International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 12, Issue 6-2025

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2025.12.06.004

Fish Diversity Patterns along River Murti: A Comparative Assessment Inside and Outside Protected Areas of Northern West Bengal, India

Adwitiya Chaudhuri
Assistant Professor, Department of Zoology, Pingla Thana Mahavidyalaya
P.O.: Maligram, Dist.: Paschim Medinipur, PIN-721140, West Bengal, India
Email ID: *adwitiya.hiya@gmail.com*

Abstract

River Murti flows through both protected and non-protected stretches, including Gorumara National Park and Chapramari Wildlife Sanctuary in northern West Bengal. This study documented 38 fish species across the river's continuum, revealing significantly higher species richness and diversity within the protected areas. In contrast, stretches outside the protected zones exhibited lower diversity and higher dominance by fewer species, likely due to anthropogenic disturbances. The findings underscore the critical role of protected areas in sustaining aquatic biodiversity and call for integrated conservation strategies and continued ecological monitoring. This study also emphasizes the need for comprehensive ichthyofaunal documentation to guide policy and habitat management in riverine ecosystems.

Keywords: River Murti, fish diversity, Gorumara National Park, Chapramari Wildlife Sanctuary, protected areas, species richness, ecological conservation, ichthyofauna

Introduction

Conservation biology has been described as the science of scarcity and abundance, and more precisely defined as "application of biology to care and protection of plants and animals to prevent their loss or waste". Protection of natural environment is one of the main conditions for preservation and conservation of living species as the natural environment provides suitable conditions to which all living communities are adapted. Protection of freshwater biodiversity is perhaps the ultimate conservation challenge because it is influenced by the upstream drainage network, the surrounding land, the riparian zone, and in the case of migrating aquatic fauna, the downstream reaches. Throughout the world freshwater environment are experiencing serious threats to both biodiversity and ecosystem stability (Suzuki and Cooke, 2006) and human activities are mainly responsible for habitat destruction of aquatic organisms (Dudgeon, 1992). The special features of freshwater habitats and the biodiversity they support that makes them especially vulnerable to human activities have been explored (Dudgeon *et al*., 2007).The alteration of aquatic ecosystem, one of the major threats to global freshwater biodiversity, is thought to play a significant role in fish community structures and in other aquatic organisms (Resh *et al.*, 1988; Poff and Ward, 1989) and may be responsible for extinction of numerous species.In the recent years conservation biologists are working worldwide to protect the species population from the verge of extinction.

Monsoonal Asia is a host to at least 3500 freshwater fish species and India is included among top ten most species rich countries in the world for freshwater fish. When world rivers are ranked according to their fish species richness, tropical Asian rivers make up 11 of the 16 top ranks. However, there is paucity of pristine water bodies and lack of reliable historical trend data concerning aquatic fauna in Asia. We are uncertain about total species richness and precise rates of species loss, but the combination of high biodiversity and the magnitude of anthropogenic threats may make Asian inland waters among the most endangered ecosystems on earth (Dudgeon, 2003).Much of the early study on the freshwater systems of the Indian subcontinent started with the works of British officers working for the East India Company, who took great interest in the natural history of the region like the works of Hamilton-Buchanan in 'The Fishes of the Ganges' (1822), by Francis Day in his 'Fishes of India' (1875-1878). Substantial literature is now available on the identification and systematics of freshwater fishes of India, starting with Hora's contributions between the 1920 and 1950s and the most recent texts by Talwar and Jhingran (1991) and Jayaram (1999). Studies on fish assemblage structure and their habitat requirements in Indian streams are lacking except a few studies in south India (Bhat, 2003; Sreekantha, 2007; Shinde 2009; Radhakrishnan and Kurup, 2010), in Arunachal Pradesh (Bagra and Das, 2010).Some studies in the hill stream fishes have been conducted in Western Ghats, Kerala and Tamilnadu. The fishes in Anamalai and Nelliampathi Hill ranges were studied by Silas (1951) and the ecology of fishes in the river Moynar and Pykara were studied by Ranjan (1963). Fish diversity and distribution in the Kerala part of Western Ghats were extensively studied by Shaji and Easa (1995) and Easa and Shaji (1997). The fish assemblage structure in association with microhabitat variables in Western Ghats revealed high habitat diversity with associated high species diversity and abundance (Arunachalam, 2000). Of the 218 species recorded, 114 (52%) are endemic to the Western Ghats and Srilanka (Daniels, 2001). Composition and diversity of fishes in Central Western Ghats were studied by Bhat (2003) in detail. But since rest of the Western Ghats is yet to be explored, the distribution patterns of many species remain unknown.On the other hand, rivers of West Bengal harbours diversified icthyofauna, the freshwater fishes are till date a poorly studied group. Some of the valuable abundance data were available for perennial water bodies in Midnapore district (Bhakta and Bandyopadhyay, 2008), Karala river in Jalpaiguri district (Patra and Datta, 2010) in West Bengal. Still there is paucity of information regarding distribution, population dynamics, threat status, ecology, behaviour, survival strategy of our valued fish fauna and most of the information available is restricted to a few well-studied locations only. Therefore, it is important to prepare a zone wise database on fish diversity in our state as well as throughout the country as a whole to analyse species diversity as well as taxonomic diversity in order to characterize biodiversity in an appropriate way.

