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Fish Diversity of Kuttanad Region in Kerala

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ABSTRACT
A study conducted for three years in the riverine system of Kuttanad identified 65 species of fish. The obtained data were statistically analysed. Monsoon season showed high diversity than post monsoon and pre monsoon seasons. North Kuttanad showed high diversity when compared to lower Kuttanad and upper Kuttanad in all three seasons. Perciformes was the dominant order and Cyprinidae was the dominant family.

Key words: Cyprinidae, Cypriniformes, Monsoon, post monsoon, pre monsoon, riverine system.

INTRODUCTION

Kuttanad (9°252 303 N 76°272 503 E) (Fig. 1) is a region which inhabited 2 to 4 feet below sea level and it is prominent for rice cultivation. Kuttanad stretches across three districts, Alappuzha, Pathanamthitta and Kottayam in Kerala state, India. Manimala, Meenachil, Pampa and Achenkovil rivers flows through Kuttanad and reaches Arabian Sea. Kuttanad is divided into upper Kuttanad, lower Kuttanad and north Kuttanad. Kuttanad is an eco-tone region where both estuarine and fresh water bodies overlaps. Vembanad Lake which is situated in the north Kuttanad is an estuarine ecosystem adjoining Arabian Sea in the west and fresh water rivers in the east. Rivers such as Manimala, Meenachil, Pampa and Achenkovil are fresh water ecosystems and these rivers flow into the Vembanad estuarine system and opens into the Arabian Sea. Vembanad region is one of the three Ramsar sites in Kerala and is the largest estuarine system of the western coastal wetland system (Jayakumar et al. 2005). Thaneermukam bund which is constructed across the Vembanad Lake prevents the saline intrusion from Arabian Sea during high tide towards the fresh water ecosystem. Opening of this bund before sowing of the rice causes saline intrusion into the fresh water area aiding in the paddy cultivation which occurs during twice a year.

Rice farming and fishing are major occupations of Kuttanad people. So decline in fish diversity have impacts on economic stability of Kuttanad society. The periodic study on fish diversity is necessary in such regions to assess socio-economic status. Estimation of biodiversity has a major role in ecology in evaluating the ecosystem.

Many studies regarding the diversity of Manimala (Plamoottil 2015), Meenachil (Cheriyan and Oommen 2020), Pampa (River Research Centre 2013) and Achenkovil (Baby et al. 2011) rivers are available. These rivers which emerge from the eastern part of Kerala and joins in the Vembanad Lake on Western part of Kerala. But these studies were unable to analyse the fish diversity of Kuttanad which covers the entire region of upper Kuttanad, lower Kuttanad and north Kuttanad.

MATERIALS AND METHODS

Fishes were collected from upper Kuttanad, lower Kuttanad and North Kuttanad regions during pre monsoon, monsoon and post monsoon seasons of three consecutive years between 2017 and 2019 using cast net and gill net. Collected samples were preserved in 5% formalin and identified using keys of Talwar and Jhingran (1991) and Jayaram (1999). Indices such as Shannon Weiner index (1949), Simpson index (1949), Berger Parker index (1970), Margalef's richness (1958) and Hill's number (1973) were calculated (Thukral 2017) using Biodiversity Pro software (Mc Aleece 1997). One-way analysis of variance (ANOVA) was calculated by SPSS software (20.0 version).

RESULTS

During the study, 65 species were identified belonging to 37 families and 13 orders (Table 1).

