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Fish Fauna Diversity in Relation to Environmental Parameters in Muthukuda Mangroves Southeast Coast of Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The seasonal variations of physico-chemical parameters on fish faunal diversity were studied in Muthukuda mangrove (Latitude 9°36'N and Longitude 78°83'E) waters from July 2022 to June 2023. The atmospheric temperature and water temperature ranged from 27.7 to 34.9°C and 25.8°C to 30.9°C respectively. The Hydrogen ion concentration of water varied from 7.3 to 8.3. The dissolved oxygen was ranged from 7.3 to 8.3. Salinity fluctuated between 10.5 to 31.9‰. The nutrients such as total phosphorus, nitrate and silicate ranged from 0.7 to 3.2 µg/l, 5.1 to 13.7 µg/l and 9.2 to 71.2 µg/l respectively. The dissolved oxygen and nutrients were found to be low in summer and high during the monsoon season. Similarly, temperature, pH and salinity were low during the monsoon season and high during the summer season. Fish faunal diversity from

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Muthukuda mangroves comprises 19 species representing 5 orders, 17 families and 19 genera. The order Perciformes were dominated by 13 species followed by Clupeiformes and Siluriformes 02, Gonorphynchiformes and Beloniformes with one species each. The higher diversity values in fish fauna observed in the present investigations clearly elucidated the healthy nature of Muthukuda mangroves.

Keywords: Physico-chemical parameters; fish faunal diversity; diversity indices analysis; muthukuda mangroves.

1. INTRODUCTION

"Mangroves are valuable ecological and economic resources, being important nursery grounds for birds, fish, crustaceans, shellfish, reptiles, and mammals, as well as a renewable resource of wood" [1,2]. "Mangrove and estuarine ecosystems are one of the profile and crucial environments for fisheries in tropical and subtropical coastal systems which enhance the fertility and productivity of marine fishery. Globally, several authors have studied the relationship between physico-chemical factors on fish abundance in mangrove and estuarine ecosystems" [3]. Chong et al. [4] have investigated "the fish faunal diversity in the Malaysian coastal mangrove ecosystem". The composition and seasonal distribution of ichthyoplankton in the Swan Estuary, Australia was studied by Gaughan et al. [5] Hayase and Fadzil [3] studied the distribution and abundance of fish fauna in the Mating and Merbok mangrove waters of Malaysia. Nurul Asyikin Binti Ya et al. [6] have reported fish diversity in the Sepang Basar estuary mangroves area of Malaysia. The temporal variation and composition of fish assemblages were investigated in the mangrove of Qinzhou, China by Liangliang Huang et al. [7]. Farid Kamal Muzaki et al. [8] studied fish larval abundance in the different root types of Rhizophora mangroves in the coastal area of Sepulu, Madura, Indonesia. Studies on the community structure and diversity of fish fauna in Karangsong mangroves, west Java, Indonesia were carried out by Vivin Silvaliandra Sihombing et al. [9]. The fisheries diversity of the mangrove waters of Lombok Island, Indonesia was investigated by Gema Wahyndewantoro [10]. Steven Mc Gregor and Nadine A. Strydom [11] studied the distribution, and abundance diversity of ichthyofauna in mangrove and non-mangrove estuaries of South Africa. Hui Jia et al. [12] assessed the seasonal variation of fishery resources in the Yangtze estuary, in East China.

Extensive work was carried out on the influence of physico-chemical parameters in the ichthyofauna diversity of mangrove and estuarine waters of India. Prince Jeyaseelan and Krishnamurthy [13] made a detailed study on fish species diversity in Pichavaram mangroves. Ramaiyan et al. [14] studied estuarine and marine fish diversity in Porto Novo coastal waters. Bijukumar and Sushama [15] documented the ichthyofauna of Ponnani estuary, Kerala. Bassoucalingum Kumaran et al. [16] worked on ichthyofaunal diversity in the Giriyampeta estuary, Yanam. Durga Prasad Behere et al. [17] reported the icthyofaunal diversity of the Bahuda estuary, Odisha. The diversity of fin fishes and shell fishes in relation to various physico-chemical parameters and nutrients of Manakudy estuary has been described by Kannappan and Karthikeyan [18]. Seasonal variations of physico-chemical parameters and fish diversity in the Aghanashini estuary of Uttara Kannada, Karnataka were studied by Mahima Bhat et al. [19].