Materials and Methods

Study Area and Fish Sampling:

River Murti originates from the Mo forest (near the Neora Valley National Park) in Darjeeling

Himalayas (2211m above sea level or asl) flowing its way along the foothills in Jalpaiguri district and finally meets the Jaldhaka River (102m asl). In the present study, the stretch of the river, having great altitudinal variation, passes through two protected areas, namely Gorumara National Park (Site 1, 26° 43.941′ N 088 ° 51.832 ′ E) (S1) and Samsing, Chapramari Wildlife Sanctuary (Site 3, 26° 58.236′ N 088 ° 50.971 ′ E) (S3). The two reaches studied outside the protected areas are the plains of North Dhupjhora (Site 2, 26 °50.631′ N 88°49.704′ E)that is named after the River Murti (S2) and Rocky Island (Site 4, 27 °00.483′ N 88°48.107′E) (S4) (Table 1). Monthly sampling was carried out for 3 years in the river at the sampling sites (for a stretch of 2 km) using cast net (mesh size of 1 cm and covering an area of about 4.5 m^2) and gill net (20 m in length with 3 cm spacing between adjacent knots). The specimens were retrieved from the net and identified morphologically to the lowest taxonomic level (Shaw and Shebbeare, 1937; Day, 1958 and Talwar and Jhingran, 1991).

Data Analysis:

In order to assess icthyofaunal diversity in the River Murti in association with antropopgenic activities and habitat structure, some of the following diversity indices were used. These were Shannon-Weaver index (H′) (Shannon and Weaver, 1949), Species evenness or equitability (J′) (Pielou, 1969), Dominance index (D) (Berger and Parker, 1970) and Species richness (Margalef, 1958). Whittaker’s beta dissimilarity was calculated using MS Excel (Van Dyke, 2008). The data was normalised prior to analysis wherever required. The variations in fish assemblage structure at different sites were graphically represented by the application of cluster analysis based on Bray-Curtis similarity index (King, 1964). To overcome sampling errors, non-parametric methods like Jacknife and Bootstrap estimators were used to ascertain actual species richness. The variation in fish assemblage structure at different sites were analysed by estimation of Phylogenetic diversity (PD) (Faith,1992), Average phylogenetic diversity (AvPD), Taxonomic distinctness (Δ) (Warwick and Clarke, 1995), Average taxonomic distinctness (Δ+) and Variation in taxonomic distinctness (VarTD,Λ+) (Clarke and Warwick, 2001) by using PRIMER (Version 6.1.15).

Results and Discussion

Four different sites of Murti River, two of which being inside Gorumara National Park and Chapramari Wildlife Sanctuary and the other two outside the protected areas, were chosen for ichthyofaunal sampling (Figure 1). The study resulted in the capture of a total of 38 species representing 25 genera, 15 families and 5 orders (Table 2). Cyprinidae (52.63%) was found to be the most abundant fish family followed by Channidae (10.53%) and Mastacembelidae (5.26%) (Figure 2). The fish assemblage was found to be most diverse and rich (total 32 species) at Site 1, with 15 species belonging to Cyprinidae, 4 species belonging to Channidae, 2 species belonging to Mastacembelidae and 1 species belonging to Nemacheilidae, Cobitidae, Psilorhynchidae, Amblycipitidae, Chacidae, Clariidae, Olyridae, Badidae, Ambassidae, Osphronemidae and Belonidae. The diversity and richness of fish assemblage (total 14 species) was found to be relatively less while having highest species dominance at Site 4 with all the species belonging to Cyprinidae. The fish diversity of Site 3 (total 20 species) was comparable with that of Site 1 though species composition was found to be different with Site 3 having 15 species belonging to Cyprinidae and 1 species belonging to Psilorhynchidae, Amblycipitidae, Olyridae, Erethistidae and Badidae (Figure 3). In Site 2, the species composition (total 19 species) was similar to that of Site 1, yet having much less species diversity and richness with 10 species belonging to Cyprinidae, 2 species belonging to Channidae and Mastacembelidae and 1 species belonging to Nemacheilidae, Amblycipitidae, Chacidae, Clariidae and Badidae(Figure 3).

A total of 38 species were recorded in river Murti whereas S estimator value is calculated to be 50 by combination of resampling methods namely Jacknife and Bootstrap method which projects an acceptable difference between the observed sampling values and the estimated sampling size. The fish diversity was also analysed from diversity estimators conducted by DIVERSE function in Primer E. The Shannon-Weaver index was found to be highest at Site 1 (3.153) with gradual declining trend in Site 3 (2.837) to Site 2 (2.711) and the least at Site 4 (1.946) suggesting the existence of more diverse fish assemblage within the protected areas compared to the study sites located outside the protected areas. Similarly, S1 was most species rich (4.640) with S3 (3.182), S2 (2.433) and S1 (1.006) showing progressive declining trend. Species evenness values indicated that species are quite evenly distributed at all the sites as evident from the values ranging from 0.98 at Site 1 to 0.95 at Site 4. Site 1 and Site 3 showed least values of dominance (0.06256 and 0.07005 respectively) while greater species dominance was found in Site 2 and Site 4 (1.1894 and 1.7353 respectively) (Figure 4). Total Taxonomic Distinctness and Phylogenetic Diversity was found to be significantly higher in S1(793.8 and 650 respectively) and S3 (960 and 800 respectively), compared to that of S2 (678.6 and 525 respectively) and S4 (550 and 500 respectively) (Table 3, Figure 5a, b). Whittaker's β diversity at the four sampling sites in river Murti showed highest value between S1 and S4 (0.91)) and lowest value between S3 and S4 (0.429). The similarity in fish species composition among four different sites was analysed using the Bray-Curtis similarity index to calculate the extent of similarity between pairs of data sets. The similarity in species composition across different sampling sites was shown as a dendogram using the complete linkage method. The hierarchial cluster analysis showed a close resemblance of species composition with lowest similarity coefficient being 50. At that level of similarity site 3 and site 4 were closer than site 1 and site 2 (Figure 6, 7).

