

Fish species diversity and hydrological characteristics as indicators of water quality in the Kodaiyar Hill Streams, Western Ghats, Tamil Nadu, India

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Abstract

The present study investigated the relationship between water quality and fish species diversity in the Kodaiyar Hill streams of the Western Ghats, Kanniyakumari District, Tamil Nadu, India. Three sampling stations were selected and monitored monthly from February to July 2005. Physicochemical parameters including temperature, dissolved oxygen, salinity, and pH were analyzed following standard procedures recommended by the American Public Health Association. Fish samples were collected using seine nets and identified using standard taxonomic keys. Species diversity was assessed using Shannon–Wiener diversity index, Simpson's dominance index, Hill's diversity numbers, Margalef's richness index, Menhinick's index, McIntosh index, Berger–Parker dominance index, and Pielou's evenness index.

A total of seven fish species were recorded from the three sampling stations. Among them, *Rasbora daniconius* and *Danio aequipinnatus* were the dominant species throughout the study period. Dissolved oxygen concentrations ranged from 6.4 to 7.5 mL L⁻¹, indicating favourable environmental conditions. Shannon–Wiener diversity index values ranged from 1.18 to 1.42 at Station I, 1.28 to 1.65 at Station II, and 0.54 to 1.39 at Station III. Station II exhibited the highest diversity and evenness, whereas Station III showed lower diversity during April, suggesting localized environmental disturbances. The findings indicate that relatively undisturbed habitats support higher fish diversity and demonstrate that fish diversity indices are effective tools for assessing ecological health and water quality in hill stream ecosystems.

Keywords: Fish diversity, water quality, Kodaiyar Hill streams, Western Ghats, freshwater fishes, biodiversity, Shannon–Wiener index

Introduction

Freshwater ecosystems are among the most productive and biologically diverse ecosystems on Earth and provide a wide range of ecological services, including nutrient cycling, water purification, and the maintenance of biodiversity. Despite their ecological significance, these ecosystems are increasingly threatened by anthropogenic disturbances, habitat degradation, and climate change, resulting in alterations in community structure and ecosystem functioning (Ramachandra and Shivamurthy, 2023) ^[14]. Fishes constitute an important component of freshwater ecosystems and are widely recognized as reliable biological indicators of environmental quality because their distribution, abundance, and community structure are strongly influenced by physicochemical characteristics of water (Wilhm and Dorris, 1968) ^[17]. Consequently, changes in water quality resulting from natural processes or human activities can significantly affect fish diversity and community composition.

India possesses rich freshwater fish diversity, comprising approximately 930 species classified as true freshwater forms (Jayaram, 1994) ^[6]. Among the biodiversity-rich regions of the country, the Western Ghats have been recognized as one of the world's major biodiversity hotspots because of their exceptional species richness and endemism. River systems and hill streams originating from this region support diverse aquatic communities owing to their varied topography, altitudinal gradients, and high rainfall patterns. Recent studies have emphasized the remarkable

ichthyofaunal diversity and conservation importance of the freshwater ecosystems of the Western Ghats (Arunkumar and Arunachalam, 2018) ^[2]; (Kolwalkar and Deb, 2023) ^[8]. In addition, the discovery of evolutionarily distinct and endemic species from this region further highlights its importance for biodiversity conservation (Chandra *et al.*, 2024) ^[4].

Biological assessment of aquatic ecosystems has gained considerable importance in recent decades because biological communities integrate the cumulative effects of environmental changes over time. Fish assemblages are particularly useful indicators of habitat quality and ecological integrity, and their diversity has been widely employed for evaluating water quality and ecosystem health. Among the various ecological indices available, the Shannon–Wiener diversity index has been extensively used to assess species diversity and ecological stability in freshwater ecosystems (Magurran, 1988) ^[9]. Recent investigations have demonstrated that fish diversity patterns can effectively reflect ecological conditions and environmental disturbances in tropical river systems (Karuppasamy and Arunachalam, 2023) ^[7].