Murugan et al. [20] investigated "spatial and temporal variability of fish diversity in Vellar estuary". "The elasmobranchs fishery resources from Gulf of Mannar were studied by Mohanraj Theivasigamani and Shanmugavel Subbiah" [21]. Seasonal variation of physico-chemical parameters in the fin fish assemblage structure was studied in Pichavaram mangrvoes by Mahesh and Sarvanakumar [22]. Physico-chemical parameters in relation ichthyofaunal diversity were studied by Sudeep S. Kairana and Ganesh [23] in Sharavathi estuary.Sivalingam Govindan and Ramanibai Ravichandran [24] studied influence of environmental parameters on the fish distribution in Pulicat Lagoon. Molly Varghese et al. [25] reported reef fishes diversity in Keelakari, Gulf of Mannar. So far, no attempt has been made to study the fish faunal diversity in relation to physico-chemical parameters on an annual basis with the seasonal variations in their abundance, composition and distribution from Muthukuda mangroves of southeast coast of India and hence the present investigation is undertaken.

2. MATERIALS AND METHODS

2.1 Study Area

The Muthukuda mangrove swamp (Latitude $9^0$51' 38"N and Longitude $79^0$8' 1.57"E) is situated in the Muthukuda village (Pudukkottai District) Palk Bay region of southeast coast of Tamil Nadu, India.

2.2 Sampling Periodicity

Water samples collections were made fortnightly preferably on every full moon and new moon days at Muthukuda mangrove swamp for a period of one year from July 2022 to June 2023. The average values of each month weretaken for the present study.

2.3 Analysis of Physico-Chemical Parameters

The nutrients such as phosphorus (Murphy and Riley Method), nitrate (Robinson Method) and silicate (Mullin and Riley Method) were estimated by adopting standard procedures [26].

The air and water temperature was measured using a 0 – 50°C mercury centigrade thermometer. The pH of water was recorded in the field by using a digital pen type pH meter. The salinity was determined by silver nitrate method (Mohr's method) and dissolved oxygen by Winkler's method as described in Strickland and Parsons [26].

2.4 Collection and Identification of Fishes

Fish collections were made at low tide by using a cast net measuring 2.5 m length, with a mesh size varying from 7 mm at the base and 15 mm at the apex was employed throughout the period of study. The net was hauled ten times during every collection at sampling site. The collected fishes were identified up to species level by using the description and keys given by Fischer and Bianchi [27] and Ramaiyan et al*.* [14].

2.5 Diversity Indices and Correlation Analysis

To assess the diversity indices of fish faunal composition, species were calculated by respective formula as Shannon species diversity index (H^1) [28]. Simpson Dominance index (D) [29] Richness index (d) [30] and Species evenness (J^1) [31]. The Karl Pearson's correlation coefficient were performed by SPSS version 20.0.

3. RESULTS

3.1 Physico-Chemical Parameters

The monthly variations in physico-chemical parameters, temperature, pH, salinity, and dissolved oxygen, nutrients such as phosphorus, and nitrate and silicate contents in Muthukuda mangrove waters were recorded for a period of one year from July 2022 to June 2023 (Figs. 1-8).

3.2 Temperature

During the study period air temperature varied from 27.7 to 34.9°C. The minimum temperature was recorded during monsoon season (December, 2022) and maximum during the summer season (June 2023) (Fig. 1). The atmospheric temperature showed a positive correlation with water temperature (r= 0.8332) at Muthukuda mangroves. The surface water temperature ranged from 25.8°C to 30.9°C. The minimum surface water temperature (25.8°C) was recorded during monsoon season (December, 2022) and maximum (30.9°C) was recorded during the summer season (May, 2023) (Fig. 2). Water temperature of the Muthukuda mangroves showed a positive correlation with salinity (r=0.8565) and pH (r=0.8889) and a negative correlation with dissolved oxygen (r=-0.8151). (Table.1).

3.3 pH

The monthly mean values of hydrogen ion concentration of water varied from 7.3 to 8.3 (Fig. 3). Maximum values of pH were observed in the summer season (May, 2023) and minimum values were recorded in the monsoon seasons (October 2022). Statistical analysis showed that the pH had positive correlation with water temperature (r=0.8889) and salinity (r=0.9564) whereas dissolved oxygen had an inverse relationship (r= - 0.8766) (Table.1).