Table 1: Location and Physico-chemical characteristics in the sampling sites of the River Murti

Sampling sites	Latitudes (North)	Longitudes (East)	Altitudes, at river bed (m asl)	River Width (m)	River Depth (m)	Velocity of water (ms^{-1})	Dissolved Oxygen (mgl^{-1})	pH	Substratum
S1	26° 43.941′	088° 51.832 ′	192	23	1.3	0.5	8.8	7.5	Sand, gravel, and bedrocks
S2	26°50.631′	88°49.704′	137	25	1.4	0.4	8.1	7.9	Sand, gravel, and bedrocks
S3	26° 58.236′	088° 50.971 ′	402	18	0.9	0.9	8.9	7.4	Sand, gravel, boulders and bedrocks
S4	27°00.483′	88°48.107′	516	16	1.2	1.1	9.2	7.1	Sand, gravel, boulders and bedrocks

Table 2: Fish fauna found in river Murti along with their order, family and threat status

Order	Family	Genus	Species	Threat Status (According to BCPP-CAMP, 1998)
Cypriniformes	Nemacheilidae/ Balitoridae	*Acanthocobitis*	*botia*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Barilius*	*barila*	Vulnerable
Cypriniformes	Cyprinidae	*Barilius*	*bendelisis*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Barilius*	*vagra*	Vulnerable
Cypriniformes	Cyprinidae	*Opsarius*	*barna*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Opsarius*	*tileo*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Cabdio*	*morar*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Danio*	*dangila*	Not evaluated
Cypriniformes	Cyprinidae	*Danio*	*rerio*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Devario*	*aequipinnatus*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Devario*	*devario*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Crossocheilus*	*latiuslatius*	Data Deficient
Cypriniformes	Cyprinidae	*Garra*	*annandalei*	Not evaluated
Cypriniformes	Cyprinidae	*Garra*	*gotylagotyla*	Vulnerable
Cypriniformes	Cyprinidae	*Garra*	*kempi*	Vulnerable
Cypriniformes	Cyprinidae	*Pethia*	*phutunio*	Lower Risk- least

Cypriniformes	Cyprinidae	*Puntius*	*terio*	Lower Risk- near threatened
Cypriniformes	Cyprinidae	*Puntius*	*vittatus*	Vulnerable
Cypriniformes	Cyprinidae	*Neolissochilus*	*hexagonolepis*	Not evaluated
Cypriniformes	Cyprinidae	*Neolissochilus*	*hexastichus*	Not evaluated
Cypriniformes	Cyprinidae	*Neolissochilus*	*stracheyii*	Not evaluated
Cypriniformes	Cobitidae	*Lepidocephalichthys*	*guntea*	Not evaluated
Cypriniformes	Psilorhynchidae	*Psilorhynchus*	*balitora*	Not evaluated
Siluriformes	Amblycipitidae	*Amblyceps*	*mangois*	Lower Risk- near threatened
Siluriformes	Chacidae	*Chaca*	*chaca*	Not evaluated
Siluriformes	Clariidae	*Clarias*	*batrachus*	Vulnerable
Siluriformes	Olyridae	*Olyra*	*longicaudata*	Not evaluated
Siluriformes	Erethistidae	*Pseudolaguvia*	*foveolata*	Not evaluated
Perciformes	Badidae	*Badis*	*badis*	Not evaluated
Perciformes	Ambassidae	*Chanda*	*nama*	Not evaluated
Perciformes	Channidae	*Channa*	*marulius*	Lower Risk- near threatened
Perciformes	Channidae	*Channa*	*orientalis*	Vulnerable
Perciformes	Channidae	*Channa*	*punctata*	Lower Risk- near threatened
Perciformes	Channidae	*Channa*	*stewartii*	Not evaluated
Perciformes	Osphronemidae	*Trichogaster*	*fasciata*	Lower Risk- near threatened
Synbranchiformes	Mastacembelidae	*Macrognathus*	*pancalus*	Lower Risk- near threatened
Synbranchiformes	Mastacembelidae	*Mastacembelus*	*armatus*	Not evaluated
Beloniformes	Belonidae	*Xenentodon*	*cancila*	Lower Risk- near threatened

Fig 1: Course of River Murti showing stretches inside Gorumara National Park and Chapramari Wildlife sanctuary

