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Freshwater Fish Diversity of Kodoor River, Kottayam, Kerala, South India

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Abstract

The present study was conducted to gain a better understanding of the variety of freshwater fishes found in the Kodoor river. The Kodoor river has an abundance of indigenous fishery resources as well as a high level of biodiversity. The current study was carried out to identify the fish diversity of the Kodoor river in different layers(upstream, middle stream and down strean) and seasons(pre monsoon, monsoon and post monsoon). The study was conducted at different seasons (Post-monsoon, Monsoon, and Pre-monsoon) during the years 2021-2022. Fish for the study were collected from various locations along the Kodoor river by local fishermen. A total of 15 fish species representing nine families were documented. Among these, *Cyprinus carpio*, *Dawkinsia filamentosa*, and *Horabagrus brachysoma* were listed as Vulnerable, while the remaining species were of Least Concern. Family-wise analysis revealed the dominance of Cyprinidae, followed by Cichlidae and Channidae, with maximum abundance recorded during the monsoon season. Seasonal comparisons demonstrated that while the monsoon period supported the highest number of individuals (420), the post-monsoon season recorded greater diversity and evenness (Shannon index 2.081; Simpson's diversity index 0.8631). This indicates that stable hydrological conditions after flooding events favor balanced species distribution. In contrast, the pre-monsoon period supported fewer individuals and comparatively lower diversity values. Spatial analysis across river stretches showed that the middle stream harbored the largest fish population (445 individuals), particularly dominated by Cyprinids, likely due to its favorable flow regimes and habitat heterogeneity. However, the downstream region exhibited the highest diversity indices (Shannon index 1.845; Simpson's diversity index 0.812), suggesting that complex habitats such as pools and backwaters promote species coexistence. The upstream region supported moderate abundance and diversity. The presence of endemic and threatened species such as *Horabagrus brachysoma* underlines the ecological and conservation significance of the Kodoor River. Furthermore, the coexistence of both edible fishes (e.g., *Wallago attu*, *Channa marulius*, *Etroplus suratensis*) and ornamental species (e.g., *Rasbora daniconius*, *Xenentodon cancila*) highlights its socio-economic role in supporting fisheries and livelihood security for local communities.

Keywords: Fish diversity, Kodoor river, Biodiversity indices, Seasonal variation, Freshwater ecosystem.

1.Introduction

Kerala, situated along the southwestern flank of the Indian peninsula, is dissected by a dense mosaic of short, steep rivers that drain the windward slopes of the Western Ghats—one of the world's most important freshwater biodiversity hotspots. The state has 44 major rivers (41 west-flowing to the Arabian Sea and three east-flowing to the Cauvery basin), most of them monsoon-fed and highly seasonal (Kerala State Planning Board, 2017; Kerenvis, 2022). These rivers, together with floodplain wetlands and backwaters, sustain a disproportionately rich ichthyofauna characterized by high endemism, ecological specialization (e.g., hill-stream loaches, rheophilic barbs), and micro-endemism linked to river basins and elevational gradients within the Ghats (Dahanukar et al., 2011; Raghavan et al., 2011). Despite this richness, Kerala's riverine fish communities face mounting pressures from hydrological alteration (dams, inter-basin diversions), sand mining, pollution, riparian degradation, overexploitation, and rapid establishment of non-native species such as Mozambique tilapia Oreochromis mossambicus and other exotics (Raghavan et al., 2008; Raghavan, 2015; Athira & Jaya, 2020; Science of the Total Environment review on sand mining, 2022). Understanding spatio-temporal patterns of diversity, endemism, and threat is thus foundational for prioritizing conservation and guiding sustainable inland fisheries management across.

The reasons to ascertain the diversity status of fishes relied upon the fish biologists to study more diverse group of taxonomic phyla (35800 species of fishes FishBase 10/2022) and has more species than vertebrates (Matthews, 1998), there by constituting more than fifty percent of vertebrate animals (Nelson et al., 2016; Thakur et al., 2021) on the biosphere. Fish contribution to global fish diversity by Indian subcontinent (2904 fish species out of which 1081 fish species as freshwater fishes) is 11.7% (Stephen et al., 2015) and 7.7% (Froese & Pauly 2020).

The Western Ghats collectively harbor ~290 described freshwater fish species with endemism exceeding 60%—and Kerala's basins contribute substantially to this total (Dahanukar et al., 2011). Within Kerala specifically, an authoritative statewide synthesis catalogued 905 fish species across inland, brackish and marine realms, consolidating taxonomy, IUCN status and legal protection; a large share pertains to inland/riverine taxa (Bijukumar & Raghavan, 2015).

