E), which is situated about six km west of Ochira town and the bank of Kayamkulam estuary, a narrow stretch of the tropical backwater on the west coast of Peninsular India. For sampling, a total of 10 stations, located almost 50 m apart were fixed in the mangrove area where pneumatophores are found (Fig. 1). Some of the selected areas have an influx of water into the mangrove. In this area, the pneumatophores are always inundated with water. Some other stations are comparatively marshy and sandy. In areas, the pneumatophores are fully bathed only during high tide. Two sites were selected for the collection of epibionts using artificial substratum (Fig. 1). The station selected were having different ecological statuses.

Fig. 1. Ayiramthengu mangrove ecosystem showing sites selected for the collection of epibionts from artificial substratum (red) and Pneumatophores (grey)

Sample collection and analysis

The two wooden frames with glass slides were immersed in water (Fig. 2a). Sampling was made to collect epibionts from pneumatophores and the artificial substratum. Samples were collected every fortnight by scraping one cm^2 patch of moist film on both lateral sides of the glass slides. Scrap the moist sample from the artificial substratum and pneumatophore (Fig. 2b) and preserved it in a sterile bottle containing 5 ml of 3% formalin. Collections were done from May to August 2017. Identification of organisms was done by using Lynn (2008) and then the enumeration of organisms was made by taking one ml sample to a Sedgewick Rafter counting chamber for counting. Species Richness, Evenness, Simpson index and Shannon-Wiener index were analysed using the software application PAST (version: 2.17).

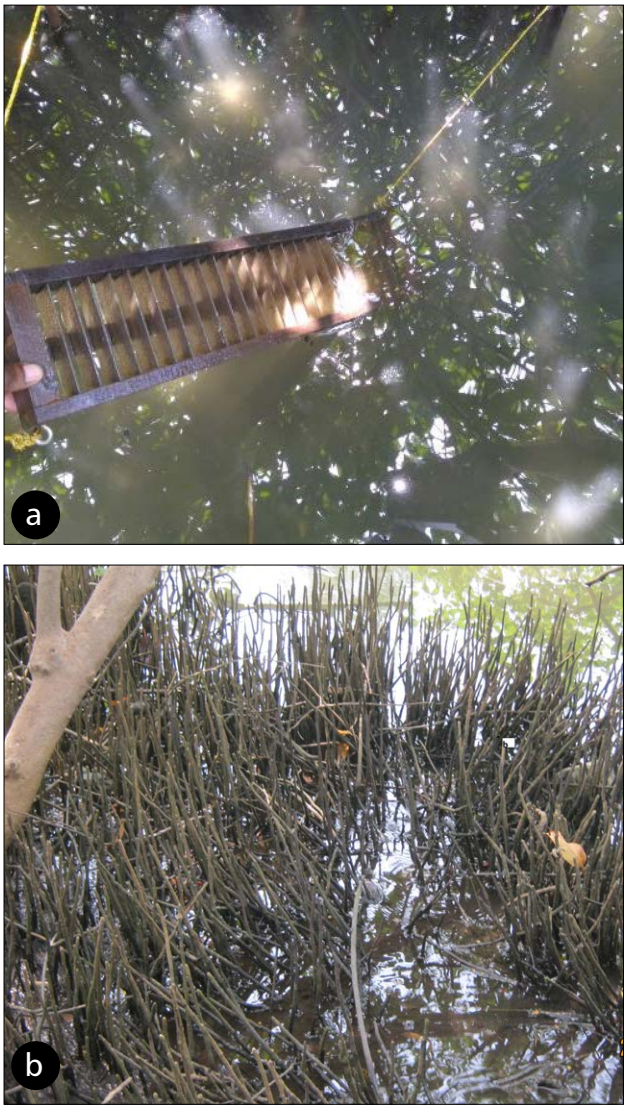

Fig. 2. (a) Artificial substratum and (b) pneumatophore used for the collection

Results

Species composition and density

A total of 46 genera were recorded, which included ciliates, flagellates, algae, diatoms, rotifers, nematodes and copepods from both substrata (Table 1). Among these, 14 genera were found to be specific to the pneumatophore, whereas 10 genera were confined only to the artificial substratum (Fig. 3) the major group recorded in terms of diversity and abundance was diatom which belongs to twenty-one genera. Eight genera were found to be specific to pneumatophore and five genera were exclusively found on the artificial substratum. But eight genera were common on both substrata. Out of the total eleven Ciliates, six genera were found on both substrata. three ciliates were only recorded from pneumatophore and two ciliates were recorded on the artificial substratum.