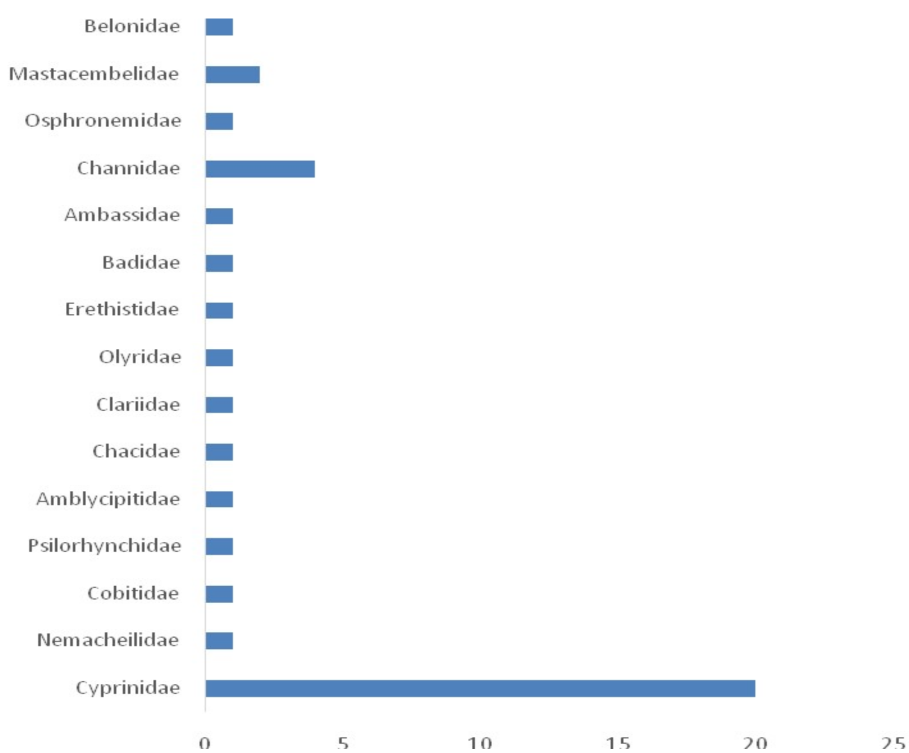

Figure 2: Graph showing species abundance of each fish family in River Murti

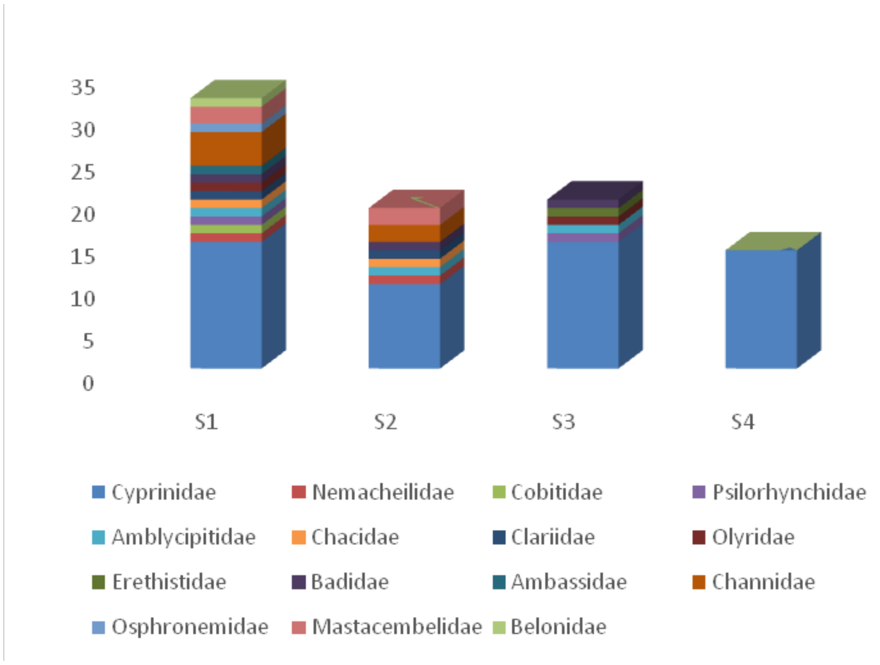

Figure 3: Abundance of existing fish family at different sampling sites in River Murti

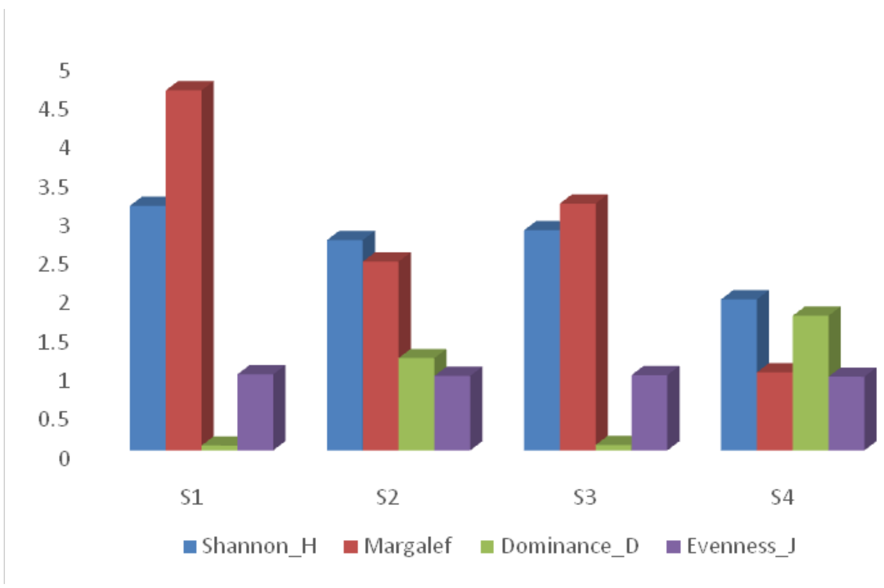

Figure 4: Site wise variation in species diversity, richness, dominance and evenness