Several environmental factors, including temperature, dissolved oxygen, pH, salinity, habitat characteristics, and food availability, influence the abundance and distribution of fish communities. Variations in these parameters due to natural seasonal fluctuations or anthropogenic disturbances may lead to changes in species richness and community structure. Studies conducted in tropical rivers of the Western

Ghats have revealed that seasonal and altitudinal gradients significantly influence fish diversity and assemblage patterns (Paul *et al.*, 2026) ^[12]. Therefore, understanding the relationship between physicochemical characteristics and fish diversity is essential for effective conservation and sustainable management of freshwater ecosystems.

Although the Kodaiyar River system represents one of the ecologically significant freshwater habitats of the southern Western Ghats, information regarding fish diversity and its association with hydrological characteristics remains limited. Therefore, the present investigation was undertaken to evaluate selected physicochemical parameters and fish species diversity in the Kodaiyar Hill streams and to assess their usefulness as indicators of ecological health and water quality. The findings of this study are expected to provide baseline information for biodiversity conservation and sustainable management of hill stream ecosystems in the Western Ghats.

Materials and Methods

Study Area

The present investigation was carried out in the Kodaiyar Hill streams situated in the southern Western Ghats of Kanniyakumari District, Tamil Nadu, India. The Kodaiyar River system originates from the Western Ghats and is surrounded by tropical evergreen forests that support diverse aquatic communities. Owing to its ecological significance and relatively undisturbed nature, the stream system provides suitable habitats for several freshwater fish species. Three sampling stations were selected for the study based on habitat characteristics and accessibility:

Station I: Mothiramalai

Station II: Mylar

Station III: Lower Kodaiyar

Monthly investigations were conducted from February 2005 to July 2005.

Collection of Water Samples

Water samples were collected once every month from the three stations during the study period. Samples were collected in biological oxygen demand (BOD) bottles and fixed immediately using manganous chloride and alkaline iodide reagents to prevent changes in dissolved oxygen concentration. Sampling and preservation procedures were carried out following the standard methods prescribed by the American Public Health Association (APHA, 1978) ^[1].

Physicochemical Analysis

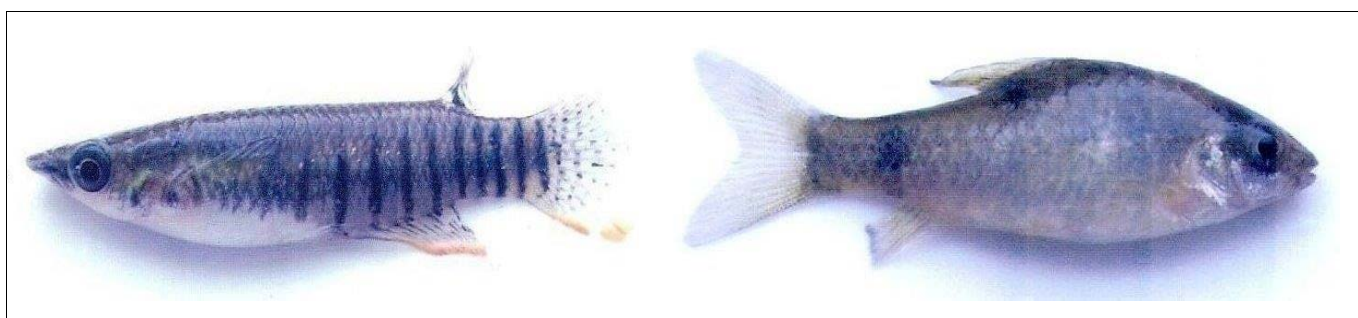
Selected physicochemical parameters, namely temperature, dissolved oxygen, salinity, and pH, were analyzed according to standard procedures recommended by APHA (1978) ^[1].

