



Seasonal restructuring of freshwater fish assemblages in the Cherupuzha tributary of the Chaliyar River under monsoonal influence

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Abstract

The present study evaluated the seasonal restructuring of freshwater fish assemblages in the Cherupuzha tributary of the Chaliyar River, Kerala, under monsoonal influence. Fish sampling conducted during pre-monsoon, monsoon, and post-monsoon seasons in 2025 recorded 26 species belonging to 8 orders and 15 families. Cypriniformes and Cyprinidae were the dominant taxonomic groups throughout the study period. Seasonal diversity analysis revealed higher diversity and evenness during the pre-monsoon season, while monsoon assemblages exhibited increased dominance and reduced diversity due to hydrological disturbance and habitat instability. Relative abundance patterns demonstrated clear seasonal turnover in fish community structure. Multivariate analyses, including NMDS ordination and cluster analysis, revealed distinct seasonal segregation of assemblages, with monsoon communities showing comparatively lower similarity to pre- and post-monsoon assemblages. The findings highlight the significant role of monsoonal hydrology in shaping fish assemblage dynamics and community organization in tropical freshwater ecosystems of the Western Ghats. The study provides baseline ecological information useful for biodiversity conservation and management of tributary ecosystems within the Chaliyar River basin.

Keywords: Freshwater fishes, seasonal variation, monsoonal hydrology, fish assemblages, cherupuzha tributary, Chaliyar River, Western Ghats, NMDS

Introduction

Freshwater ecosystems are among the most biologically productive yet highly threatened ecosystems in the world, supporting diverse assemblages of aquatic organisms and providing essential ecological services including nutrient cycling, fisheries production, habitat provision, and maintenance of regional biodiversity^[1, 2]. Riverine ecosystems of the Indian subcontinent are particularly important due to their high ichthyofaunal richness and endemism, especially within the Western Ghats, one of the world's recognized biodiversity hotspots^[3].

The Western Ghats possess a rich freshwater fish fauna characterized by high levels of endemism and ecological specialization^[4]. However, freshwater biodiversity in this region is increasingly threatened by anthropogenic disturbances such as habitat modification, pollution, river regulation, sand mining, invasive species introduction, and hydrological alterations associated with changing climatic regimes^[4, 5]. The ecological integrity of tropical river systems is strongly influenced by seasonal hydrological fluctuations, particularly monsoon-driven variations in discharge, flow velocity, sediment transport, and habitat availability, which collectively regulate fish assemblage structure and distribution.

Among the west-flowing rivers of Kerala, the Chaliyar River is ecologically significant due to its diverse freshwater habitats and hydrological connectivity with the Western Ghats landscape. The river originates from the Elambalari hills of the Western Ghats and traverses through Wayanad, Malappuram, and Kozhikode districts before draining into the Arabian Sea^[6, 7]. Previous investigations on the ichthyofauna of the Chaliyar river basin documented considerable fish diversity and highlighted the ecological sensitivity of the river system^[8]. Recent studies further

emphasized the influence of seasonal and hydrological gradients on fish diversity patterns within the Chaliyar river system^[6, 7].

Seasonal variation plays a critical role in structuring tropical freshwater fish assemblages. Monsoon-induced hydrological disturbances can alter habitat heterogeneity, substrate composition, turbidity, dissolved oxygen dynamics, and resource availability, thereby influencing species richness, abundance, and community organization. Several studies from the Western Ghats have reported significant temporal variation in fish diversity associated with monsoonal hydrology and habitat complexity^[1, 6]. Furthermore, multivariate ecological approaches such as cluster analysis, diversity indices, and ordination techniques have proven effective in understanding assemblage restructuring and ecological gradients in tropical river ecosystems^[2, 6].