3.4 Salinity

The seasonal variations of salinity in Muthukuda mangroves are graphically represented in Fig. 4. A marked seasonal changes in salinity were observed throughout the study period. Minimum salinity (10.5‰) was recorded during monsoon (October 2022) and was slowly increased during post-monsoon and attained maximum (31.9‰)

during summer seasons (May 2023). The salinity of the Muthukuda mangroves showed a positive correlation between water temperature (r=0.8565) and pH (r=0.9564) while it showed a negative correlation with dissolved oxygen (r = - 0.8643) (Table1).

3.5 Dissolved Oxygen

Dissolved oxygen (DO) in Muthukuda mangroves varied between 3.5 and 6.2 ml/l. Minimum DO was recorded during the month of April 2023 and maximum in November 2022 (Fig. 5). Statistical analysis showed that dissolved oxygen had a negative correlation with water temperature (r= -0.8151), salinity (r= -0.8643) and pH (r= -0.8766) (Table.1).

3.6 Total Phosphorus

The monthly variations of total phosphorus recorded in Muthukuda mangroves are shown in Fig. 8. The total phosphorus was minimum (0.7 µg/l) in the month of April 2023 and maximum (3.2 µg/l) in the month of November 2022(Fig. 6). Total phosphorus showed a positive correlation with dissolved oxygen (r=0.9077) and negative correlation with pH (r= -0.8812) and salinity (r= -0.9037). (Table.1)

Fig. 1. Monthly variations of atmospheric temperature during July 2022 to June 2023

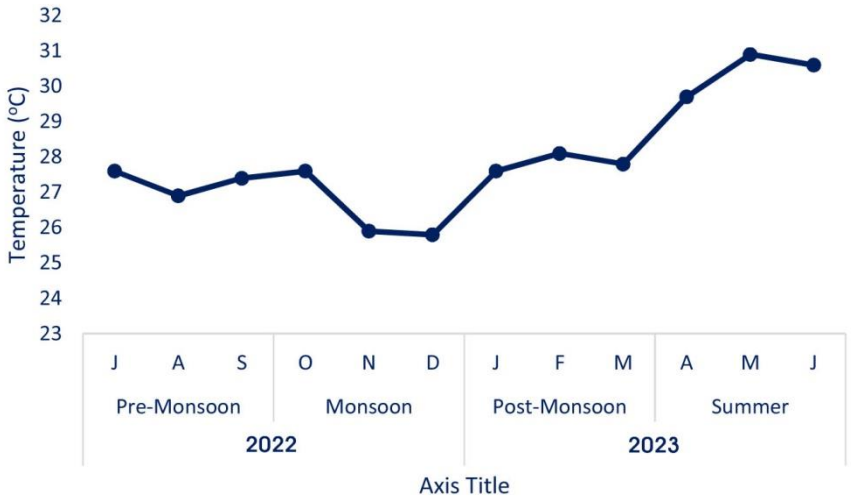

Fig. 2. Monthly variations of water temperature during July 2022 to June 2023

Table 1. Karl Pearson's correlation coefficient between various physico-chemical parameters and fish abundance in Muthukuda mangroves

	Atmospheric Temperature	Water Temperature	pH	Salinity	DO	Total Phosphorus	Nitrate	Silicate	Fish
Atmospheric Temperature	1								
Water Temperature	0.8332	1							
pH	0.8683	0.8889	1						
Salinity	0.9249	0.8565	0.9564	1					
DO	-0.7494	-0.8151	-0.8766	-0.8643	1				
Total Phosphorus	-0.7915	-0.7839	-0.8812	-0.9037	0.9077	1			
Nitrate	-0.7744	-0.7439	-0.8594	-0.9012	0.8775	0.9175	1		
Silicate	-0.8213	-0.7747	-0.8553	-0.8802	0.8979	0.9167	0.9648	1	
Fish	0.8564	0.8700	0.9537	0.9690	-0.9292	-0.8855	-0.8793	-0.8509	1