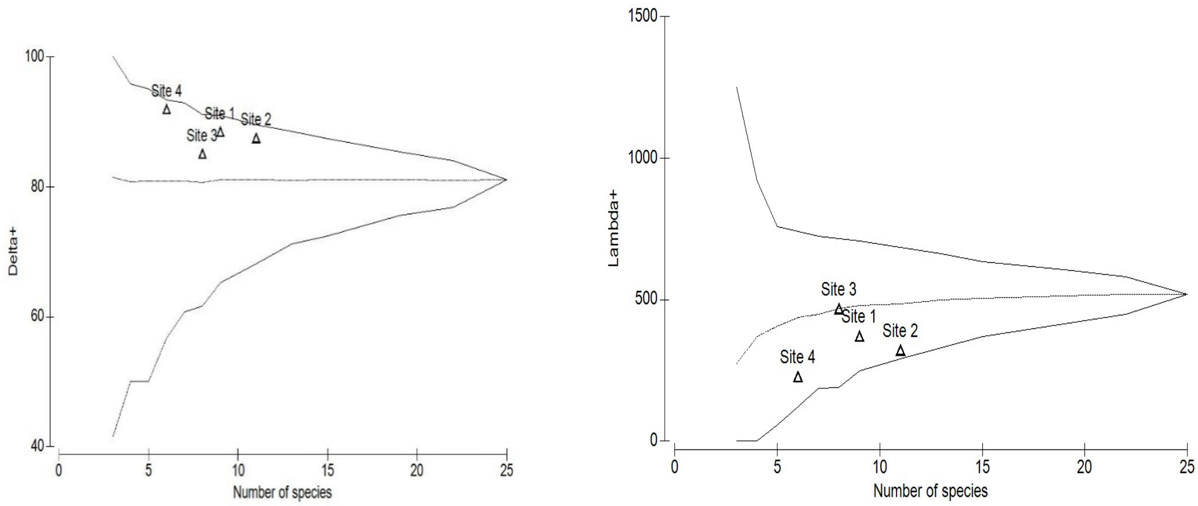

Figure 5: Funnel plot showing (a) Average taxonomic distinctness (Δ+) and (b) Variation in taxonomic distinctness (VarTD,Λ+) of the fish assemblage in four sites of River Murti

Thin line in the middle indicates mean of 1000 simulations confirming theoretical unbiasedness. Continuous line indicates 95% probability limit for each

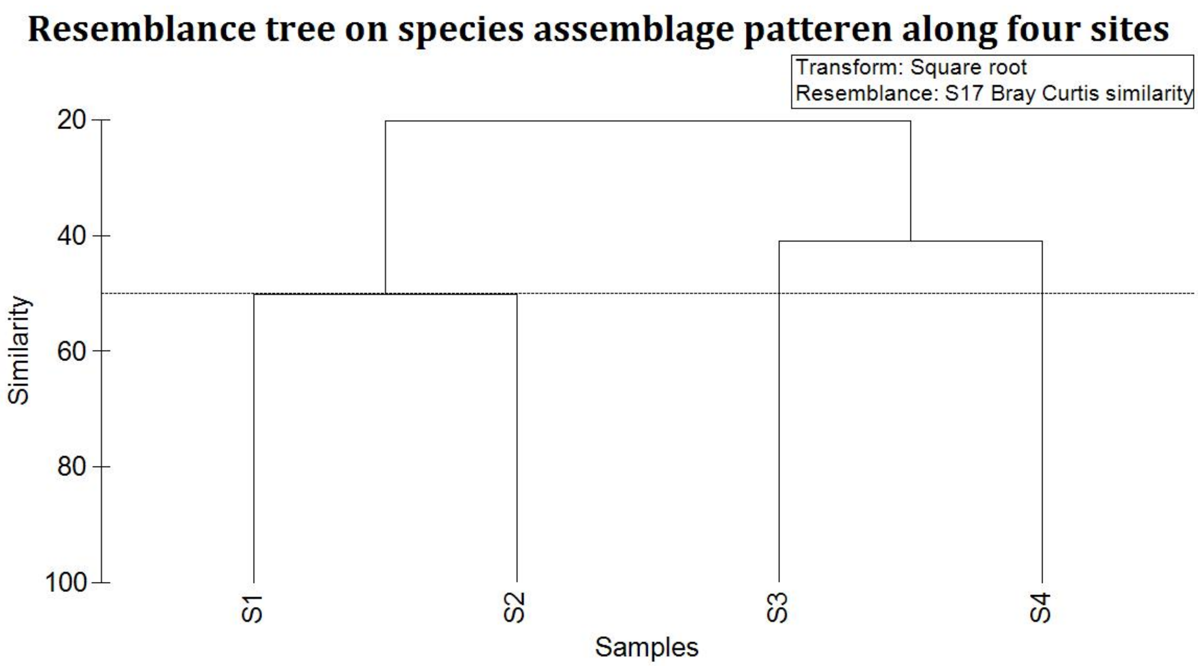

Figure 6: Resemblance tree on species assemblage pattern along four sites in River Murti