Water temperature was measured in degrees Celsius (°C). Dissolved oxygen concentration was estimated using the modified Winkler method. Salinity and pH were determined using conventional analytical procedures. Monthly variations in these parameters were recorded for each sampling station.

Fish Collection and Identification

Fish samples were collected monthly from each station using seine nets. Three nettings were performed during each sampling period, and the average number of individuals captured was used for subsequent analysis.

The collected specimens were identified to species level using the taxonomic descriptions provided by Talwar and Jhingran (1991) ^[17]. The following species were recorded during the study:



Aplocheilichthys lineatus

Danio annandalei



Danio aequipinnatus

Etroplus maculatus



Garra sp

Glossogobius giuris



Rasbora daniconius

Species Diversity Analysis

Species diversity was evaluated using several ecological indices to assess community structure and environmental quality.

Shannon–Wiener Diversity Index (H') (1949) ^[15].

$$H' = - \sum P_i \ln P_i$$

Where P_i represents the proportion of individuals belonging to the i^{th} species.

Simpson's Dominance Index (D) (1949) ^[16].

$$D = \sum P_i^2$$

Hill's Diversity Numbers (1973) ^[5].

$$N1 = e^{H'}$$

$$N2 = 1/D$$

Margalef's Richness Index (1972) ^[10].

$$Ma = (S - 1)/\ln N$$

Menhinick's Richness Index (1964) ^[11].

$$Me = S/\sqrt{N}$$

Berger–Parker Dominance Index (1970) ^[3].

$$d = N_{\max}/N$$

Pielou's Evenness Index (1966) ^[13]. $J = H'/\ln S$

Where:

S = total number of species;

N = total number of individuals;

P_i = proportional abundance of the i^{th} species;

$N_{\max}$ = number of individuals in the most abundant species.

These indices were used to determine species richness, dominance, and evenness and to evaluate ecological stability at each sampling station.

Statistical Analysis

Descriptive statistics were employed to evaluate monthly variations in physicochemical parameters and fish diversity indices. Species diversity patterns among the three stations

were interpreted using Shannon–Wiener diversity index (1991) ^[15], dominance indices, and evenness values. The ecological status of the streams was assessed based on variations in species richness and community structure.

Results

Table 1: Range of Physico chemical parameters recorded in the three sampling station

Parameter	Station I Moithiramalai	Station II Mylar	Station III Lower Kodaiyar
Temp (°C)	27.5 – 29.5	26 – 29	30 – 32
Dissolved Oxygen (mL L ⁻¹)	6.8 – 7.0	6.9 – 7.5	6.4 – 6.6
Salinity (‰)	0.6 – 0.5	0.5	0.4
pH	7.0 – 7.1	6.8 – 6.9	7.2

Table 2: Shanon Weiner Diversity index (H_i) of fish communities

Station	Minimum (H_i)	Maximum (H_i)
I	1.18	1.42
II	1.28	1.65
III	0.54	1.39

Table 3: Fish species recorded in Kodaiyar hill streams

Sl.No	Species	Common name
1	<i>Etroplus maculatus</i>	Orange chromide
2	<i>Glossogobius giuris</i>	Tank Goby
3	<i>Rasbora daniconius</i>	Slender Rasbora
4	<i>Danio annandalei</i>	Annandale Danio
5	<i>Danio aequipinnatus</i>	Giant Danio
6	<i>Aplocheilichthys lineatus</i>	Striped Panchax
7	<i>Garra sp.</i>	Sucker Head

Physicochemical Characteristics of Water

The monthly variations in selected physicochemical parameters recorded from the three sampling stations of the Kodaiyar Hill streams are presented in Table 1. Temperature exhibited only minor fluctuations throughout the study period. Station II recorded comparatively lower temperatures (26–29 °C), whereas Station III showed relatively higher values (30–32 °C).