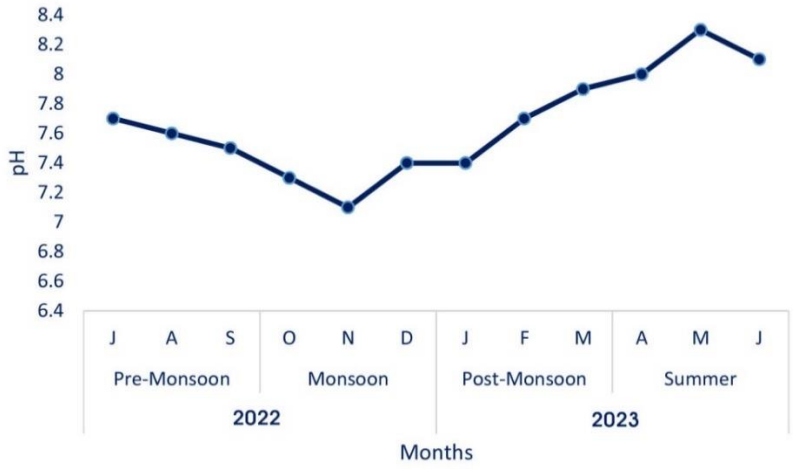

Fig. 3. Monthly variations of pH during July 2022 to June 2023

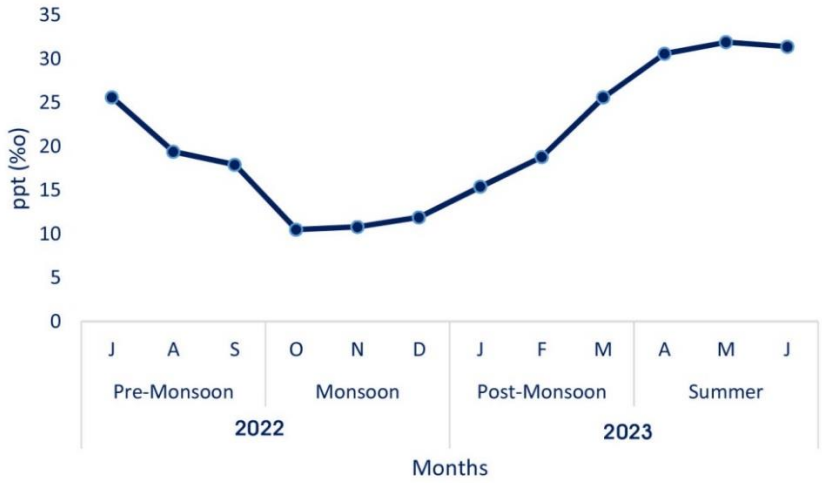

Fig. 4. Monthly variations of salinity during July 2022 to June 2023

3.7 Nitrate

The nitrate content of Muthukuda mangroves varied from 5.1 to 13.7 µg/l. The minimum was recorded during the month of May 2023, whereas the maximum during the month of October 2022 (Fig. 7). Statistical analysis showed that the nitrate had a positive correlation with DO (r=0.8775) and a negative correlation with pH (r=-0.8594) and salinity (r=-0.9012) (Table.1).

3.8 Silicate

The monthly variations of silicate of the water observed in Muthukuda mangroves during the study period (July 2022 - June 2023) are graphically represented in Fig. 8. The silicate content showed a minimum value of 9.2µg/l (May 2023) and a maximum value of 71.2µg/l (December 2022) (Table.1). Silicate showed negative correlation with water temperature (r = -0.7747), pH (r = -0.8553) and salinity (r = -0.8802), and positive correlation with DO (r = 0.8979), total phosphorus (r = 0.0167) and nitrate (r = 0.9648). Throughout the study period, mean seasonal temperature, pH, salinity, dissolved oxygen, phosphorus, nitrate, and silicate contents were not uniform in Muthukuda mangroves.

Fig. 5. Monthly variations of dissolved oxygen during July 2022 to June 2023

Fig. 6. Monthly variations of total phosphorus during July 2022 to June 2023

3.9 Fish Species Composition

"Fish faunal diversity from Muthukuda mangroves comprises 19 species representing 5 orders, 17 families and 19 genera. The order Perciformes were dominated by 13 species followed by Clupeiformes and Siluriformes 02, Gonorphynchiformes and Beloniformes with one species each. In the sampling site, the percentage wise catches of fishes was order Perciformes (71.75%) followed by Siluriformes (9.6%), Gonorphynchiformes (8.9%), Clupeiformes (8.13%) and Beloniformes (1.55%). Among the 19 species recorded in the present study, *Mugil cephalus*was dominant species contributed about 12.01% whereas *Liza parsia* accounted for about 9.68% as the second dominant species" [32]. The third dominanat species was *Chanoschanos* with a contribution of 8.91% followed by *Leiognathusequulus* (8.52%). The catfish *Mystusgulio* and *Siganuscaniculatus* ranked fifth and sixth each accounting for about 7.75% and 7.36% of the total catch respectively. *Teraponjarbua, Gerres filamentous* (5.81%) and *Thryssamystax, Etroplussuratensis* (5.42%) were equally abundant ranking (seventh and eighth) in its abundance. *Lates calcarifer* (4.26%), tilapia fish, *Oreochromis mossambicus* (3.48%) were