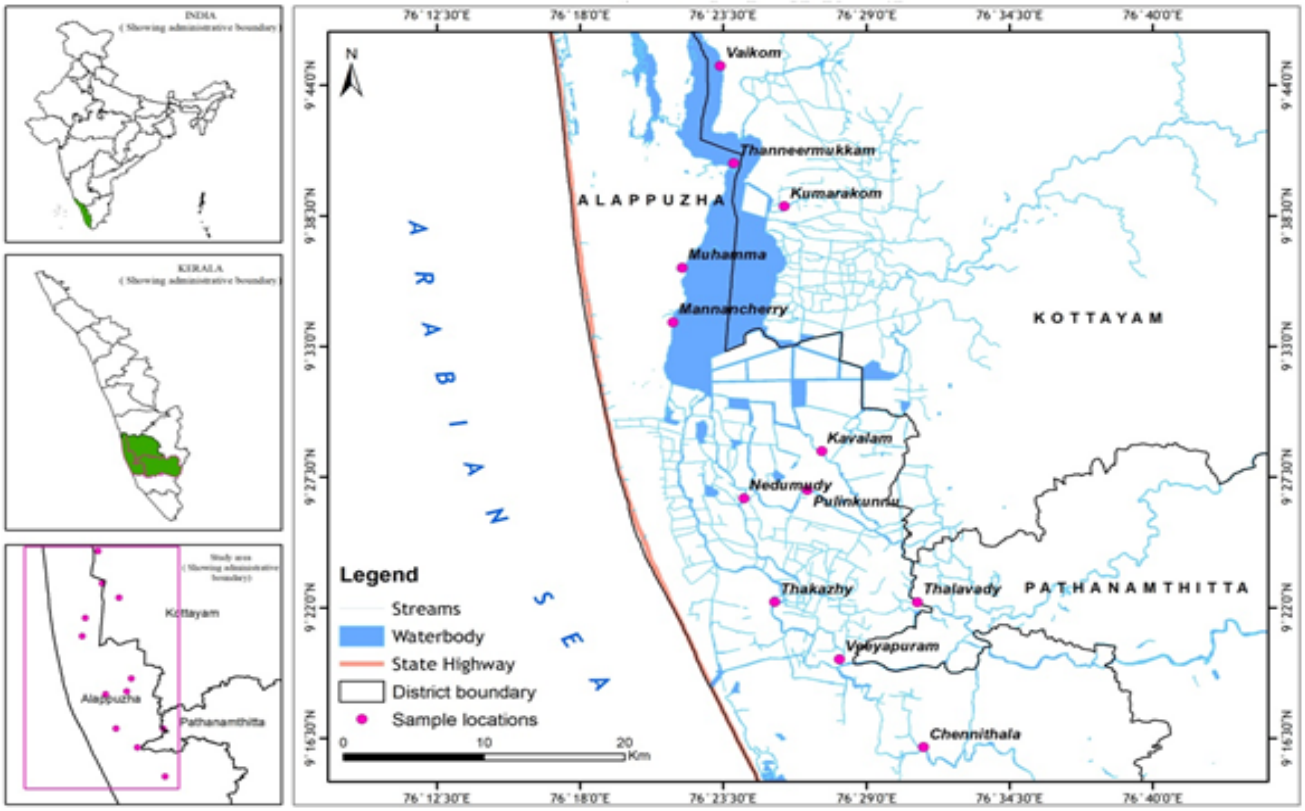

Figure 1. Study Area - Kuttanad

Table 1. Fish species of Kuttanad

S. No.	Species	Order	Family	IUCN status
1.	*Anguilla bengalensis*	Anguilliformes	Anguillidae	Near threatened
2.	*Xenentodon cancila*	Beloniformes	Belonidae	Least concern
3.	*Hyporhamphus limbatus*	Beloniformes	Hemiramphidae	Vulnerable
4.	*Hyporhamphus xanthopterus*	Beloniformes	Hemiramphidae	Least concern
5.	*Stolephorus indicus*	Clupeiformes	Engraulidae	Least concern
6.	*Nematalosa nasus*	Clupeiformes	Clupeidae	Least concern
7.	*Amblypharyngodon melettinus*	Cypriniformes	Cyprinidae	Least concern
8.	*Catla catla*	Cypriniformes	Cyprinidae	Least concern
9.	*Dawkinsia filamentosus*	Cypriniformes	Cyprinidae	Least concern
10.	*Labeo dussumieri*	Cypriniformes	Cyprinidae	Least concern
11.	*Labeo rohita*	Cypriniformes	Cyprinidae	Least concern
12.	*Tor khudree*	Cypriniformes	Cyprinidae	Least concern
13.	*Puntius amphibius*	Cypriniformes	Cyprinidae	Least concern
14.	*Rasbora daniconius*	Cypriniformes	Cyprinidae	Least concern
15.	*Puntius vittatus*	Cypriniformes	Cyprinidae	Vulnerable
16.	*Systomus subnasutus*	Cypriniformes	Cyprinidae	Least concern
17.	*Puntius madhusoodhani*	Cypriniformes	Cyprinidae	Not evaluated
18.	*Puntius mahecola*	Cypriniformes	Cyprinidae	Least concern
19.	*Cyprinus carpio*	Cypriniformes	Cyprinidae	Not evaluated
20.	*Cirrhinus mrigala*	Cypriniformes	Cyprinidae	Not evaluated
21.	*Gonoproktopterus curmuca*	Cypriniformes	Cyprinidae	Endangered
22.	*Aplocheilus lineatus*	Cyprinodontiformes	Aplocheilidae	Not evaluated
23.	*Poecilia reticulata*	Cyprinodontiformes	Poeciliidae	Least concern
24.	*Chanos chanos*	Gonorynchiformes	Chanidae	Not evaluated
25.	*Mugil cephalus*	Mugiliformes	Mugilidae	Critically endangered
26.	*Parambassis thomassi*	Beloniformes	Ambassidae	Vulnerable
27.	*Parambassis dayi*	Beloniformes	Ambassidae	Least concern
28.	*Anabas testudineus*	Perciformes	Anabantidae	Vulnerable

S. No.	Species	Order	Family	IUCN status
29.	*Channa marulius*	Perciformes	Channidae	Least concern
30.	*Channa striata*	Perciformes	Channidae	Least concern
31.	*Channa diplogramma*	Perciformes	Channidae	Not evaluated