Several Kerala rivers are repeatedly flagged for exceptional diversity and narrow endemics. The Chalakudy River (central Kerala) supports >70–100 freshwater species and hosts multiple Western Ghats endemics—including Horabagrus spp. and Sahyadria chalakkudiensis—yet faces strong exotic incursion and hydrological stress (Ajithkumar et al., 1999; Raghavan et al., 2008; Chalakudy River profile). Recent fisheries monitoring further records high proportions of non-native species in Chalakudy catches, underscoring biodiversity erosion (Renjithkumar et al., 2017). Bharathapuzha (River Nila) similarly exhibits rich assemblages but is impacted by dams, sand mining, riparian loss, pollution and non-native species (Raghavan et al., 2013). Studies across Ashambu/Agasthyamalai landscapes (southern Kerala) also document high diversity and range-restricted taxa, highlighting conservation gaps in terrestrial-focused protected areas (Oryx analysis; Ashambu landscape surveys).

Dams, barrages and flow regulation fragment habitats, alter thermal/flow regimes, and disrupt longitudinal connectivity crucial for migratory cyprinids and catfishes (KSBB monitoring report; Bharathapuzha study). Sand mining—extensive in mid- and lower reaches—degrades channel morphology, depletes spawning substrates, and destabilizes banks; global syntheses emphasize its far-reaching ecological effects and potential to favor invasive taxa (Science of the Total Environment review, 2022).

Point and non-point pollution (urban sewage, agro-chemicals) and riparian vegetation loss are consistently associated with reduced native richness and benthic specialist declines (Bharathapuzha assessment; KSBB 2019 monitoring).

Kerala's rivers have among India's best-documented freshwater fish invasions. Seminal observations from the Chalakudy basin recorded widespread establishment of O. mossambicus, Gambusia affinis, Osphronemus goramy and livebearers across an upstream–downstream gradient, with tilapia even at >1000 m a.s.l. (Raghavan et al., 2008). Subsequent basin-level fisheries assessments show persistent and often dominant non-native components in catches (Renjithkumar et al., 2017), while statewide perspectives identify >30 alien fishes across the Kerala segment of the Ghats (Radhakrishnan et al., 2012).

The catastrophic August 2018 floods reconfigured channel–floodplain connectivity and likely redistributed native and non-native taxa; post-event analyses called for targeted biodiversity impact assessments and long-term monitoring (Raghavan, 2020).

Kerala has benefited from multiple synthesis products: a state-level checklist integrating nomenclature, IUCN categories and legal schedules (Bijukumar & Raghavan, 2015); Western Ghats-wide assessments and checklists (Dahanukar et al., 2011; 2013 update); and basin-specific faunal inventories in JoTT and allied

outlets (KSBB reports; JoTT checklists portal). These provide essential baselines for tracking conservation status and guiding habitat restorations (e.g., recent stock-enhancement of native Horabagrus spp. and other threatened taxa in Chalakudy by NBFGR/KUFOS).

The Kodoor River is an integral component of the aquatic network of the Kottayam and Alappuzha districts of Kerala. It originates in the hills between the Kottayam and Pathanamthitta districts and flows downstream to finally empty into the Meenachil River. The Meenachil River, into which the Kodoor drains, is a significant river system in its own right, with a length of 78 kilometers and a catchment area of 1272 square kilometers. Contemporary land use patterns along the Kodoor River's course are a significant factor in its ecological health. The river flows through areas with extensive rubber cultivation, small towns, and urban centers, where activities such as the operation of fish markets, slaughterhouses, and car service stations are concentrated along its banks. These human activities are a source of direct impact on the river's water quality and habitat integrity, a pattern consistent with riverine ecosystems in rapidly developing regions.

2.Materials and Methods

2.1 Sampling stations

Twelve stations of the Kodoor river were selected for sampling(Table : 2.1).