Although several studies have documented fish diversity within major river systems of Kerala, detailed investigations focusing on tributary ecosystems of the Chaliyar basin remain limited. Tributaries often function as ecologically important microhabitats supporting localized fish assemblages, seasonal refugia, breeding grounds, and trophic interactions. However, the ichthyofaunal diversity and seasonal assemblage dynamics of the Cherupuzha tributary remain poorly documented despite its ecological importance within the Chaliyar river network.

Therefore, the present study was undertaken to evaluate the seasonal restructuring of freshwater fish assemblages in the Cherupuzha tributary of the Chaliyar River under monsoonal influence. The study specifically aimed to: (i) document the freshwater fish assemblage composition of the study area, (ii) assess seasonal variations in diversity, dominance, and evenness patterns, and (iii) evaluate seasonal assemblage restructuring using multivariate

ecological analyses. The findings of the present investigation are expected to contribute to the ecological understanding and conservation management of tropical freshwater ecosystems within the Western Ghats region.

Materials and Methods

1. Study Area

The present study was conducted in the Cherupuzha River, an important tributary of the Chaliyar River, one of the major west-flowing river systems of northern Kerala, India. The study area is located in and around Mavoor in Kozhikode district, Kerala. The river traverses the midland region of the Malabar zone and is characterized by pronounced seasonal fluctuations in water level and flow regime primarily regulated by the southwest monsoon.

Three sampling stations were selected along the Cherupuzha tributary based on habitat heterogeneity and accessibility: (a) Nalloli, (b) Nochikatt and (c) Thengilakadav (Fig.1). These stations collectively represent diverse freshwater microhabitats within the river system. The Cherupuzha River supports heterogeneous habitat types including riffles, runs, pools, and marginal vegetated zones that provide suitable ecological niches for diverse freshwater fish assemblages.

The river experiences distinct pre-monsoon, monsoon, and post-monsoon seasons, which strongly influence hydrology, habitat availability, substrate characteristics, and fish distribution patterns. Such hydrological seasonality is characteristic of west-flowing rivers originating from the Western Ghats and plays a significant role in structuring ichthyofaunal diversity and assemblage composition [3, 5].

The study area was selected due to the limited availability of detailed ichthyofaunal documentation from the Cherupuzha tributary and its ecological significance within the Chaliyar river basin. The river system supports a variety of freshwater habitats and provides an ecologically important environment for evaluating seasonal restructuring of fish assemblages under monsoonal influence.

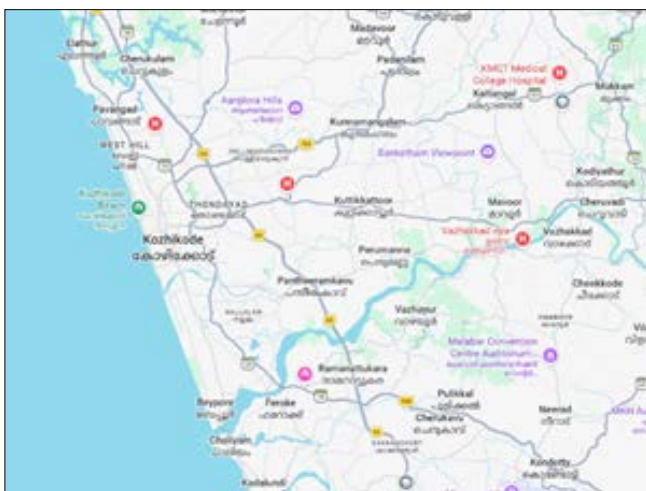


Fig 1: Map showing study locations

2. Sampling Design and Fish Collection

Fish sampling was carried out during 2025 across three major seasonal periods, namely pre-monsoon, monsoon, and post-monsoon, from the three selected sampling stations of the Cherupuzha tributary: Nalloli, Nochikatt, and

Thengilakadav. Seasonal sampling was undertaken to evaluate temporal variation in freshwater fish assemblage structure under monsoonal influence.