Dissolved oxygen concentrations remained relatively high in all stations and ranged from 6.4 to 7.5 mL L⁻¹. The highest dissolved oxygen concentration was recorded at Station II during July (7.5 mL L⁻¹), whereas the lowest value was observed at Station III during June (6.4 mL L⁻¹). Salinity showed very little variation during the investigation, remaining constant at 0.6‰, 0.5‰, and 0.4‰ in Stations I, II, and III, respectively. The pH values varied only slightly and indicated near-neutral to slightly alkaline conditions. Station III exhibited relatively stable pH values throughout the study period.

Overall, the physicochemical parameters suggested favourable environmental conditions and indicated that the Kodaiyar Hill streams were subjected to minimal anthropogenic disturbances.

Fish Species Composition

A total of seven freshwater fish species belonging to different taxonomic groups were recorded from the three sampling stations during the study period. The species identified were:

Among these species, *Rasbora daniconius* and *Danio aequipinnatus* were the dominant species and were consistently abundant throughout the study period. Station II (Mylar) supported the highest species richness, whereas Station III (Lower Kodaiyar) exhibited comparatively lower species abundance during certain months.

Species Diversity Indices

Monthly variations in species diversity indices for the three stations are summarized in Table 2.

Station I (Mothiramalai)

The Shannon–Wiener diversity index (*H'*) varied from 1.18 to 1.42. The highest value was recorded during March and April, whereas the lowest value was observed during July. Evenness values ranged from 0.606 to 0.729, indicating a relatively uniform distribution of species.

Station II (Mylar)

Station II exhibited the highest diversity among the three stations. Shannon–Wiener index values ranged from 1.28 to 1.65. Maximum diversity and evenness were observed during April, with an evenness value of 0.847. Hill's diversity numbers also indicated greater species richness and ecological stability at this station.

Station III (Lower Kodaiyar)

Species diversity at Station III was comparatively lower. Shannon–Wiener index values ranged between 0.54 and 1.39. The minimum diversity value recorded during April indicated dominance by a few species and suggested localized environmental stress. Evenness values varied from 0.277 to 0.714, reflecting uneven distribution of individuals among species.

Among the seven species encountered during the investigation, *Rasbora daniconius* and *Danio aequipinnatus* constituted the dominant components of the fish community. Their abundance across all stations may be attributed to their broad ecological tolerance and adaptability to varying environmental conditions.

Comparison of diversity indices among the three stations indicated that Station II possessed greater ecological stability and supported higher species richness and

evenness. Station I exhibited moderate diversity, whereas Station III showed reduced diversity and increased dominance during certain months, indicating comparatively disturbed environmental conditions.

The overall results demonstrate that relatively undisturbed habitats support greater species diversity and that fish community structure can serve as an effective indicator of water quality and ecological status in hill stream ecosystems.

Discussion

The present study demonstrated that the physicochemical characteristics of the Kodaiyar Hill streams remained relatively stable during the study period, thereby providing favourable conditions for sustaining freshwater fish diversity. Temperature, dissolved oxygen, salinity, and pH exhibited only minor fluctuations, suggesting that the stream ecosystem was subjected to minimal anthropogenic disturbances. Similar observations have been reported from tropical lotic ecosystems of the Western Ghats, where stable environmental conditions contributed to the maintenance of aquatic biodiversity (Ramachandra and Shivamurthy, 2023). Water temperature is one of the most important environmental factors influencing the metabolic activities, growth, reproduction, and distribution of aquatic organisms. The slight fluctuations observed during the present investigation are likely attributable to seasonal variations. Similar patterns have been reported from riverine ecosystems of southern India and the Western Ghats, where seasonal changes influenced thermal regimes without significantly affecting aquatic biodiversity (Paul *et al.*, 2026). Environmental variables such as temperature and flow characteristics have been recognized as major determinants of fish assemblage structure in tropical streams (Karuppasamy and Arunachalam, 2023).