32.	*Channa orientalis*	Perciformes	Channidae	Not evaluated
33.	*Channa micropeltes*	Perciformes	Channidae	Least concern
34.	*Pseudoetroplus maculatus*	Perciformes	Cichlidae	Least concern
35.	*Etroplus suratensis*	Perciformes	Cichlidae	Least concern
36.	*Oreochromis mossambicus*	Perciformes	Cichlidae	Least concern
37.	*Glossogobius giuris*	Perciformes	Gopiidae	Least concern
38.	*Scatophagus argus*	Perciformes	Scatophagidae	Least concern
39.	*Nandus nandus*	Perciformes	Nandidae	Least concern
40.	*Pristolepis marginata*	Perciformes	Nandidae	Not evaluated
41.	*Macropodus cupanus*	Perciformes	Osphronemidae	Least concern
42.	*Siganus javus*	Perciformes	Siganidae	Not evaluated
43.	*Pristolepis rubripinnis*	Perciformes	Nandidae	Not evaluated
44.	*Leiognathus equula*	Perciformes	Leiognathidae	Least concern
45.	*Lates calcarifer*	Perciformes	Latidae	Not evaluated
46.	*Terapon jarbua*	Perciformes	Terapontidae	Least concern
47.	*Sillago sihama*	Perciformes	Sillaginidae	Not evaluated
48.	*Lutjanus argentimaculatus*	Perciformes	Lutjantidae	Not evaluated
49.	*Brachirus orientalis*	Pleuronecetiformes	Soleidae	Not evaluated
50.	*Cynoglossus macrostomus*	Pleuronecetiformes	Cynoglossidae	Not evaluated
51.	*Arius subrostratus*	Siluriformes	Ariidae	Not Evaluated
52.	*Caranx sexfasciatus*	Perciformes	Carangidae	Least concern
53.	*Mystus gulio*	Siluriformes	Bagridae	Least concern
54.	*Mystus oculatus*	Siluriformes	Bagridae	Least concern
55.	*Clarias gariepinus*	Siluriformes	Calriidae	Not evaluated
56.	*Heteropneustes fossilis*	Siluriformes	Heteropneustidae	Endangered
57.	*Ompok malabaricus*	Siluriformes	Siluridae	Least concern
58.	*Ompok bimaculatus*	Siluriformes	Siluridae	Endangered
59.	*Wallago attu*	Siluriformes	Siluridae	Near threatened
60.	*Horabagrus brachysoma*	Siluriformes	Horobagridae	Vulnerable
61.	*Mastacembelus armatus*	Synbranchiformes	Mastacembilidae	Least concern
62.	*Macrognathus guentheri*	Synbranchiformes	Mastacembilidae	Vulnerable
63.	*Carinotetraodon travancoricus*	Tetraodontiformes	Tetraodontidae	Vulnerable
64.	*Triacanthus biaculeatus*	Tetraodontiformes	Triacanthidae	Not evaluated
65.	*Pastinachus sephen*	Myliobatiformes	Dasyatidae	Not evaluated