Fish specimens were collected using locally operated cast nets, gill nets, drag nets, and hand nets of varying mesh sizes following standard freshwater fish sampling procedures [2, 6, 7]. Sampling was conducted with the assistance of local fishermen to ensure adequate representation of fishes inhabiting different microhabitats including riffles, runs, pools, and vegetated margins.

The collected specimens were photographed immediately after capture and preserved in 10% formalin for taxonomic identification and further analysis. Fish species were identified using standard taxonomic keys and identification manuals provided by Talwar and Jhingran (1991) and Jayaram (1999, 2010) [2, 6]. The identified fishes were systematically categorized into respective orders, families, and species.

3. Data Analysis

Season-wise abundance data of fish assemblages were pooled and analyzed to assess diversity structure, dominance patterns, and seasonal assemblage variation.

Species Richness

Species richness (S) was determined as the total number of species recorded during each sampling season.

Dominance Index

Dominance index (D) helps to identify the dominant fish species in the selected area of study (Harper, 1999). The minimum index value is 1. It is calculated using the following equation

$$D = \sum (n_i/n)^2$$

Where N_i is the number of individuals of taxon I, and n is the total number of individuals in the sample.

Shannon–Wiener Diversity Index

Shannon diversity index (SD) is a measure of species abundance as well as richness and is used to quantify the diversity of the species. In most ecological studies, the Shannon–Wiener diversity index typically ranges between 1.5 and 3.5 (Ulfah et al., 2019); however, values above 4 are rarely observed in natural communities (Magur ran, 2004). It is calculated as (Shannon and Weiner, 1949):

$$SD = \sum P_i \log 2p_i$$

Where P_i is the proportion of the number of individuals of the i th species, within the sample; N_i is the number of individuals in the i th species and N is the total number of individuals.

Evenness Index

Pielou's evenness index (J) was calculated to determine the uniformity of species distribution within the fish assemblage.

4. Multivariate Analysis

To evaluate seasonal restructuring of fish assemblages, multivariate ecological analyses were performed using abundance data of recorded fish species.

Non-metric Multidimensional Scaling (NMDS)

Non-metric multidimensional scaling (NMDS) ordination based on Bray–Curtis similarity matrices was employed to visualize seasonal variation in fish assemblage composition and ecological similarity among seasons^[6].

Cluster Analysis

Hierarchical cluster analysis using Bray–Curtis similarity coefficients was performed to determine similarity patterns among seasonal fish assemblages and to evaluate seasonal grouping of fish communities^[2, 6].

The diversity indices and graphical analyses were performed using Microsoft Excel and ecological statistical tools. The generated visualizations included seasonal diversity plots, relative abundance plots, heatmaps, NMDS ordination plots, and cluster dendrograms for interpreting assemblage restructuring under monsoonal influence.

Results

1. Species Composition

A total of 26 freshwater fish species belonging to 8 orders and 15 families were recorded from the Cherupuzha tributary of the Chaliyar River during the study period in 2025. The recorded ichthyofauna exhibited considerable taxonomic diversity, reflecting the ecological heterogeneity of the river system.

Among the recorded orders, Cypriniformes constituted the dominant group in terms of species richness, followed by Perciformes and Siluriformes. The family Cyprinidae represented the most dominant family with the highest number of species, indicating the prevalence of cyprinid assemblages within the freshwater habitats of the study area. Similar dominance of Cypriniformes and Cyprinidae has been previously reported from the river systems of the Western Ghats and the Chaliyar River basin^[1, 2, 6, 8].

The fish assemblage included species belonging to diverse ecological guilds inhabiting riffles, runs, pools, and marginal vegetated habitats of the river system. Several species recorded during the study belonged to the IUCN Least Concern category, while a few taxa represented vulnerable and not-evaluated conservation categories, indicating the ecological significance of the tributary in supporting freshwater biodiversity.

Seasonal variation in species occurrence and abundance was observed among pre-monsoon, monsoon, and post-monsoon periods, suggesting the influence of monsoon-driven hydrological fluctuations on fish assemblage organization. Variations in habitat availability, flow regime, and substrate characteristics during different seasons likely contributed to the observed restructuring patterns within the fish community.