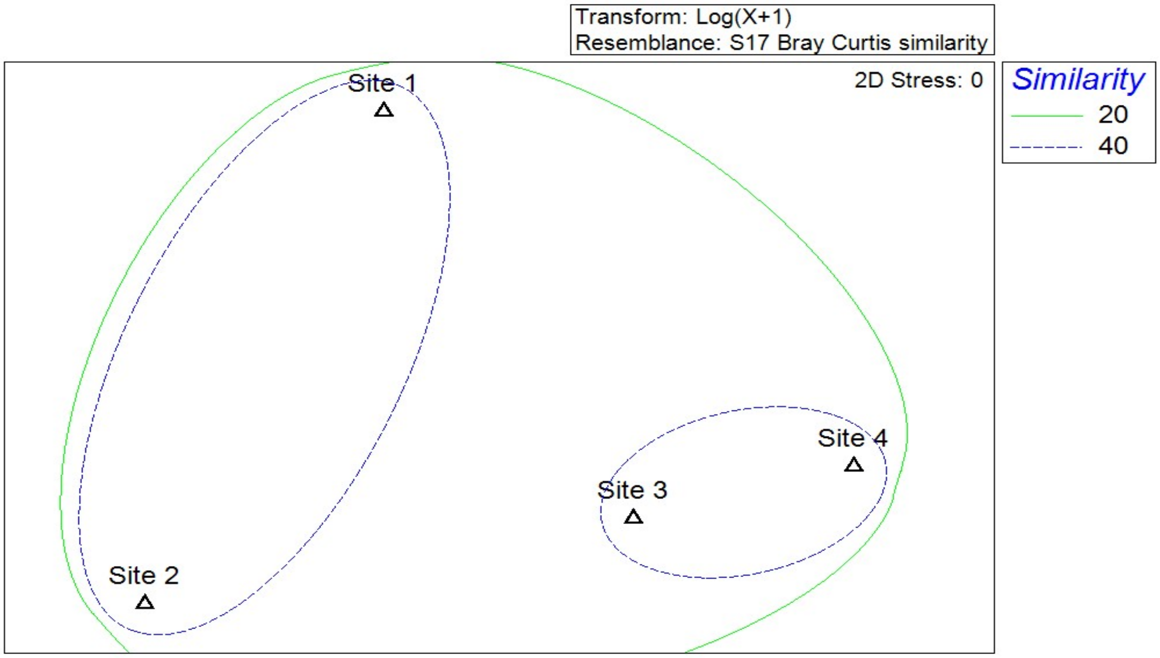

Figure 7: Percentage of similarity between fish assemblage structure atfour sites of River Murti based on Bray_Curtis similarity index

Table 3: Sitewise variation in Taxonomic Diversity Estimators in River Murti

	Site 1	Site 2	Site 3	Site 4	F Value	Sig Value
Taxonomic Diversity	85.45	82.5	77.01	81.15	17.99	0.0117
Taxonomic Distinctness	87.81	86.36	84.44	92.34	23.78	.0498
Total Taxonomic Distinctness	793.8	960	678.6	550	72.78211	0.000142
Average Taxonomic Distinctness	88.19	87.27	84.82	91.67	30.08	0.247
Variation in Taxonomic Distinctness	364.1	315.3	461.6	222.2	45.99841	0.000502
Phylogenetic Diversity	650	800	525	500	80.33969	0.000108
Average Phylogenetic Diversity	72.22	72.73	65.63	83.33	364.6288	0.133

Fu *et al*. (2003) documented 361 species and subspecies of which 177 are endemic and analysed that Hydrological alterations are perhaps the largest threat to fish biodiversity. Chu *et al.* (2003) integrated indices of freshwater fish biodiversity, environmental conditions, and anthropogenic stress to identify priority watersheds for conservation and management.

Chu *et al.* (2014) applied different conservation and management scenarios to evaluate the robustness of that prioritization approach. Freshwater ecosystems and the fisheries they support are increasingly threatened by human activities. To aid in the management and protection of freshwater ecosystems and fisheries, nine key principles were outlined for supporting healthy and productive ecosystems based on the best available science, including laws of physics and chemistry apply to ecology; population dynamics are regulated by reproduction, mortality, and growth; habitat quantity and quality are prerequisites of fish productivity; connectivity among habitats is essential for movements of fishes and their resources; freshwater species and their habitats are tightly linked to surrounding watersheds; biodiversity can enhance ecosystem resiliency and productivity; global processes affect local populations; anthropogenic stressors have cumulative effects; and evolutionary processes can be important. Based on these principles, Lapointe *et al*. (2014) provided general recommendations for managing and protecting freshwater ecosystems and the fisheries they support, with examples of successful implementation for each strategy. The present study described fish assemblage structure in the river Murti exhibiting altitudinal zonation and documented fish species distribution inside as well as outside of protected areas. Cyprinid fishes are overall dominant in the river Murti following the same pattern found in most of the other North-Eastern Himalayan rivers like Brahmaputra (Biswas and Boruah, 2000), Gandaki (Edds,1993) etc. The ichthyofaunal diversity as well as species richness were found to be higher within the reaches falling inside Gorumara national Park (S1) and Chapramari Wildlife Sanctuary (S3), compared to that of the other sites of river Murti (S2 and S4), whereas dominance followed the reverse trend. Such results may depict increased anthropogenic activities disrupting the natural habitat conditions of the ichthyofauna in the stretches of River Murti falling outside the protected areas, thus lowering species diversity and richness, while only toterant species could survive, causing higher values of dominance in S4 and S2 respectively.