The maximum abundance of organisms was on pneumatophores (Fig. 4). Diatoms and ciliates showed maximum density in pneumatophores and artificial substratum, respectively while flagellates and algae recorded the minimum density on pneumatophore and artificial substratum, respectively. The most dominant genera from both substrata were *Vorticella* followed by *Cocconeis, Gyrosigma, Pleurosigma, Nitzschia* and *Navicula.* The least dominant genera of ciliate on pneumatophore was *Tetrahymena* and in artificial substratum was *Ephelota*. The minimum density of epibionts was recorded from pneumatophore in June at station 7 (65 no./cm) and the maximum density was recorded in August at station 6 (615 no./cm^2). The samples from pneumatophores of stations 1, 2, 6, 9 and 10 showed the maximum occurrence of epibionts compared to other stations. In pneumatophore, the most dominant group was diatom and the least density was for flagellates. Among diatoms, *Navicula* was the most frequently recorded species and the least was *Amphora* and *Striatella* on pneumatophore. In the case of ciliata, *Vorticella*

Table 1. Occurrence and distribution of epibionts on Pneumatophores and artificial substratum at Station 1 to 10 from May to August 2017

Generic name	Stations /Samples																			
	1		2		3		4		5		6		7		8		9		10	
Ciliata	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
Vorticella	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vaginicola	+	+	+	+	+	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+
Pyxicola	+	+	+	+	+	+	—	+	+	+	+	+	+	+	—	+	+	+	+	+
Zoothamnium	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Stentor	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—
Epistylis	+	—	+	—	+	—	—	—	+	—	+	—	+	—	+	—	+	—	+	—
Cothurnia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tetrahymena	+	—	+	—	+	—	+	—	—	—	+	—	+	—	—	—	—	—	+	—
Thuricola	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Frontonia	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Ephelota	—	+	—	+	—	+	—	+	—	+	—	—	—	—	—	—	—	—	—	—
Flagellata																				
Acineta	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Peranema	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Algae																				
Chroococcus	+	—	+	—	+	—	+	—	+	—	+	—	+	—	—	—	+	—	+	—
Oscillatoria	+	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+	—	+	+	+
Diatoms																				
Cocconeis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pleurosigma	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gyrosigma	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amphora	+	—	+	—	+	—	—	—	—	—	+	—	+	—	—	—	+	—	+	—
Biddulphia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	+	+	+	+	+
Coscinodiscus	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—

Generic name	Stations /Samples																			
Cyclotella	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—
Cymbella	+	+	+	+	+	+	+	+	+	—	+	—	+	—	+	—	+	—	+	—
Navicula	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nitzschia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Melosira	+	—	+	—	+	—	+	—	+	—	+	+	+	+	+	+	+	+	+	+
Campylodiscus	+	—	+	—	+	—	—	—	+	—	+	—	+	—	—	—	+	—	+	—
Bacillaria	+	—	+	—	+	—	+	—	+	—	+	—	—	—	+	—	+	—	+	—
Diploneis	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—
Licmophora	+	—	+	—	+	—	+	—	—	—	+	—	+	—	+	—	+	—	+	—
Striatella	+	—	+	—	—	—	+	—	—	—	+	—	—	—	+	—	+	—	+	—
Cyclostephanus	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Puncticulata	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Lindavia	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Pinnularia	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Encyonopsis	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Rotifera																				
Lepadella	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Adineta	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Branchionus	+	—	+	—	+	—	+	—	+	—	+	—	+	—	—	—	+	—	+	—
Anuraeopsis	+	+	+	+	+	+	—	+	+	+	—	—	—	—	—	—	—	—	—	—
Mytilina	—	—	+	—	—	—	—	—	—	—	+	—	+	—	—	—	+	—	+	—
Philodina	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Rotaria	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+
Others																				
Nematodes	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Harpacticus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	+	+	+	+	+
Cyclops: larva	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

P - Pneumatophore; S - Artificial Substratum; Prescence - Absence

Fig. 3. Pictures showing ciliates, flagellates, diatoms

was the frequent genera observed from pneumatophores. On artificial substratum, the first five samples from station one always showed the highest colonization than other samples of station 2. The most dominant and frequently recorded genera were *Vorticella* followed by *Navicula*, *Pleurosigma*, *Nitzschia* and *Pinnularia* of group diatom. The rotifer, *Philodina* genus showed high density.