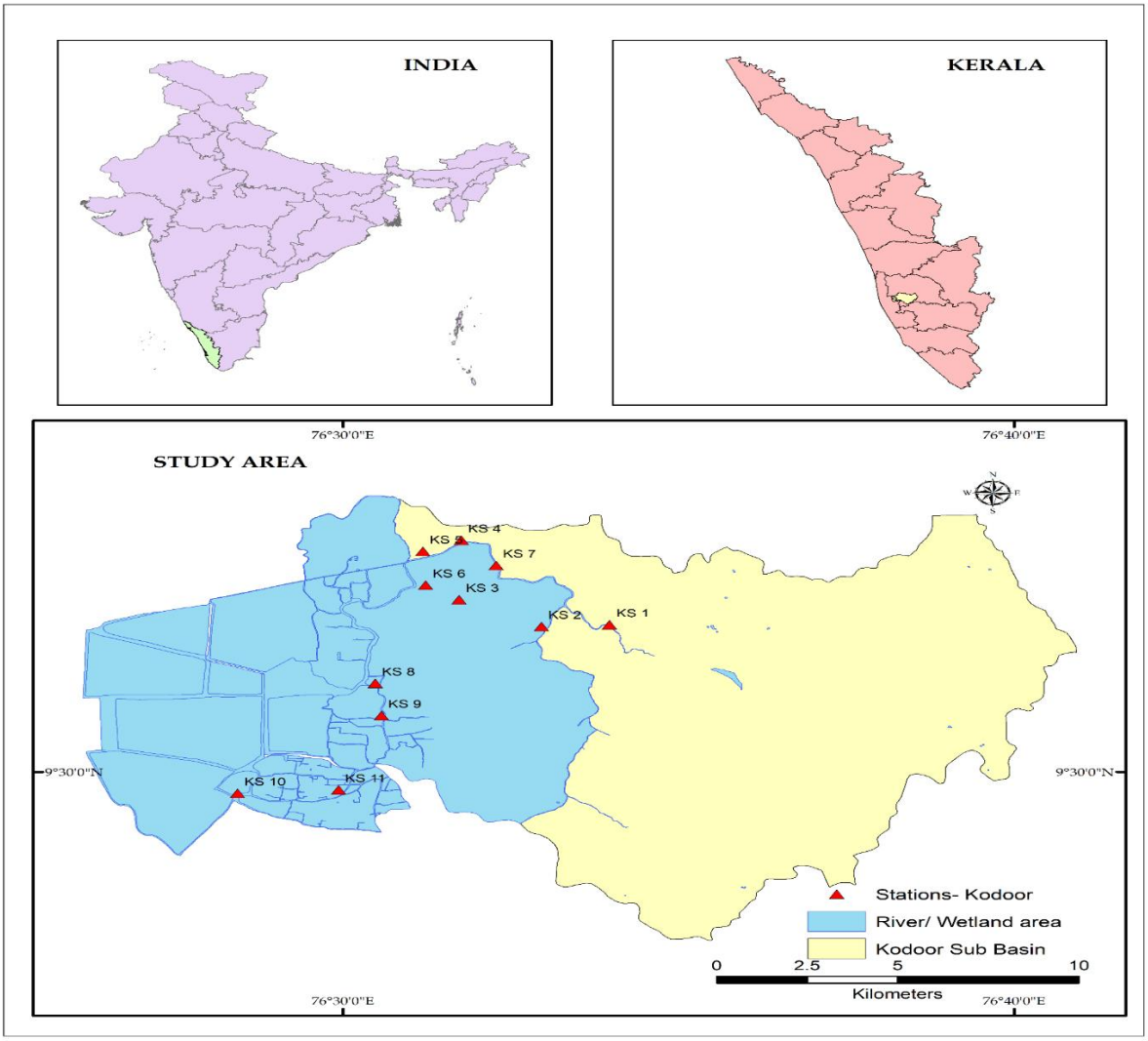

Figure -2.1 Map of sampling stations of Kodoor River

Table 2.1: Sampling stations of Kodoor river .

Station Code	Station Name	Layers	Location	
			Latitude(°N)	Longitude(°E)
KS 1	Puthuppally	Upstream	9.55233607	76.56619382
KS 2	Parekkadavu		9.55171959	76.54929419
KS 3	Kalithikadavu		9.56128603	76.5288436
KS 4	Erayilkadavu		9.58238989	76.52937866
KS 5	Kodimatha	Middle stream	9.57843345	76.51986267
KS 6	Manipuzha		9.56642072	6.52053899
KS 7	Parechal Jetty/ Moolavatom		9.57345563	76.53801632
KS 8	Pallam		9.53153702	76.50798366
KS 9	Chingavanam	Down stream	9.52008936	76.50955649
KS 10	Kavalam		9.4924813	76.47381684
KS 11	Kurichy		9.49365159	76.49892056
KS 12	Changanassery		9.44490155	76.52896581

2.2 Sampling and preservation of fishes

Fish samples were collected from different stations with the assistance of local fishermen using various types of nets, including gill nets, cast nets, and dragnets. The collected fishes were identified with the help of experts and standard books (Shaji, C. P., & Easa, P. S. 2003). The collected fishes were preserved in 10% formalin (APHA, 2017). The study was conducted during the year 2021.

3. Observations and Results

Table 3.1 presents the list of fish species recorded from different stretches (upstream, midstream, and downstream) of the Kodoor River along with their IUCN conservation status. A total of 15 species belonging to diverse ecological and economic importance were identified, of which the majority fall under the *Least Concern (LC)* category. Three species, namely *Cyprinus carpio* (Common Carp), *Dawkinsia filamentosa* (Blackspot Barb), and *Horabagrus brachysoma* (Yellow Catfish), are listed as *Vulnerable (VU)*, indicating localized threats to their populations.