Dissolved oxygen concentration is considered a critical indicator of water quality and ecological health. The relatively high dissolved oxygen levels recorded throughout the study period indicate good aeration and favourable environmental conditions for fish survival. High dissolved oxygen concentrations are characteristic of unpolluted freshwater ecosystems and are essential for maintaining biological productivity and species diversity. Similar observations have been reported from the river systems of the Western Ghats, where dissolved oxygen and habitat quality were found to exert a significant influence on fish community composition (Ramachandra and Shivamurthy, 2023).

The pH values recorded at the three stations indicated near-neutral to slightly alkaline conditions. Such conditions are generally favourable for freshwater fish communities and are indicative of healthy aquatic environments. Variations in pH may result from natural biological processes or anthropogenic inputs; however, no significant changes attributable to pollution were evident in the present study. Similar physicochemical conditions have been reported from relatively undisturbed streams of the southern Western Ghats (Arunkumar and Arunachalam, 2018).

A total of seven fish species were recorded from the three sampling stations. Among them, *Rasbora daniconius* and *Danio aequipinnatus* were found to be the dominant species. Their dominance may be attributed to broad ecological tolerance, adaptability to varying environmental conditions, and diverse feeding preferences. Similar patterns of

dominance by cyprinid species have been reported in freshwater ecosystems of the Western Ghats and other tropical river systems (Kolwalkar and Deb, 2023). The occurrence of these species also reflects the suitability of the habitat for sustaining native fish communities.

The Shannon–Wiener diversity index varied considerably among the sampling stations. Station II exhibited the highest diversity values and evenness, indicating greater ecological stability and a more balanced distribution of species. In contrast, Station III recorded comparatively lower diversity values, particularly during April, when the Shannon–Wiener index decreased markedly. Lower diversity values are often associated with habitat alterations and localized disturbances that favour the dominance of a few species. Similar trends have been observed in hill streams of the Anamalai Tiger Reserve, where relatively undisturbed habitats supported greater species richness and diversity (Karuppasamy and Arunachalam, 2023).

Species evenness provides valuable information regarding community structure and stability. The higher evenness values observed at Station II indicate a relatively uniform distribution of individuals among species, whereas lower evenness values recorded at Station III suggest uneven species distribution and increased dominance. Such differences in community organization reflect variations in habitat quality and ecological conditions among the sampling stations. According to Magurran (1988), evenness and diversity indices provide important insights into community organization and ecosystem stability.

The findings of the present investigation support the concept that relatively undisturbed habitats harbour greater species diversity and ecological stability. Diversity indices, particularly the Shannon–Wiener index and Pielou's evenness index, proved to be effective tools for assessing environmental quality and ecological status. These indices integrate the effects of physicochemical conditions and biological interactions and therefore provide reliable measures of ecosystem health (Magurran, 1988). Recent studies have similarly demonstrated the usefulness of fish assemblages as indicators of ecological integrity in freshwater ecosystems (Karuppasamy and Arunachalam, 2023).

Although the Kodaiyar Hill streams currently experience limited anthropogenic pressure, increasing developmental activities, deforestation, and land-use changes in the Western Ghats may adversely affect aquatic habitats in the future. Recent investigations have highlighted the vulnerability of endemic freshwater fishes to habitat degradation and environmental changes and have emphasized the need for effective conservation strategies (Chandra *et al.*, 2024). Therefore, continuous monitoring of physicochemical parameters and fish diversity is essential for the sustainable management and conservation of these ecologically important freshwater ecosystems.

Overall, the present study highlights the importance of integrating hydrological characteristics and biological indicators in evaluating water quality and emphasizes the role of fish communities as sensitive indicators of ecological integrity in tropical hill stream ecosystems. The information generated through this study provides valuable baseline data

for future monitoring and biodiversity conservation programs in the Western Ghats.