the ninth and tenth abundant species respectively. *Sardinella longiceps, Ambassiscommersoni* (2.71%); *Sillagosihama*, *Lutjanus argentimaculatus* (2.32%) and *Caranx ignobilis*, *Arius jella* (1.93%) were equally abundant ranking (eleventh, twelfth and thirteenth) in its total abundance. *Hemirampusmarginatus* contributed 1.55% as the least percentage of the total catch. (Fig. 9).

3.10 Fish Population Density

The seasonal mean population density was maximum in summer (13.18% in May 2023) and post-monsoon periods (10.47% in March 2023) and minimum during monsoon (3.49% in November 2022), followed by pre-monsoon period (5.81% in September 2022) (Fig. 10).

3.11 Species Diversity

The species diversity (H^1) of ichthyofauna in Muthukuda mangroves fluctuated between 2.025 in October 2022 to 2.811 in July 2022. It can be seen that the diversity indices for ichthyofauna were high in the summer period when compared to other seasons (Fig. 11).

Fig. 7. Monthly variations of nitrate during July 2022 to June 2023

Fig. 8. Monthly variations of silicate during July 2022 to June 2023

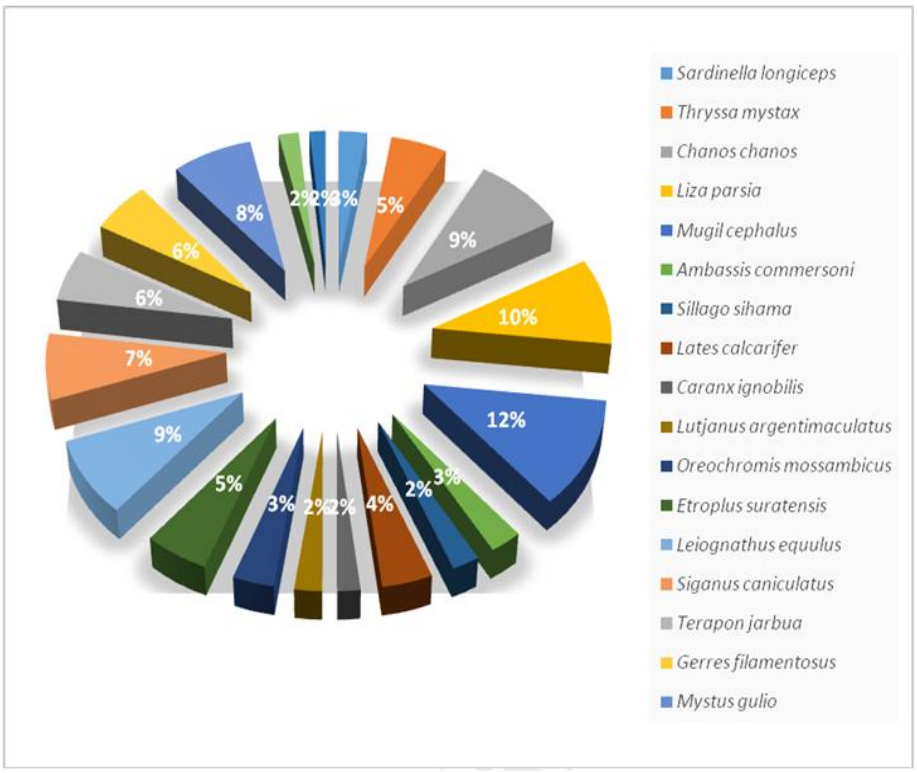

Fig. 9. Percentage composition of fishes recorded in Muthukudamangroves

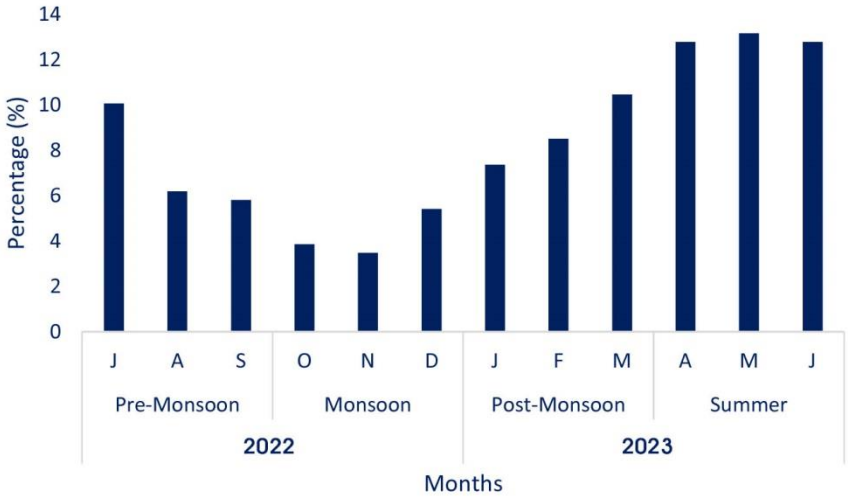

Fig. 10. Percentage of fish population density recorded in Muthukuda mangroves

3.12 Species Richness