The overall species composition recorded from the Cherupuzha tributary indicates that the river system supports a moderately diverse freshwater fish assemblage despite increasing ecological pressures associated with habitat alteration and hydrological variability within the Chaliyar river basin.

Order	Family	Species	IUCN
Cypriniformes	Cyprinidae	<i>Puntius mahecola</i>	LC
	Danionidae	<i>Devario malabaricus</i>	LC
	Cyprinidae	<i>Systomus rufus</i>	NE
	Cyprinidae	<i>Devario aquipinnatus</i>	LC
	Cobitidae	<i>Lepidocephalichthys thermalis</i>	LC
	Cyprinidae	<i>Pethia punctata</i>	LC
	Cyprinidae	<i>Haludaria fasciata</i>	LC
	Cyprinidae	<i>Rasbora daniconius</i>	LC
Siluriformes	Cyprinidae	<i>Dawkinsia filamentosa</i>	LC
	Bagridae	<i>Mystus malabaricus</i>	LC
	Bagridae	<i>Horabagrus brachysoma</i>	VU
	Siluridae	<i>Wallago attu</i>	LC
	Cyprinidae	<i>Barilius gatensis</i>	LC
	Heteropneustidae	<i>Heteropneustes fuscus</i>	NE
Perciformes	Siluridae	<i>Ompok malabaricus</i>	LC
	Ambassidae	<i>Ambassis ambassis</i>	LC
	Cichlidae	<i>Etroplus maculatus</i>	LC
	Gobiidae	<i>Glossogobius giurius</i>	LC
Anabantiformes	Cichlidae	<i>Etroplus suratensis</i>	LC
	Channidae	<i>Channa marulius</i>	LC
	Channidae	<i>Channa striatus</i>	LC
Beloniformes	Anabantidae	<i>Anabas trsteudineus</i>	LC
Beloniformes	Belonidae	<i>Xenentodon cancila</i>	LC
Elopiiformes	Megalopidae	<i>Megalops cyprinoides</i>	LC
Mugiliformes	Mugilidae	<i>Mugil cephalus</i>	LC
Synbranchiformes	Mastacembelidae	<i>Mastacembelus armatus</i>	LC

2. Seasonal Diversity Analysis

Seasonal variation in freshwater fish assemblage structure was evident across the pre-monsoon, monsoon, and post-monsoon periods of the study. Diversity indices including species richness, dominance index, Shannon–Wiener diversity index, and evenness index exhibited measurable seasonal fluctuations associated with monsoonal hydrological variation in the Cherupuzha tributary.

A total species richness of 26 species was recorded during all three seasons. However, the abundance distribution and community organization varied seasonally. The pre-monsoon season exhibited the highest Shannon diversity value ($H' = 3.222$), followed by the post-monsoon season ($H' = 3.197$), whereas comparatively lower diversity was observed during the monsoon season ($H' = 3.167$) (Table 1; Fig. 2). The reduction in diversity during monsoon indicates seasonal restructuring of fish assemblages under increased hydrological disturbance and fluctuating habitat conditions.

The dominance index was highest during the monsoon season ($D = 0.0446$), followed by post-monsoon ($D = 0.0427$) and pre-monsoon ($D = 0.0411$). Increased dominance during monsoon suggests that a relatively smaller number of species became numerically dominant under high-flow conditions, possibly due to habitat filtering and seasonal displacement of sensitive taxa.

Evenness values remained consistently high throughout the study period, ranging from 0.972 to 0.989. The highest evenness was observed during the pre-monsoon season ($J = 0.989$), indicating comparatively uniform species distribution and stable assemblage structure during periods of reduced hydrological disturbance. Slight reduction in

evenness during monsoon reflects moderate shifts in species abundance patterns associated with seasonal hydrological fluctuations.