The species were further categorized based on their utility, with most being edible (e.g., *Anabas testudineus*, *Etroplus suratensis*, *Channa marulius*) and a few having ornamental value (e.g., *Xenentodon cancila*, *Rasbora daniconius*). Distribution analysis shows that fish richness is comparatively higher in the midstream, where almost all species were encountered, while upstream and downstream stretches supported comparatively fewer species. The occurrence of ornamental species like *Rasbora daniconius* across all zones highlights the ecological diversity of the river.

Table 3.1 List of fishes with their IUCN status of Koodor river

Sl. No	Zoological Name	Common Name	Edible/Ornamental	IUCN status	Upstream	Middle stream	Down stream
1	*Anabas testudineus*	Climbing perch	Edible	LC	-	+	+
2	*Heteropneustes fossilis*	Stinging Catfish	Edible	LC	-	+	+
3	*Puntis sarana*	Olive barb	Edible	LC	-	+	-
4	*Etroplus suratensis*	Pearl spot	Edible	LC	-	-	+
5	*Etroplus maculatus*	Orange chromide	Edible	LC	-	+	+
6	*Xenentodon cancila*	Freshwater Garfish	Ornamental	LC	-	+	-
7	*Rasbora daniconius*	Slender Rasbora	Ornamental	LC	+	+	+
8	*Labeo dussumieri*	Malabar Labeo	Edible	LC	-	+	+
9	*Cyprinus carpio*	Common Carp	Edible	VN	+	+	-

10	*Dawkinsia filamentosa*	Blackspot barb	Edible	VN	-	+	+
11	*Clarius batrachus*	Walking Catfish	Edible	LC	-	+	-
12	*Wallago attu*	Wallago Catfish	Edible	LC	+	+	+
13	*Channa striata*	Striped Snakehead	Edible	LC	-	+	-
14	*Channa marulius*	Great snakehead fish	Edible	LC	+	+	+
15	*Horabagrus brachysoma*	Yellow cat fish	Edible	VN	-	+	-
VU-Vulnerable, NT- Near threatened, LC - Least concern ,EN-Endangered.(+) Sign indicates the presence of species and (-) Sign indicates absence of species in the particular area ,							

Table 3.2 depicts the seasonal variation in fish diversity of the Kodoor River during the study period (2021–2022). A total of 15 fish species belonging to different orders and families were recorded, showing distinct fluctuations in abundance across pre-monsoon, monsoon, and post-monsoon seasons. The highest number of individuals was consistently observed during the monsoon season, indicating that increased water flow, nutrient availability, and favourable breeding conditions during this period support higher fish abundance. Among the recorded species, *Rasbora daniconius* (Cyprinidae) was the most abundant, with 28, 51, and 32 individuals during pre-monsoon, monsoon, and post-monsoon respectively, followed by *Puntius sarana* and *Cyprinus carpio*. Species such as *Xenentodon cancila* and *Clarias batrachus* showed comparatively lower abundance but also peaked during the monsoon. Notably, most Cyprinids exhibited high seasonal abundance, reflecting their dominance and adaptability to changing riverine conditions.

Table 3.2 Seasonal variation in fish diversity of the Kodoor River

Fish diversity -Kodoor river 2021-2022			No. of observations		
Fish Species	**Order**	**Family**	**Pre monsoon**	**Monsoon**	**Post monsoon**
Anabas testudineus	Anabantiformes	Anabantidae	15	25	18
Channa marulius	Anabantiformes	Channidae	8	16	12
Channa striata	Anabantiformes	Channidae	12	22	15
Clarias batrachus	Siluriformes	Clariidae	6	12	8
Cyprinus carpio	Cypriniformes	Cyprinidae	23	38	28
Dawkinsia filamentosa	Cypriniformes	Cyprinidae	20	32	27
Etroplus maculatus	Cichliformes	Cichlidae	18	31	22
Etroplus suratensis	Cichliformes	Cichlidae	15	24	17
Heteropneustes fossilis	Siluriformes	Heteropneustidae	12	22	18
Horabagrus brachysoma	Siluriformes	Bagridae	8	18	12
Labeo dussumieri	Cypriniformes	Cyprinidae	16	31	21
Puntius sarana	Cypriniformes	Cyprinidae	24	41	28
Rasbora daniconius	Cypriniformes	Cyprinidae	28	51	32
Wallago attu	Siluriformes	Siluridae	17	37	24
Xenentodon cancila	Beloniformes	Belonidae	7	20	11

Table 3.3 summarizes the seasonal distribution of fish families in the Kodoor River during the study period. A total of nine families were recorded, with distinct variations in abundance across pre-monsoon, monsoon, and post-monsoon seasons. The family Cyprinidae dominated the assemblage, contributing the highest number of individuals (111, 193, and 136 during pre-monsoon, monsoon, and post-monsoon, respectively), reflecting their ecological adaptability and dominance in tropical freshwater systems.Other families such as Cichlidae, Channidae, and Siluridae also showed considerable representation, particularly peaking in the monsoon season, which coincides with favorable breeding and feeding conditions. Families like Clariidae, Belonidae, and Bagridae exhibited comparatively lower abundance but maintained consistent presence throughout the seasons.