Species diversity indices

The dominance index and species diversity values of organisms are given in (Fig. 5). Shannon diversity index varied between 2.02-2.08 in pneumatophore and 1.73-2.02 in the artificial substratum. Dominance index value on pneumatophore ranged from 0.12 -0.14 and on artificial substratum, it was between 0.14-0.19. So the dominance of organisms on the artificial

Fig. 4. Population density of epibionts (no./cm²) on pneumatophore and artificial substratum from May to August 2017

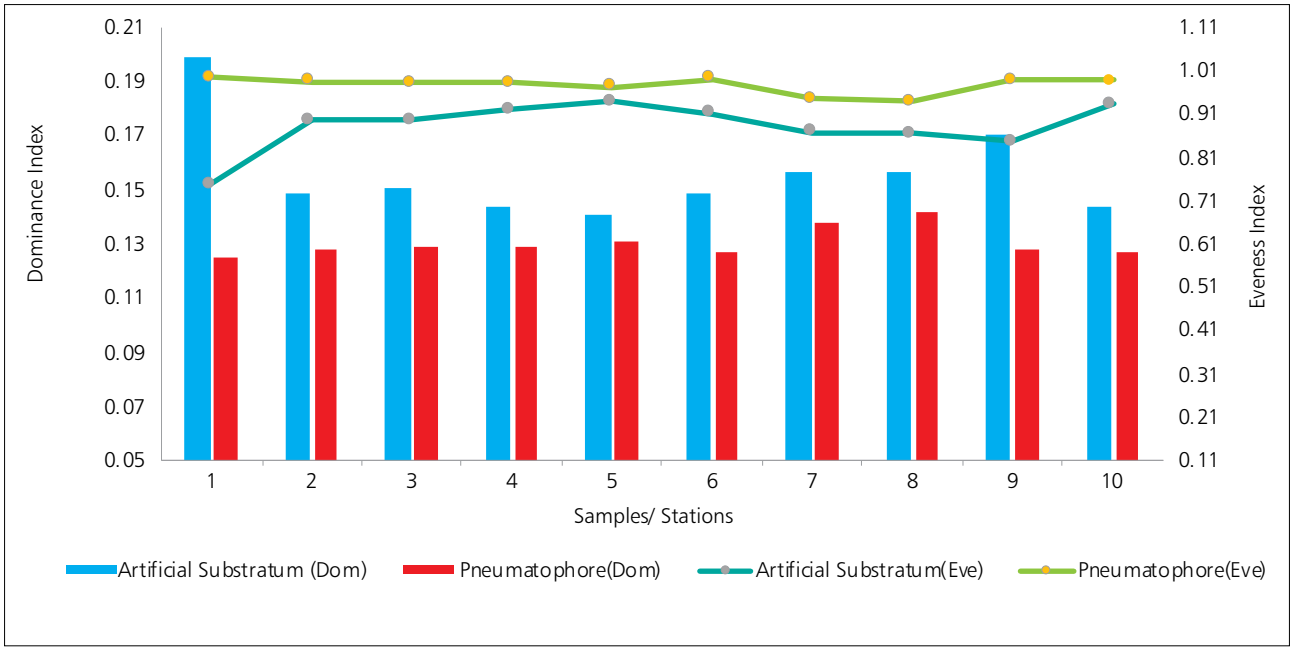

Fig. 5. Dominance index of artificial substratum and pneumatophore

substratum is slightly higher than the root due to the expansion of the open surface area.

Discussion

The comparative analysis of the epibiotic community of pneumatophore and artificial substratum revealed that pneumatophore was more highly distributed with diatom community than ciliates. But on artificial substratum the most abundant group was ciliates. The maximum density of organisms was found on the pneumatophores. The tidal inundation process occurring around pneumatophores duly reflected and favoured the maximum abundance of diatoms. According to Mithavkar and Anil (2006), the diatom abundance was lowest during monsoon and highest during post-monsoon. Murughanatham and Gopalakrishnan (2012), reported that the number and density of the diatom population might vary due to various physicochemical and biological factors. Pneumatophores of stations 1, 2, 6, 9 and 10 were found to be dominated by the algal filament. These algal filaments provide a substratum for the attachment of epibionts. According to Telford *et al.* (2006) and Proches and David (2002), Bacillariophyceae communities showed optimal variation in diversity and species composition that cannot be driven alone by local environmental conditions and determined by habitat availability. Diatoms associated with pneumatophores form an attractive food item for molluscs and crustaceans (Snoeiji, 1989).