Overall, the diversity analysis demonstrated clear seasonal variation in fish assemblage structure within the Cherupuzha tributary. The observed pattern suggests that monsoon-driven hydrological changes influence species abundance, dominance structure, and community organization in the river ecosystem.

Table 1: Seasonal diversity indices of freshwater fish assemblages in the Cherupuzha tributary

Season	Total Abundance (N)	Species Richness (S)	Dominance Index (D)	Shannon Diversity (H')	Evenness (J)
Pre-monsoon	677	26	0.0411	3.222	0.989
Monsoon	584	26	0.0446	3.167	0.972
Post-monsoon	726	26	0.0427	3.197	0.981

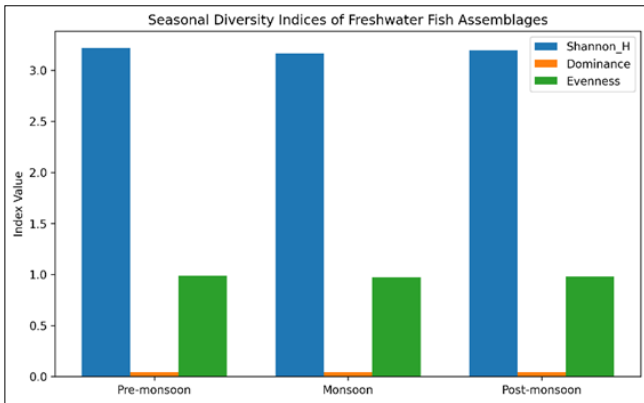


Fig 2: Seasonal variation in dominance index, Shannon diversity index, and evenness index of freshwater fish assemblages in the Cherupuzha tributary.

3. Relative Abundance Structure of Fish Assemblages

The relative abundance analysis revealed distinct seasonal variation in the composition and dominance structure of freshwater fish assemblages in the Cherupuzha tributary. Several taxa exhibited noticeable fluctuations in abundance across pre-monsoon, monsoon, and post-monsoon seasons, indicating seasonal restructuring of the fish community under varying hydrological conditions. Cyprinid fishes constituted a major proportion of the assemblage throughout the study period and remained one of the dominant taxonomic groups across all seasons. Members of Ambassidae, Cichlidae, Bagridae, Siluridae, and Mastacembelidae also contributed substantially to the assemblage structure. Seasonal shifts in the abundance of these taxa were evident during the monsoon period, suggesting the influence of hydrological disturbances on habitat utilization and species distribution.

During the pre-monsoon season, relatively higher abundance of certain cyprinid and ambassid species was observed, indicating comparatively stable habitat conditions and favorable ecological niches. In contrast, the monsoon season exhibited altered abundance patterns characterized by increased dominance of a few taxa and reduction in the relative contribution of several species. Such variation may

be associated with increased water discharge, habitat instability, turbidity, and displacement of fishes during high-flow conditions. Post-monsoon assemblages showed partial recovery in abundance distribution with comparatively balanced representation of multiple taxa. This pattern suggests recolonization and stabilization of habitat conditions following monsoon-induced hydrological disturbances. The relative abundance structure clearly demonstrated seasonal turnover in fish assemblages within the Cherupuzha tributary. The observed variations indicate that monsoonal hydrology plays an important role in regulating assemblage composition, dominance patterns, and ecological organization of freshwater fishes in the river ecosystem.

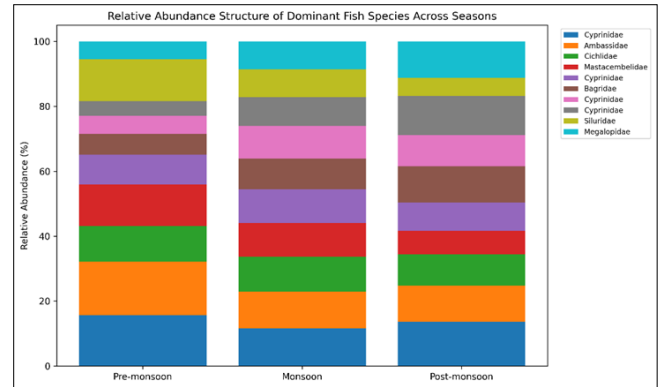


Fig 3: Relative abundance structure of dominant freshwater fish assemblages across pre-monsoon, monsoon, and post-monsoon seasons in the Cherupuzha tributary.