Measures of phylogenetic structure, based on analysis of cladograms of particular groups of organisms have been proposed by conservation biologists as a means of assigning conservation priorities that preserve the greatest amount of phylogenetic diversity or ‘evolutionary history’ (Faith, 1992, 1994; Humphries *et al.*, 1995; Nee and May, 1997). Warwick and Clarke (1995) introduced the concept of taxonomic distinctness (Δ) as a measure of the average degree to which individuals in an assemblage are related to each other. Warwick and Clarke (1998) applied this measure to data on free-living marine nematodes from degraded and non-degraded locations around the British Isles, and provided evidence for a loss of average taxonomic distinctness in locations that were affected by various types of pollution. Little attention, however, has been drawn devoted to this sort of analysis for riverine fish assemblage. In the current study, attention was paid to estimators of taxonomic diversity. In conjunction with previous findings regarding diversity, richness, evenness and dominance indices in all the four sites, significantly higher values of Total Taxonomic Distinctness (average taxonomic distance between species in a community) and Phylogenetic Diversity (average evolutionary distance between species in a community) in S1 and S3 (within the protected areas) is indicative of more distant taxonomic relationship between the fish species present within each protected area. Such higher values of Total Taxonomic Distinctness and Phylogenetic Diversity may be beneficial for ecosystem functioning and conservation as they offer a greater range of functional traits, provide a wider range of ecosystem services while being more resistance to disturbance, thus forming a more diverse and resilient community.

Beta dissimilarity depicts a clear idea about closest association of a species assemblage pattern and similarly its turnover along them (Legendre and De Cáceres, 2013). Several beta diversity components could be used for community assemblage analysis. Beta-diversity is likely to get different along the longitude universally due to geographic gradients. In this study we choose to focus on Whittaker beta dissimilarity value along with Bray-Curtis similarity to address habitat choices of inhabiting species (Bojsen and Barriga, 2002; Legendre *et al.*, 2005). The highest beta dissimilarity was found between S1 and S4, the stretch running through the plains within Gorumara national park and the uppermost sampling site in river Murti flowing outside the protected areas. The minimum number of shared species among the two sites may indicate very high variation in species assemblage pattern, pointing out towards habitat specificity of the fish fauna as well as anthropogenic interference. The values of beta dissimilarity remained consistently high for S2 -S4 and S2-S3, which gradually lowered in S1-S3 and relatively low values were obtained for S1-S2 and S3-S4 suggesting that upper and lower reaches are greatly dissimilar while difference in species composition between two sites of both upper (S1 and S2) and lower reaches (S3 and S4) are less. The results were supported by Bray-Curtis similarity analysis which accounted that S1 may show similarity in terms of species composition with S2, though varied regarding species diversity, richness and dominance, and the same is pertinent between S3 and S4.

Conclusion

The river Murti provides refuge to a diverse fish population but is under continuous threat of habitat alterations because of unsustainable use of resources, increased anthropogenic activity and tourism. The present study demonstrated that a combination of altitudinal zonation and anthropogenic disturbances may be responsible for structuring habitat pattern of fish assemblage and ichthyofaunal diversity in this swift flowing riverine system. The knowledge of such specialised habitat and the inhabiting fish species may be the key to form appropriate conservation strategies of such precious habitats.

References

Arunachalam, M. (2000). Assemblage structure of stream fishes in the Western Ghats (India). *Hydrobiologia*, **430**, 1-31.

Bagra, K. and Das, D.N. (2010). Fish diversity of river Siyom of Arunachal Pradesh, India: a case study. *Our Nature*, **8**, 164-169.

Berger, W.H. and Parker, F.L. (1970). Diversity of planktonic foraminifera in deep sea sediments.*Science*, *168*, 1345-1347.

Bhakta, J.N. and Bandyopadhyay, P.K. (2008). Fish diversity in freshwater perennial water bodies in Midnapore district of West Bengal, India. *International Journal of Environmental Research*, **2 (3)**, 255-260.

Bhat, A. (2003). Diversity and composition of freshwater fishes in river systems of Central Western Ghats, India. *Environmental Biology of Fishes*, **68**, 25-38.

Biswas, S., &Boruah, S. (2000). Fisheries ecology of thenortheastern Himalayas with special reference to theBrahmaputra River. *Ecological Engineering, 16*(1),39-50.