The increase in the density of diatoms like *Navicula* and *Nitzschia* during the collection of the first two months and its diminishing trend in the other study period may be due owing to the density-dependent factor interaction among the different groups of the epibionts. Admiraal and Jong (1984) reported the species interactions in the form of predation among the epibiont group. In the present study, the density of rotifers increased during July and August while the density of diatoms declined. Rotifers are mostly free-living organisms and are found attached to all substrates. They comprise an integral link in the aquatic food chain and are valuable bio-indicators to detect water quality (Sharma, 1991; Molly, 2006). Molly (2009), reported that the higher density of rotifers in an ecosystem is highly productive, supporting fish and shrimp culture and opined that salinity influences the abundance of rotifers. Nair *et al.* (1971) and Gopakumar (1998) also emphasized that salinity favours the rotifer community.

Maximum colonization occurred for ciliates such as *Vorticella, Zoothamnium, Thuricola* and *Pyxicola* in the order of their abundance on an artificial substratum. Ciliated protozoa were present in most water bodies (Pinheiro *et al.*, 2007). They form the most successful heterotrophic group that responds very quickly to changes in environmental conditions (Roberts *et al.*, 1996). According to Chitra and Sunil (2015), the mangrove prop roots and litter were highly colonized by ciliates and flagellates. Roots showed the maximum density of organisms. The density of ciliates on pneumatophores varied in different stations. This variation may be due to the increased organic particles, predation and other environmental conditions prevailing in each station (Kim *et al.*, 2003).

The coexistence and interaction of major epibiont groups such

as diatoms, ciliates, flagellates, rotifers, algae, nematodes and copepods on both substrata in the Ayiramthengu mangrove region were duly evident, based on field study and analysis of samples. Among dominant epibiont forms, the prolonged occurrence of diatoms genera like *Cocconeis, Pleurosigma, Gyrosigma, Biddulphia, Navicula* and *Nitzschia* while *Vorticella*, *Pyxicola* and *Vaginicola* represent coexistence and interactions among taxa. Interspecific interactions of organisms after the colonization of artificial substratum from the mangrove habitat was reported earlier (Mumby *et al*., 2004, Barbour *et al*., 2010). The community structure developed around the pneumatophores and its composition and abundance seem to be influenced by tidal rhythm, the depth of the water column above the benthic substratum. On the other hand, on artificial substratum after colonization and building of the epibiont community never showed an increasing trend in population and attained maximum density. This may be due to the effect of predation among the group of epibionts and which has been reported by several workers (Beers, 1933; Brown and Austin, 1973; Barbour *et al*., 2010). The study also revealed that population density and species diversity of epibionts showed not many variations in the two entirely different substrata, while certain epibiont genera showed substratum preference. It can be concluded that the epibiont community prevailing in mangrove areas as in the present study has a tremendous role to play in promoting the trophic status, thereby improving the stability of the ecosystem and this crucial role in fisheries point of view concerning feeding and breeding aspects being highly significant. Moreover, the epibiont colonization and subsequent building in artificial substrata are commendable. The selection of proper artificial substrata and keeping them permanently in the ecosystem for a prolonged period is recommended to increase fishing productivity in the protected Ayiramthengu mangrove region or elsewhere in the aquaculture system associated with mangrove waters.

Acknowledgements

The authors are grateful to Dr Mathew P Joseph, Principal, Catholicate College, Pathanamthitta for the facilities provided.

References

Admiraal, W. and Loes-de Jong. 1984. Competition between three estuarine benthic diatom species in mixed cultures. *Mar. Ecol. Prog. Ser.*, 18: 269-275.

Alongi, D. M. 2009. Coastal wetlands; an integrated ecosystem approach. 22, 615-631. Chapman, V. J., 1976. Mangrove Vegetation. *J. Cramer, Vaduz*, 447pp.

Barbour, A. B., M. L. Montgomery, A. A. Adamson and B. R. Silliman. 2010. Mangrove use by the invasive lionfish *Pterois Volitans. Mar. Ecol. Prog. Ser.*, 401: 291- 294.

Beers, D. 1933. The ingestion of large amoeba by ciliate *Frontonia leucas. J. Mitchell Soc.*, 17: 223-227.

Brown, S. D. and A. P. Austin. 1973. Diatom succession and interaction in littoral periphyton and plankton. *Hydrobiologia*. 43: 333-356.