4. Non-metric Multidimensional Scaling (NMDS) Analysis

Non-metric multidimensional scaling (NMDS) ordination analysis revealed distinct seasonal variation in freshwater fish assemblage composition within the Cherupuzha tributary. The ordination pattern demonstrated ecological separation among pre-monsoon, monsoon, and post-monsoon assemblages, indicating seasonal restructuring of the fish community under varying hydrological conditions. The monsoon assemblage exhibited comparatively distinct positioning in the ordination space relative to pre-monsoon and post-monsoon assemblages, suggesting substantial alteration in species composition and abundance structure during periods of increased hydrological disturbance. Such separation may be associated with monsoon-induced changes in water discharge, habitat heterogeneity, turbidity, and substrate instability, which can influence habitat utilization and distribution of freshwater fishes.

Pre-monsoon assemblages were characterized by relatively stable ecological organization, whereas post-monsoon assemblages showed partial convergence towards pre-monsoon conditions, indicating recovery and recolonization of fish communities following monsoonal disturbance. The ordination pattern therefore suggests that seasonal hydrological fluctuations play a significant role in regulating fish assemblage dynamics within the river ecosystem. The NMDS analysis further demonstrated that fish community composition in the Cherupuzha tributary is strongly influenced by temporal environmental variability associated with monsoonal hydrology. The observed seasonal segregation of assemblages provides ecological evidence for monsoon-driven restructuring of freshwater fish communities in the tributary system.

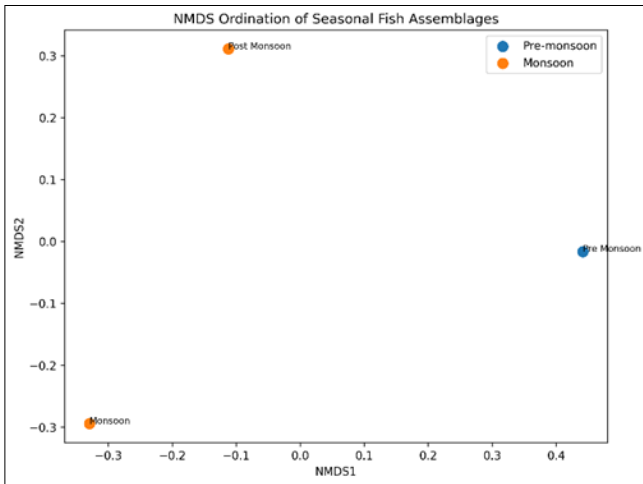


Fig 4: NMDS ordination plot showing seasonal variation in freshwater fish assemblage composition in the Cherupuzha tributary

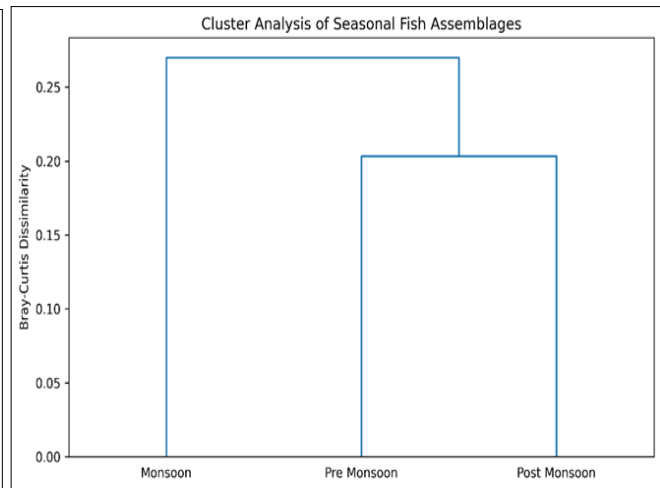


Fig 5: Hierarchical cluster dendrogram showing seasonal similarity patterns of freshwater fish assemblages in the Cherupuzha tributary