Table 3.3 Seasonal distribution of fish families in the Kodoor River

Fish Family	Number of observations		
	Pre monsoon	Monsoon	Post monsoon
Anabantidae	15	25	18
Channidae	20	38	27
Clariidae	6	12	8
Cyprinidae	111	193	36
Cichlidae	33	55	39
Heteropneustidae	12	22	18
Bagridae	8	18	12
Siluridae	17	37	24
Belonidae	7	20	11

Table 3.4 illustrates the family-wise distribution of fish species across different stretches (upstream, middle stream, and downstream) of the Kodoor River. The family Cyprinidae was the most dominant group, with the highest abundance recorded in the middle stream (220 individuals), followed by upstream (98) and downstream (22). This dominance highlights the ecological significance and adaptability of Cyprinids in the river system. Families such as Channidae, Siluridae, and Cichlidae also showed considerable abundance, with peak numbers generally recorded in the middle and downstream stretches. Interestingly, Cichlidae displayed a marked increase in abundance downstream (64 individuals), while Belonidae was least represented in upstream and middle stretches but showed a sharp rise in the downstream (28 individuals), indicating habitat preference. In contrast, families like Clariidae, Bagridae, and Heteropneustidae had relatively lower overall abundance, although their presence across all stretches signifies broad ecological tolerance.

Table 3.4 Family-wise distribution of fish species – Kodoor river

Fish Family	Number of observations		
	Upstream	Middle stream	Down stream
Anabantidae	18	30	10
Channidae	21	44	20
Clariidae	5	18	3
Cyprinidae	98	220	22
Cichlidae	26	35	64
Heteropneustidae	10	28	14
Bagridae	12	24	2
Siluridae	15	42	21
Belonidae	4	4	28

3.1 Fish diversity in family wise in different seasons - Kodoor river

The bar graph(Fig.3.1) illustrates the family-wise fish diversity in the Kodoor River across different seasons (Post-monsoon, Monsoon, and Pre-monsoon) during the years 2021-2022. The family, Cyprinidae exhibits the overwhelmingly highest diversity among all families, particularly prominent during the Monsoon season, where its count approaches 200 individuals. It also shows a significant presence in the Pre-monsoon season (over 100 individuals) and Post-monsoon season (around 100 individuals). The family,Cichlidae also shows substantial diversity, notably during the Monsoon and Post-monsoon seasons, with counts ranging from approximately 40 to 50 individuals. Channidae demonstrates a notable presence, particularly in the Monsoon and Post-monsoon seasons, with counts around 30-40 individuals. Siluridae shows moderate diversity, particularly in the Monsoon season, with counts around 30. Other families such as Belonidae, Bagridae, Heteropneustidae, Clariidae, and Anabantidae generally exhibit lower diversity, with counts typically below 20 individuals across all seasons. The graph clearly indicates significant seasonal variations in the diversity of different fish families within the Kodoor River, with the Monsoon season generally showing higher individual counts for many families.