Perciformes represents higher number of species followed by Cypriniformes. Most dominant family was Cyprinidae followed by Channidae. Dominant fish species were *Stolephorus indicus, Oreochromis mossambicus, Xenentodon cancila, Scatophagus argus, Glossogobius giuris, Dawkinsia filamentosus, Mugil cephalus, Pristolepis marginata, Aplocheilus lineatus, Pseudoetroplus maculatus, Hyporhamphus xanthopterus* and *Amblypharyngodon melettinus*.

Out of the 65 species, 1 species (*Mugil cephalus*) was critically endangered, 3 species (*Ompok bimaculatus, Heteropneustes fossilis*, and *Gonoproktopterus curmuca*) were endangered, 7 species (*Hyporhamphus limbatus, Puntius vittatus, Parambassis thomassi, Anabas testudineus, Horabagrus brachysoma, Macrognathus guentheri* and *Carinotetraodon travancoricus*) were vulnerable and 2 species were (*Anguilla bengalensis* and *Wallago attu*) near threatened.

Shannon – Weiner index showed a high value of 1.64 ± 0.028 seen during monsoon in North Kuttanad. In the monsoon season lower Kuttanad showed a value of 1.524 ± 0.021 and upper Kuttanad showed a value of 1.40 ± 0.101. These values indicate North Kuttanad showed a high diversity in monsoon season when compared to lower Kuttanad and upper Kuttanad. Although the diversity was seen varied during three seasons, North Kuttanad showed a high diversity than lower Kuttanad and upper Kuttanad in all three seasons. Among three different seasons, monsoon season showed a high diversity than post monsoon and pre monsoon seasons. Lowest diversity was seen during pre monsoon season (Table 2).

Simpson's diversity index showed a lowest value of 0.025 ± 0.005 in north Kuttanad during monsoon season. In lower Kuttanad and upper Kuttanad lowest