The species richness (d) in Muthukuda mangroves ranged from a minimum of 3.04 in October 2022 to a maximum of 5.218 in July 2022. In general, the high species richness coincided with summer followed by pre monsoon period, low species richness was recorded during monsoon (Fig. 12).

3.13 Species Evenness

The species evenness (J^1) in Muthukuda mangroves recorded a low value (0.9525) in

March 2023 to a high value (0.9837) in September 2022(Fig. 13). Throughout the study period, the seasonal mean evenness was high during pre-monsoon followed by monsoon, summer and post monsoon seasons.

3.14 Species Dominance

The species dominance (D) fluctuated between 0.9481(February 2023) to 0.981 (September 2022) (Fig. 14). Seasonal average values of species dominance were maximum during pre-monsoon and minimum during summer period. The diversity indices obtained in the present study do not show many differences among seasons.

The ichthyofauna was related with physico-chemical parameters and nutrients in Muthukuda mangroves during July 2022 and June 2023 by using correlation co-efficient (Table 1). Ichthyofauna with physico-chemical parameters such as atmospheric temperature (r=0.8564), water temperature (r=0.8700), pH (r=0.9573) and salinity (r=0.9690) observed positive correlation. In contrast, it showed a negative correlation with oxygen (r=-0.9292) nitrate (r=-0.8793), phosphate (r=-0.8855) silicate (r=-0.8509).