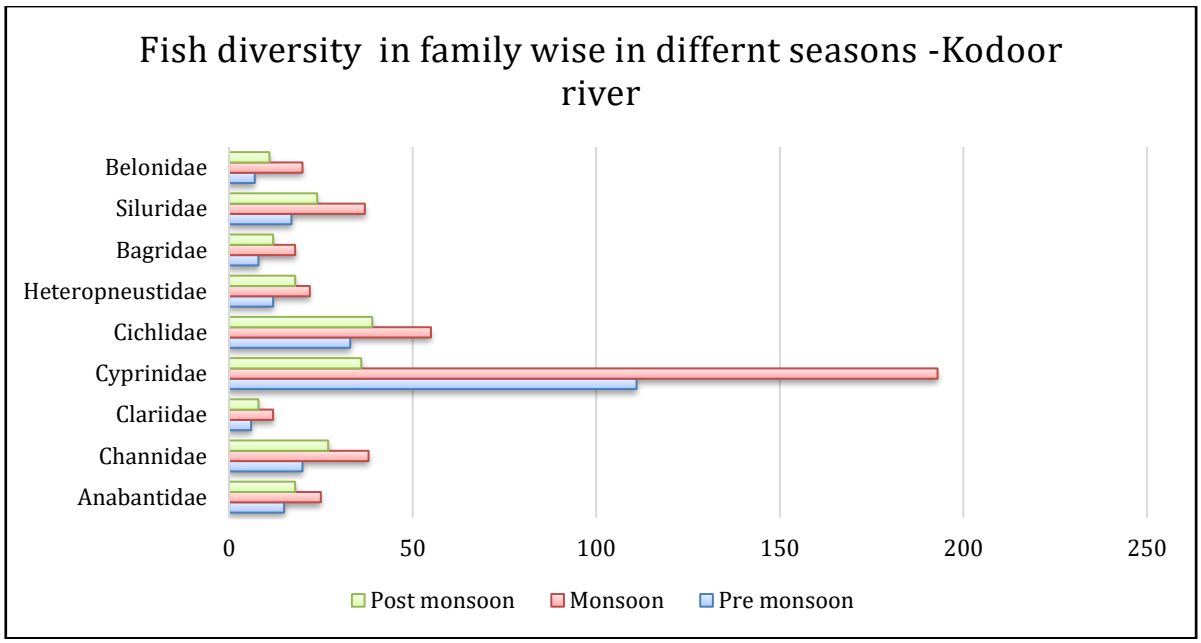

Figure 3.1 Fish diversity in family wise in different seasons - Kodoor river

3.2 Fish diversity in family wise in different layers of Kodoor river

The bar graph(Fig.3.2) illustrates the family-wise fish diversity across different layers (Downstream, Middle stream, and Upstream) of the Kodoor River. The family Cyprinidae is overwhelmingly the most dominant family, showing exceptionally high diversity, particularly in the Middle stream, where its count approaches 220 individuals. It also maintains a strong presence in the Upstream (around 100 individuals) and Downstream (around 100 individuals) sections. Cichlidae also exhibits significant diversity, especially in the Downstream section (around 60 individuals), with notable presence in the Middle stream and Upstream as well (around 40-50 individuals). Channidae shows a considerable presence, particularly in the Middle stream (around 45 individuals), with consistent counts across all layers. Siluridae contributes moderately to the diversity, predominantly in the Middle stream (around 40 individuals). Other families such as Belonidae, Bagridae, Heteropneustidae, Clariidae, and Anabantidae generally exhibit lower diversity, with individual counts typically below 30 across all layers. The graph clearly indicates spatial variations in the abundance of various fish families within the Kodoor River, suggesting that certain river layers might provide more favorable habitats for specific fish families. The Middle stream appears to support the highest overall fish diversity for many dominant families.