5. Cluster Analysis

Hierarchical cluster analysis based on Bray–Curtis similarity coefficients revealed distinct seasonal grouping patterns among freshwater fish assemblages of the Cherupuzha tributary. The dendrogram demonstrated comparatively higher similarity between pre-monsoon and post-monsoon assemblages, whereas monsoon assemblages formed a relatively separate cluster. The clustering pattern indicates that monsoon-induced hydrological disturbances substantially influence fish community composition and assemblage organization within the river system. Increased water discharge, flow turbulence, turbidity, and habitat alteration during the monsoon period likely contributed to the observed divergence of monsoon assemblages from the comparatively stable pre-monsoon and post-monsoon communities.

The close association between pre-monsoon and post-monsoon assemblages suggests partial recovery and stabilization of habitat conditions following the monsoon period. Such recovery patterns indicate recolonization and redistribution of fish species after seasonal hydrological disturbance. Similar seasonal clustering patterns have been reported from other tropical river ecosystems of the Western Ghats, where monsoonal variation significantly influenced assemblage structure and community similarity [2, 6, 7]. Overall, the cluster analysis provided strong ecological evidence for seasonal restructuring of freshwater fish assemblages in the Cherupuzha tributary under monsoonal influence. The observed seasonal segregation highlights the importance of hydrological variability in shaping community organization and ecological dynamics of tropical freshwater fishes.

Discussion

The present investigation revealed considerable seasonal variation in freshwater fish assemblage structure within the Cherupuzha tributary of the Chaliyar River, indicating the strong influence of monsoonal hydrology on community organization and species distribution. A total of 26 species belonging to 8 orders and 15 families were recorded during the study period, reflecting the ecological heterogeneity and habitat complexity of the river system. Similar dominance of Cypriniformes and the family Cyprinidae has been

widely reported from river systems of the Western Ghats and the Chaliyar basin [1, 2, 6, 8].

The Shannon diversity values obtained during the study indicated relatively high species diversity throughout the river system, with the highest diversity observed during the pre-monsoon season. Reduced diversity during the monsoon period suggests seasonal restructuring of fish assemblages associated with hydrological disturbance. Monsoon-driven increases in water discharge, flow velocity, turbidity, and substrate instability can alter habitat availability and influence fish movement, feeding behavior, and distribution patterns. Similar seasonal fluctuations in ichthyofaunal diversity associated with monsoonal variation have been documented from tropical river ecosystems of Kerala and the Western Ghats [1, 6, 7].

The comparatively higher dominance index recorded during monsoon indicates that a limited number of taxa became numerically dominant under disturbed environmental conditions. Such dominance patterns may result from ecological filtering, where hydrological stress selectively favors species capable of tolerating fluctuating environmental conditions. Conversely, sensitive or habitat-specialist taxa may undergo temporary displacement or reduction in abundance during periods of intense flow disturbance. Similar observations have been reported from other freshwater ecosystems where seasonal hydrological variability strongly influenced assemblage stability and species dominance [2, 6].

The consistently high evenness values observed throughout the study suggest comparatively balanced species distribution within the assemblage despite seasonal hydrological fluctuations. High evenness generally reflects ecological stability and the absence of excessive monopolization by a few dominant taxa. However, the slight reduction in evenness during monsoon indicates moderate shifts in abundance structure associated with hydrological perturbation and habitat modification.

The relative abundance analysis and heatmap visualization further demonstrated clear seasonal turnover in fish assemblages. Several taxa exhibited marked fluctuations in abundance across seasons, indicating differential ecological

responses to monsoon-driven environmental changes. Certain taxa maintained relatively stable abundance throughout the study period, suggesting broader ecological tolerance and adaptability to hydrological variation, whereas others exhibited strong seasonal variability indicative of habitat-specific sensitivity.