Chitra, P. and R. Sunil Kumar. 2015. Preliminary studies on epibiotic Protista in the Mangrove ecosystem in Ayiramthengu. *J. Mar. Biol. Ass. India,* 57(2): 90-94.

Gill, A. M. and P. B. Tomilinson. 1997. Studies on the growth of Red mangrove (Rhizophora mangle). 4. The adult root system. *Biotropica*. 9: 145-155.

Gopakumar, G. 1998. *Studies on brackish water rotifers of Kerala with special reference to Brachionus plicatilis O.F. Muller as live feed aquaculture*. Ph. D. Thesis, University of Kerala.

Gregorio Fernandez., T. Chatterjee, D. Devidas and I. Baban. 2013. New records of epibionts ciliates from Indian coast (mangrove) with description of six new species, *Cah. Biol. Mar.*, 54: 143-159.

Kim, B. H., E. Y. Moon, S. Hong and M. S. Han. 2003. Seasonal variation of planktonic ciliates with reference to their prey in a shallow and eutrophic Korean Stream. *J. Freshwater. Ecol.*, 18(4): 577-584.

Lynn, D. H. 2008. The ciliated Protozoa: Characterization, Classification and Guide to the Literature, 3rd ed. Springer., 606 pp.

Mithavkar, S. and A. C. Anil. 2006. Diatoms of the microphytobenthic community in a tropical intertidal sand flat influenced by monsoon: Spatial and temporal variations. *Mar. Biol.*, 148: 693-709.

Molly Varghese. 2006. Studies on taxonomy, distribution, ecology and reproductive potential of rotifers from selected centers in Cochin backwater system, Kerala. CMFRI. p. 1-343.

Molly Varghese. 2009. Distribution of Zooplankton in selected centres of Cochin backwaters. *J. Mar. Biol. Ass. India.*, 50(2): 194-198.

Murughanatham, P. and P. Gopalakrishnan. 2012. Seasonal variatiation and diversity of planktonic diatoms of Muthupet and Aarukattu-thurai, south east coast of India, *Adv. Appl. Sci. Res*., 3(2): 919-929.

Mumby, P. J., A. J. Edwards, J. E. Arias-Gonzales and K. C. Lindeman. 2004. Mangroves enhance the biomass of coral reef fish communities in the Caribbean. *Nature*., 427: 533-536.

Nair, K. K. N. and C. K. G. Nayar. 1971. A preliminary study of the rotifers of Irinjalakuda and neighbouring places. *J. Kerala Acad. Biol*., 3: 31-43.

Pinheiro, M. D. O., M. E. Power, B. Buttler, V. R. Dayeh, R. Slawson, L. E. J. Lee, D. H. Lynn, and N. C. Bols. 2007. Use of *Tetrahymena thermophila* to study the role of protozoa in inactivation of viruses in water. *Appl. Environ. Microbiol.*, 73(2): 643–649.

Proches, S. and J. M. David. 2002. Epiphytic algal cover and sediment deposition as determinants of arthropod distribution and abundance on mangrove Pneumatophores. *J. Mar. Biol. Assoc. UK*, 82: 937-942.

Robert, M., D. M. Rivail, M. Lamotte, O. F. X. Donard and E. J. Soriano-Sierra. 1996. Metal contamination in surface sediments of mangroves, lagoons and Southern Bay in Florianopolis Island. *Environ. Technol*., 17(10): 1035-1046.

Sasekumar, A. and V. C. Chong. 1998. Faunal diversity in Malaysian mangroves. *Glob. Ecol. Biogeogr.*, 1: 57-60.

Sharma, B. K. 1991. Rotifera. In: Animal Resources of Indian Protozoa to Mammalia: State of Art. Zoological Survey of India., p. 69- 88.

Snoeji, P. 1989. Effects of increasing water temperature and flow rates on epilithic fauna in a cooling water discharge basin. *J. Appl. Ecol*., 26: 935-956.

Telford, R. J., V. Vandvik and H. J. B. Birks. 2006. Dispersal limitation matters for microbial morphospecies. *Science.,* p. 312-1015.

Vishal, V., N. Rahees and K. Vidyasagaran.. 2015. Floristic diversity and Structural dyanamics of mangroves in the south west coast of Kerala, Applied ecology and environmental research. *J. Plant. Dev. Scie*., 7(7): 549-553.

Wahl, M. 1989. Marine epibiosis. Fouling and antifouling: some basic aspects. *Mar. Ecol. Prog. Ser*., 58: 175-189.