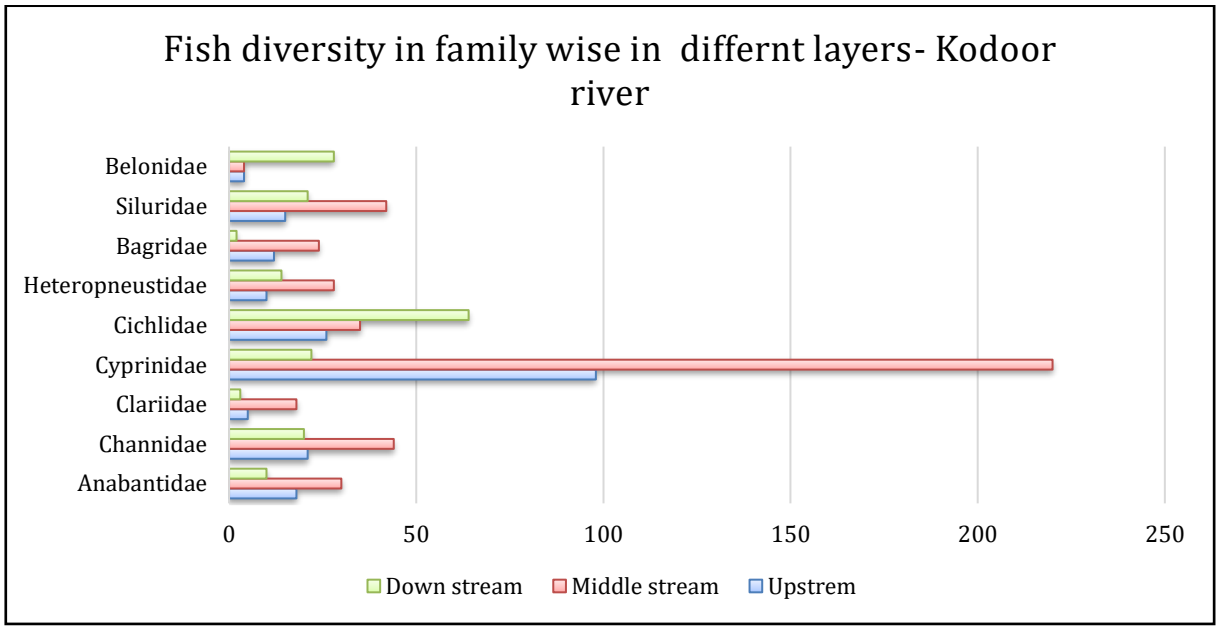

Figure 3.2 Fish diversity in family wise in different layers - Kodoor river

3.3 Fish biodiversity index - Simpson and Shanon Index - Kodoor river - season wise

The table(3.3) presents fish biodiversity indices for the Kodoor River, categorized by season (Pre-monsoon, Monsoon, and Post-monsoon). These indices provide a quantitative assessment of the diversity and evenness of fish communities in each period. Taxa_S (Species Richness): This row indicates the total number of distinct fish taxa (likely families, given the context of previous discussions) recorded in each season. The table shows a consistent richness of 9 taxa across all three seasons (Pre-monsoon, Monsoon, and Post-monsoon). Individuals: This row represents the total count of individual fish sampled during each season. The Monsoon season recorded the highest number of individuals (420), followed by Pre-monsoon (229), and then Post-monsoon (193). Dominance_D (Simpson's Dominance Index): This index measures the probability that two randomly selected individuals will belong to the same species. A higher value indicates lower diversity and greater dominance by a few species. The values are 0.2787 (Pre-monsoon), 0.2555 (Monsoon), and 0.1369 (Post-monsoon). Notably, the Post-monsoon season shows the lowest dominance, implying higher diversity. Simpson_1-D (Simpson's Diversity Index): This index, calculated as 1 minus the Dominance Index, represents the probability that two randomly selected individuals will not belong to the same species. Higher values indicate greater diversity. The values are 0.7213 (Pre-monsoon), 0.7445 (Monsoon), and 0.8631 (Post-monsoon). This indicates that fish diversity, based on the Simpson index, is significantly highest during the Post-monsoon season, followed by Monsoon, and then Pre-monsoon. Shannon_H (Shannon-Weaver Diversity Index): This index considers both the abundance and evenness of species. Higher values suggest greater diversity. The values are 1.688 (Pre-monsoon), 1.759 (Monsoon), and 2.081 (Post-monsoon). Consistent with the Simpson index, the Shannon index also points to the Post-monsoon season having the highest diversity. Evenness_e^H/S (Pielou's Evenness Index): This index measures how evenly individuals are distributed among the different species. A value closer to 1 indicates a more even distribution. The values are 0.6012 (Pre-monsoon), 0.6451 (Monsoon), and 0.8904 (Post-monsoon). This suggests that the distribution of individuals among fish taxa is most even during the Post-monsoon season. In summary, the table highlights seasonal variations in fish biodiversity in the Kodoor River during 2022-2023. While species richness remained constant across seasons, the Post-monsoon period consistently exhibited the highest overall diversity and evenness (as indicated by the lowest dominance and highest Simpson and Shannon indices, and highest Evenness), despite having the lowest total number of individuals. The Monsoon season had the highest individual count and moderate diversity, while the Pre-monsoon season generally showed the lowest diversity measures.

Table 3.3 Fish bio diversity index - Simpson and Shanon Index - Kodoor river - season wise

Index	Pre monsoon	Monsoon	Post monsoon
Taxa_S	9	9	9
Individuals	229	420	193
Dominance_D	0.2787	0.2555	0.1369
Simpson_1-D	0.7213	0.7445	0.8631
Shannon_H	1.688	1.759	2.081
Evenness_e^H/S	0.6012	0.6451	0.8904

3.4 Fish bio diversity index - Simpson and Shanon Index - Kodoor river - layer wise

The table(3.4) presents fish biodiversity indices for the Kodoor River, categorized by different river layers (Upstream, Middle stream, and Downstream) for the years 2022-2023. Taxa_S (Species Richness): This row indicates the total number of distinct fish taxa (likely families, consistent with previous analyses) identified in each river layer. The table consistently shows 9 taxa across the Upstream, Middle stream, and Downstream sections, indicating a uniform number of fish families throughout these river segments. Individuals: This row represents the total count of individual fish sampled in each river layer. The Middle stream recorded the highest number of individuals with 445, followed by the Upstream with 209, and then the Downstream with 184 individuals. This suggests the middle section of the river supports a higher overall abundance of fish. Dominance_D (Simpson's Dominance Index): This index measures the probability that two randomly selected individuals will belong to the same species. A higher value indicates lower diversity and greater dominance by a few species. The values are 0.261 (Upstream), 0.2808 (Middle stream), and 0.188 (Downstream). Notably, the Downstream section exhibits the lowest dominance, suggesting higher diversity, while the Middle stream shows the highest dominance. Simpson_1-D (Simpson's Diversity Index): This index, calculated as 1 minus the Dominance Index, represents the probability that two randomly selected individuals will not belong to the same species. Higher values indicate greater diversity. The values are 0.739 (Upstream), 0.7192 (Middle stream), and 0.812 (Downstream). This indicates that fish diversity, based on the Simpson index, is highest in the Downstream section, followed by the Upstream, and then the Middle stream. Shannon_H (Shannon-Weaver

Diversity Index): This index considers both the abundance and evenness of species. Higher values suggest greater diversity. The values are 1.701 (Upstream), 1.676 (Middle stream), and 1.845 (Downstream). Consistent with the Simpson index, the Shannon index also points to the Downstream section having the highest diversity. Evenness_e^H/S (Pielou's Evenness Index): This index measures how evenly individuals are distributed among the different species. A value closer to 1 indicates a more even distribution. The values are 0.6088 (Upstream), 0.594 (Middle stream), and 0.7035 (Downstream). This indicates that the distribution of individuals among fish taxa is most even in the Downstream section.