Table 2. Fish diversity during different seasons

	Pre Monsoon	Monsoon	Post Monsoon
Upper Kuttanad			
Shannon H' Log Base 10.	1.34 ± 0.085	1.40 ± 0.101	1.408 ± 0.062
Simpson's Diversity (D)	0.052 ± 0.008	0.044 ± 0.009	0.046 ± 0.007
Hill's Number H0	27 ± 5.56	33.66 ± 8.08	33 ± 4.58
Margalef's M Base 10.	15.16 ± 0.851	15.38 ± 1.88	13.82 ± 0.589
Alpha	5.773 ± 0.938	7.73 ± 0.998	6.38 ± 0.665
Lower Kuttanad			
Shannon H' Log Base 10.	1.45 ± 0.003	1.524 ± 0.021	1.48 ± 0.005
Simpson's Diversity (D)	0.041 ± 0.001	0.033 ± 0.002	0.037 ± 0.001
Hill's Number H0	38 ± 0		39 ± 0.00
Margalef's M Base 10.	14.56 ± 1.003	14.67 ± 1.558	13.53 ± 0.425
Alpha	8.45 ± 1.091	9.30 ± 1.562	7.61 ± 0.408
North Kuttanad			
Shannon H' Log Base 10.	1.49 ± 0.042	1.64 ± 0.028	1.63 ± 0.025
Simpson's Diversity (D)	0.037 ± 0.003	0.025 ± 0.005	0.026 ± 0.002
Hill's Number H0	40 ± 3.61	53 ± 0.0	49.66 ± 2.309
Margalef's M Base 10.	18.35 ± 1.64	18.04 ± 2.92	15.85 ± 0.987
Alpha	8.33 ± 0.58	12.01 ± 3.52	8.49 ± 0.479

Simpson's value was 0.033 ± 0.002 and 0.044 ± 0.009 respectively in monsoon season. Simpson's value showed that high diversity was in monsoon season and north of lower Kuttanad had a high diversity when compared to lower Kuttanad and upper Kuttanad. Simpson's value also indicates that highest diversity seen during monsoon season and lowest diversity seen during pre monsoon season (Table 2).

Hill's number showed a high score of 53 ± 0.0 during monsoon season in north Kuttanad. Lower Kuttanad showed a score of 40.33 ± 1.15 and upper Kuttanad showed a score of 33.66 ± 8.08 in monsoon season. Lowest Hill's number value of 27 ± 5.56 showed during pre monsoon season in upper Kuttanad. Diversity analysis using Hill's number showed that highest diversity seen during monsoon season in north Kuttanad and lowest diversity seen during pre monsoon season in upper Kuttanad (Table 2).

Margalef's index showed species richness in a particular area. Species richness was higher during pre monsoon season (18.35 ± 1.64) in north Kuttanad followed by upper Kuttanad (15.16 ± 0.851) and lower Kuttanad (14.56 ± 1.003). As per Margalef's index lowest species richness was seen during post monsoon season in lower Kuttanad (13.53 ± 0.425). So species richness agreed to a fact that it descending in the order of pre monsoon, monsoon and post monsoon seasons (Table 2).

Alpha diversity showed a high value of 12.01 ± 3.52 during monsoon season in north Kuttanad and lowest value of 5.773 ± 0.938 during monsoon in upper Kuttanad. Alpha diversity values showed a trend in accordance with Shannon – Weiner index, Simpson's index and Hill's number (Table 2).

Regarding diversity indices values highest diversity was observed in monsoon season accompanied by post monsoon and pre monsoon seasons. Region wise diversity can ascertain in the order of north Kuttanad, lower Kuttanad and upper Kuttanad (Table 2).

DISCUSSION

A total of 65 species were identified during the present study. Among them *Stolephorus indicus, Pseudoetroplus maculatus, Systomus subnasutus, Puntius mahecola, Labeo dussumieri, Oreochromis mossambicus, Xenentodon cancila, Hyporhamphus xanthopterus, Hyporhamphus limbatus, Scatophagus argus, Glossogobius giuris, Dawkinsia filamentosus, Mugil cephalus, Pristolepis marginata* and

Aplocheilus lineatus were the most abundant species. Each of these species represents more than 1% of total fish population.

Vijayasree and Radhakrishnan (2014) identified 62 species from rivers of Kuttanad. George et al. (2016) identified 35 fish species from upper Kuttanad. Asha et al. (2014) identified 80 fish species from Vembanad Lake which is a part of Kuttanad and suggested that construction of Thanneermukkam bund across the Vembanad Lake changed the ecosystem. It is a reason for declining fish diversity. Sahib (2017) studied that Vembanad Lake had a fish assemblage of 20 species belonging to 18 families and discussed that low fish species composition reveals that Vembanad Lake is under degradation due to anthropogenic and climatic factors.