Conclusion

The present investigation revealed that the Kodaiyar Hill streams possess relatively stable physicochemical characteristics and support moderate freshwater fish diversity. Dissolved oxygen concentration, pH, salinity, and temperature exhibited only minor fluctuations during the study period, indicating favourable environmental conditions for aquatic life.

A total of seven fish species were recorded from the three sampling stations, among which *Rasbora daniconius* and *Danio aequipinnatus* were the dominant species. Station II (Mylar) exhibited the highest species diversity and evenness, suggesting greater ecological stability, whereas Station III (Lower Kodaiyar) showed comparatively lower diversity during certain months, indicating localized environmental disturbances.

The results clearly demonstrate that relatively undisturbed habitats support greater species richness and more balanced fish communities. Diversity indices, particularly the Shannon–Wiener index and Pielou's evenness index, proved to be valuable tools for evaluating ecological integrity and water quality in hill stream ecosystems.

The study emphasizes the importance of regular monitoring of physicochemical parameters and fish community structure for the conservation and sustainable management of freshwater ecosystems in the Western Ghats. Considering the increasing anthropogenic pressures on aquatic habitats, effective conservation strategies are essential to preserve the biodiversity and ecological functions of these ecologically significant streams.

References

1. American Public Health Association (APHA). Standard methods for the examination of water and wastewater. 17th ed. American Public Health Association, 1978.
2. Arunkumar AA, Arunachalam M. Freshwater fish fauna of rivers of the southern Western Ghats, India. *Earth System Science Data*, 2018;10:1735–1752.
3. Berger WH, Parker FL. Diversity of planktonic foraminifera in deep-sea sediments. *Science*, 1970;168:1345–1347.
4. Chandra S, Abhilash R, Sidharthan A, Raghavan R, Dahanukar N. Complete mitogenome of *Lepidopygopsis typus*, an evolutionarily distinct endangered cyprinid fish from the Western Ghats biodiversity hotspot: Phylogenetic relationships and implications for conservation. *Gene*, 2024;898:148098.
5. Hill MO. Diversity and evenness: A unifying notation and its consequences. *Ecology*, 1973;54:427–432.
6. Jayaram KC. Ecology and distribution of freshwater fishes, amphibians and reptiles. In: *Fauna of India. Zoological Survey of India*, 1994.
7. Karuppasamy MK, Arunachalam M. Species diversity, distributions and conservation implications of ichthyofauna of hill streams of Anamalai Tiger Reserve, Southern Western Ghats, India. *Research Square*, 2023.
8. Kolwalkar S, Deb P. A review study of the diversity of fishes in the Western Ghats of India. *Ecology, Environment and Conservation*, 2023;29(4):1773–1777.

9. Magurran AE. Ecological diversity and its measurement. Croom Helm, 1988.
10. Margalef R. Homage to Evelyn Hutchinson: Why there is an upper limit to diversity. Transactions of the Connecticut Academy of Arts and Sciences, 1972;44:211–235.
11. Menhinick EF. A comparison of some species-individual diversity indices applied to samples of field insects. Ecology, 1964;45:859–861.
12. Paul T, Deepa S, Ajoy S, Suresh K, Samantha M. Temporal variations in fish diversity in the main channel of the Chaliyar River, Western Ghats, Kerala, India. Indian Journal of Fisheries, 2026, 73(1).
13. Pielou EC. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 1966;13:131–144.
14. Ramachandra TV, Shivamurthy V. Ecohydrological footprint and climate trends in lotic ecosystems of Central Western Ghats. Water, 2023;15(18):3169.
15. Shannon CE, Weaver W. The mathematical theory of communication. University of Illinois Press, 1949.
16. Simpson EH. Measurement of diversity. Nature, 1949;163:688.
17. Talwar PK, Jhingran AG. Inland fishes of India and adjacent countries. Vols. I–II. Oxford and IBH Publishing Co., 1991.
18. Wilhm JL, Dorris TC. Biological parameters for water quality criteria. BioScience, 1968;18:477–481.