Table 3.4 Fish bio diversity index - Simpson and Shanon Index - Kodoor river - layer wise

Index	Upstream	Middle stream	Down stream
Taxa_S	9	9	9
Individuals	209	445	184
Dominance_D	0.261	0.2808	0.188
Simpson_1-D	0.739	0.7192	0.812
Shannon_H	1.701	1.676	1.845
Evenness_e^H/S	0.6088	0.594	0.7035

4. Discussion and conclusion

The present study on the freshwater fish diversity of the Kodoor River revealed significant spatio-temporal variations in species abundance and community composition. A total of 14 species belonging to nine families were recorded across different seasons and stream layers, indicating that the Kodoor River sustains considerable ichthyofaunal richness despite increasing anthropogenic pressures. The dominance of the family Cyprinidae, particularly during the monsoon season and in the middle stream region, aligns with observations from other tropical river systems in Kerala, where Cyprinids have been reported as the most abundant freshwater fish family due to their wide ecological tolerance and adaptive feeding habits (Abraham et al., 2011; Raghavan et al., 2008).

Seasonal variations strongly influenced fish diversity. The highest abundance of individuals was observed during the monsoon, which may be attributed to increased water flow, nutrient availability, and habitat heterogeneity created by flooding (Dahanukar et al., 2012). However, diversity indices such as Shannon and Simpson revealed that the post-monsoon season exhibited the greatest species evenness and overall diversity, despite having fewer individuals. This pattern indicates that while monsoon conditions support large populations, they are often dominated by a few species, whereas the post-monsoon period allows for a more balanced distribution of taxa. Similar seasonal patterns in fish diversity have been documented in the Bharathapuzha and Periyar rivers of Kerala, where post-monsoon stability enhances species coexistence (Bijukumar & Sushama, 2000; Arunachalam, 2000).

Spatial distribution across different stream layers further highlighted ecological preferences of fish communities. The middle stream harbored the maximum abundance of individuals, particularly Cyprinids, likely due to the availability of diverse microhabitats and moderate flow regimes conducive for feeding and breeding. In contrast, the downstream region recorded the highest diversity indices, suggesting that heterogeneous habitats, including pools and backwaters, provide refugia and promote species coexistence. Comparable findings were reported in the Chalakudy River, where downstream stretches supported greater fish diversity due to habitat complexity and nutrient availability (Johnson et al., 2007).

The presence of vulnerable species such as *Cyprinus carpio*, *Dawkinsia filamentosa*, and *Horabagrus brachysoma* underscores the conservation importance of the Kodoor River. *Horabagrus brachysoma*, endemic to the Western Ghats and listed as Vulnerable, is of particular concern, as its populations are declining due to overfishing and habitat degradation (Raghavan et al., 2011). The occurrence of such species indicates that Kodoor River serves as a critical habitat, warranting focused conservation measures. Moreover, the dominance of edible species such as *Wallago attu*, *Channa marulius*, and *Etroplus suratensis* highlights the river's role in sustaining local livelihoods, consistent with the findings from other rivers in Kerala (Nguyen et al., 2013).

Overall, the study indicates that fish diversity in the Kodoor River is shaped by both seasonal hydrological cycles and spatial habitat heterogeneity. Conservation of its ichthyofaunal wealth requires controlling anthropogenic pressures such as sand mining, pollution, and overfishing, which have been shown to negatively impact riverine fish communities across Kerala (Raghavan et al., 2008; Daniels, 2002). Future studies incorporating long-term monitoring, water quality assessment, and genetic diversity analyses are necessary to understand population trends and formulate effective management strategies.

In conclusion, the Kodoor River sustains a diverse ichthyofaunal community shaped by seasonal hydrological cycles and spatial habitat variations. Conservation strategies focusing on habitat protection, sustainable fishing practices, and continuous monitoring are essential to safeguard its biodiversity. Future research integrating ecological, genetic, and water quality assessments will provide a stronger basis for developing long-term management and conservation policies for the Kodoor River and other freshwater ecosystems of Kerala.

Ethical Statement

The authors are confirm that all ethical issues have been dealt with the research ethics guidelines provided by the PG and Research Department of Zoology, NSS Hindu College Changanacherry.

Author Contributions

Sojomon Mathew: Conceptualization, Investigation, Experiments, Original draft writing; *Radhika R.*: Resources, Supervision, Formal data analysis, Data curation.

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Conflict of Interest

The authors declare no conflicts of interest.

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