Fig. 11. Monthly variations in fish species diversity of Muthukuda mangroves

Fig. 12. Monthly variations in fish species richness of Muthukuda mangroves

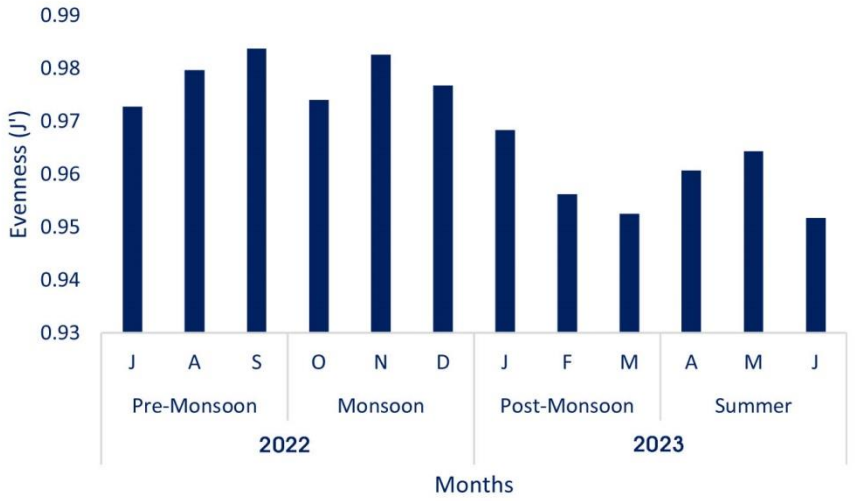

Fig. 13. Monthly variations in fish species evenness of Muthukuda mangroves

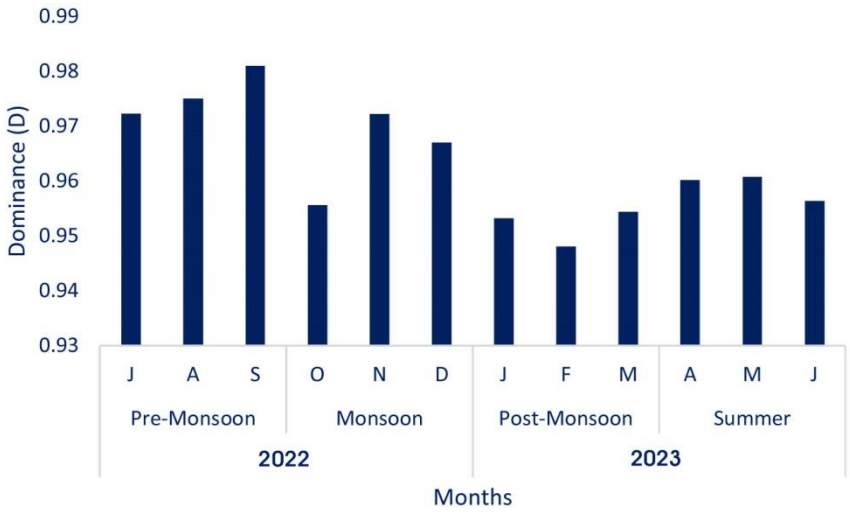

Fig. 14. Monthly variations in fish species dominance of Muthukudamangroves

4. DISCUSSION

In the present investigation, a total of 19 fish species belonging to 19 genera,17 families and 5 orders were collected and the abundance of ichthyofauna varied with the seasons as summer>pre monsoon>post monsoon>monsoon. The maximum abundance during post-monsoon and summer seasons was already reported by Mahesh and Saravanakumar [22] from the Pichavaram mangrove ecosystem and they recorded 45 species of fishes belonging to 38 genera, 29 families. Such findings in Pichavaram mangrove during post monsoon and the author attributed salinity and depth of the water are the vital factors for the abundance of the fish fauna. Bharadhirajan et al. [33] recorded the maximum diversity and richness of fish fauna during summer period and lowest during monsoon period of the Celeroon estuary. Similar findings were observed by Pavinkumar et al. [34] in the Manakudy estuary. The present findings are in agreement with the above reports.

“Several workers have noticed the lowest number of icthyofauna during monsoon and

suggested that reduction in salinity during heavy influx of freshwater and low p^H were responsible for low density" (Bassoucalingam Kumaran et al.,2012). The present study is in agreement with the report of previous investigations. A total of 19 fin fish species were recorded in the Muthukuda mangroves. But Prince Jeyaseelan and Krishnamurthy (1980) reported about 67 species of fishes, belonging to 51 genera and 33 families of the Pichavaram mangrove forests, whereas Mahesh and Saravanakumar [22] reported 45 species of fishes belonging to 38 genera and 29 families from the same study area. Eric Ramanujam and Anbarasan [35] reported 75 species of fish under 14 orders and 37 families from Yedayanthittu estuary, Tamil Nadu. Pavinkumar et al. [34] identified 77 fish species under 41 families belongs to 11 orders from Manakudy estuary, Kanyakumari. Mahima Bhat et al. [19] recorded 77 fish species from 47 families in the Aghanashini estuary of Uttara Kannada, Karnataka. Bassoucaligam Kumaran et al. [16] observed 36 species of fishes comprising 5 orders and 13 families in the Giriyampeta estuary, Yanam and their study revealed that the physico-chemical parameters was found as major factors for species seasonal distribution. Murugan et al. [20] recorded 95 species of fishes in 3 zones of Vellar estuary and included 8 freshwater species, 9 estuarine species and 63 estuarine and marine species and 13 marine species. Sivalingam Govindan and Ramanibai Ravichandran [24] were conducted a survey on fish faunal diversity and reported 83 fish species belonging to 14 orders and 50 families from Pulicat Lagoon in Tamil Nadu [36].

5. CONCLUSION

The higher diversity values in fish fauna observed in the present investigations clearly elucidated the healthy nature of Muthukuda mangroves.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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