Multivariate analyses provided strong ecological evidence for seasonal restructuring of fish communities within the Cherupuzha tributary. The NMDS ordination demonstrated distinct separation of monsoon assemblages from pre-monsoon and post-monsoon communities, indicating substantial seasonal variation in assemblage composition. Similarly, cluster analysis revealed greater similarity between pre-monsoon and post-monsoon assemblages, while monsoon assemblages formed a comparatively separate group. These findings collectively suggest that monsoonal hydrology acts as a major ecological driver regulating fish assemblage dynamics in the river ecosystem. Hydrological seasonality is considered a fundamental ecological characteristic of tropical river systems of the Western Ghats [4, 5]. Seasonal variation in flow regime influences habitat complexity, substratum composition, dissolved oxygen availability, and food resource distribution, thereby affecting fish diversity and assemblage organization. Previous studies conducted in the Chaliyar river system also highlighted the importance of hydrological and environmental gradients in determining ichthyofaunal diversity and community structure [6, 7].

The Cherupuzha tributary supports ecologically important freshwater habitats including riffles, pools, runs, and vegetated margins that function as feeding grounds, shelter zones, and seasonal refugia for fishes. However, increasing anthropogenic pressures including habitat modification, sand mining, pollution, and hydrological alteration may threaten the ecological integrity of the tributary system. Conservation and continuous ecological monitoring of tributary ecosystems are therefore essential for sustaining freshwater fish diversity within the Chaliyar river basin. Overall, the present study demonstrated that seasonal hydrological variation significantly influences freshwater fish assemblage structure in the Cherupuzha tributary. The observed patterns of diversity, dominance, abundance distribution, and multivariate assemblage segregation collectively indicate monsoon-driven restructuring of fish communities within the river ecosystem.

Conclusion

The present study demonstrated significant seasonal variation in freshwater fish assemblage structure within the Cherupuzha tributary of the Chaliyar River under monsoonal influence. A total of 26 fish species belonging to 8 orders and 15 families were recorded, indicating moderate ichthyofaunal diversity and ecological heterogeneity within the tributary ecosystem.

Seasonal diversity analysis revealed comparatively higher diversity and evenness during the pre-monsoon period, whereas monsoon assemblages exhibited increased dominance and distinct community restructuring associated with hydrological disturbance. Relative abundance patterns, NMDS ordination, and cluster analysis collectively demonstrated clear seasonal segregation of fish

assemblages, emphasizing the strong influence of monsoonal hydrology on community organization and species distribution.

The observed similarity between pre-monsoon and post-monsoon assemblages suggests partial recovery and stabilization of habitat conditions following monsoonal disturbance. The study further highlights the ecological significance of tributary ecosystems in maintaining freshwater fish diversity within the Chaliyar river basin.

Considering the increasing anthropogenic pressures on tropical river ecosystems, including habitat alteration, pollution, and hydrological modification, continuous ecological monitoring and conservation-oriented management strategies are essential for sustaining freshwater biodiversity in the Cherupuzha tributary and associated riverine systems of the Western Ghats.

The findings of the present investigation contribute to the ecological understanding of seasonal fish assemblage dynamics in tropical freshwater ecosystems and provide baseline information for future biodiversity assessment and conservation planning in the Chaliyar river basin.

Acknowledgement

Authors are thankful to Dr. A.K. Khaja Nazeemudeen, Secretary and Correspondent, Dr. D.I. George Amalarethinam, Principal and Dr. M. Aneez Mohamed, Head, P.G. and Research Department of Zoology, Jamal Mohamed College (Autonomous), Affiliated to Bharathidasan University, Tiruchirappalli for Institutional support.

Conflict of Interest

The authors declare that there is no conflict of interest.

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