In this study diversity indices values such as Shannon – Weiner index value, Simpson's diversity value, Hill's number, Margalef's richness and Alpha diversity values indicates the current diversity status of Kuttanad. Shannon – Weiner Index value (H') is not much higher even though there is a difference among study sites and seasons. It represents low fish diversity in Kuttanad region. These low values are due to fishing gears used having high selectivity effect (Keskin and Unsal 1998). Inappropriate use of fishing gear can limit fish diversity. Blyth – Skyrme et al. (2006) reported that limited home range species and species with early age at maturity were survived in a greater rate within fishing gear restrictions zone. Effect of fishing gears on fish diversity was not considered in this study. Even though Kuttanad people rely on fishing for livelihood, restrictions have to be implemented on fishing gears used in monsoon season since it is the breeding season of fish species (Shaji and Laladhas 2013). Kuttanad is also an eco-tourism centre which causes habitat destruction and there by leads to low diversity. Different factors eventually leads to habitat destruction alters fish diversity (Wolter and Arlinghaus 2003)

Monsoon season showed the highest diversity accompanied by post monsoon and pre monsoon seasons. Seasonal variations in the nutrients availability in the aquatic system affect the coexistence of different types of fish species. Environmental conditions and seasonal migrations of fish species have a leading role in the seasonal variations of fish diversity (Hossain et al. 2012).

North Kuttanad showed high diversity than lower Kuttanad and upper Kuttanad in all three seasons (North Kuttanad>Lower Kuttanad>upper Kuttanad). It is due to north Kuttanad is a brackish aquatic system, thus a transition area between marine and fresh water aquatic system. Due to this edge effect, north Kuttanad shows a high diversity when compared to lower Kuttanad and upper Kuttanad (Smith et al. 2008).

In this study there is a remarkable absence of one native fish *Clarias dussumieri*, a cat fish which was abundant in the Kuttanad region. This species was recorded up to 2014 (Kurup et al. 2004, Renjithkumar et al. 2011, Vijayasree and Radhakrishnan 2014). In the Vembanad region it was locally extinct from 2008 (ATREE 2012). Local extinction of *C.dussumieri* is also reported from Thrissur district, Kerala (Shaji and Bijukumar 2016). Aneesh et al. (2013) reported that deterioration of natural habitat and breeding grounds of *C.dussumieri* due to the farming of African cat fish, *C.gariepinus* and excessive use of pesticides and fertilizers will lead to the local extinction of this fish species. Salin (2013) recommended for revising the position of *C.dussumieri* in IUCN red list from 'Near threatened' to 'Critically endangered'. So the seven vulnerable species in the present study needs attention in conservation of the natural habitat it inhabits. Proper fishing methods, sustainable agricultural practices and suitable restrictions in the exporting of ornamental fish will have a positive impact on conserving fish diversity.

CONCLUSIONS

Sixty five fresh and brackish water fish species identified from Kuttanad region. Season wise diversity showed monsoon season had a high diversity than post monsoon and pre monsoon seasons. North of Kuttanad showed a high diversity than lower and upper Kuttanad. Results revealed that Kuttanad fish diversity is declining when compared to previous year studies.

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DATA AVAILABILITY STATEMENT

Data given in this study is a part of first authors' Ph.D. Thesis entitled "Study on Status of Essential Trace Elements and Hydrochemical Parameters in Distribution and Diversity of Fishes in Kuttanad", Mahatma Gandhi Univesity, Kottayam, Kerala, India.

Conflict of Interest: The authors hereby declare that there was no conflict of interest concerning this research work.

Authors' contributions: SMG conceptualised the work and completed the acquisition, analysis, and interpretation of data presented in this article. JPM revised the manuscript critically for important and provided intellectual support.

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