Bojsen, B., &Barriga, R. (2002). Effects of deforestation onfish community structure in Ecuadorian Amazonstreams. *Freshwater Biology, 47*(11), 2246-2260.

Chu, C., Minns, C.K., and Mandrak, N.E. 2003. Comparative regional assessment of factors impacting freshwater fish biodiversity in Canada. *Can. J. Fish. Aquat. Sci.***60**(5), 624–634. doi:10.1139/f03-048.

Chu, C., Minns, C.K., Lester, N.P. and Mandrak, N.E. (2014). An updated assessment of human activities, the environment, and freshwater fish biodiversity in Canada. *Can. J. Fish. Aquat. Sci.***72**, 1–14 (2015) dx.doi.org/10.1139/cjfas-2013-0609

Daniels, R.J.R (2001). Endemic fishes of the Western Ghats and the Satpura Hypothesis. *Current Science*, **81 (3)**, 240-244.

Day, F. 1889. *The fauna of British India: Fishes.* Taylor and Francis, London, 1 :i-xx + 1-548.

Dudgeon, D. (1992). Endangered ecosystems: a review of the conservation status of tropical Asian rivers. *Hydrobiologia*, **248**, 167-191.

Dudgeon, D. (2003). The contribution of scientific information to the conservation and management of freshwater biodiversity in tropical Asia. *Hydrobiologia*, **500**, 295-315.

Dudgeon, D.,Arthington, A.H.,Gessne, M.O.,Kawabata, Z.I., Knowler, D.J., Lévêque, C., Naiman, R.J.,Richard, A.H.P.,Soto, D.,Stiassny, M.L.J. and Sullivan, C.A. (2007). Freshwater biodiversity: importance, threats, status and conservation challenges. DOI: 10.1017/S1464793105006950

Easa, P.S., Shaji, C.P. (1997). Freshwater fish diversity in Kerala part of the Nilgiri Biosphere Reserve. *Current Science*, **73**, 180-182.

Edds, D. R. (1993). Fish assemblage structure and environmental correlates in Nepal's Gandaki River.*Copeia*, 48-60.

Faith, D.P. (1992). Conservation evaluation and phylogenetic diversity. *Biological Conservation*, **61**, 1-10.

Faith, D.P. (1994). Phylogenetic pattern and the quantification of original biodiversity. *Philosophical Transactions of Royal Society of London, Series B, Biological Science*, **345**, 45-58.

Fu, C., Wu, J., Chen, J., Wu. Q. and Lei, G. (2003). Freshwater fish biodiversity in the Yangtze River basin of China: patterns, threats and conservation. *Biodiversity and Conservation,* **12,**1649-1685.

Humphries, C.J., Williams, P.H. and Vane-Wright, R.I. (1995). Measuring biodiversity value for conservation. *Annual Review of Ecology and Systematics*, **26**, 93-111.

Jayaram, K.C. (1999). The freshwater fishes of Indian Region. Narendra Publishing House, Delhi-6, 551 pp.

King, C.E. (1964). Relative abundance of species and MacArthur's model. *Ecology*, *45*, 716-727.

Lapointe, N.W.R., Cooke, S.J., Imhof, J.G., Boisclair, D., Curry, C.R.A., Langer, O.E., McLaughlin, R.L., Minns, C.K., Post, J.R., Power, M., Rasmussen, J.B., Reynolds, J.D., Richardson, J.S. and Tonn, W.M. (2014). Principles for ensuring healthy and productive freshwater ecosystems that support sustainable fisheries. *Environ. Rev.***22**, 110–134.

Legendre, P., & De Cáceres, M. (2013). Beta diversity as the variance of community data: dissimilarity coefficients and partitioning. *Ecology letters, 16*(8),951-963.

Legendre, P., Borcard, D., & Peres-Neto, P. R. (2005).Analyzing beta diversity: partitioning the spatial variation of community composition data. *Ecological Monographs, 75*(4), 435-450.

Margalef, R. 1957. Information theory in ecology. *General Systematics*, **3**, 36-71.

Nee, S. and May, R.M. (1997). Extinction and the loss of evolutionary history. *Science*, **278**, 692-694.

Patra, A.K and Datta, T. (2010). Diversity of Cypriniformes fish fauna in Karala river, a tributary of Teesta river at Jalpaiguri district of West Bengal, India. *Research Journal of Biological Sciences*, **5 (1)**, 106-110.

Pielou, E.C. 1969. *An Introduction to Mathematical Ecology*. Wiley, New York.

Poff, N.L., and J.V. Ward, (1989). Implication of stream flow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. *Canadian Journal of Fisheries and Aquatic Science*, **46**, 1805-1818.

Radhakrishnan, K.V. and Kurup, B.M. (2010). Icthyodiversity of Periyar tiger reserve, Kerala, India. *Journal of Threatened Taxa*, **2(10),** 1192-1196.

Ranjan, S. (1963). Ecology of the fishes of the rivers Pykara and Moyar (Nilgiris), South India. *Proceedings of Indian Academy of Sciences*, **58 (B)**, 291-323.

Resh, V.H., Brown, V., Covich, A.P., Gurtz, M.E., Li, H.W., Minshall, G.W., Reice, S.R., Sheldon, A.L., Wallace, J.B, and R. Wissmar, (1988). The role of disturbance in stream ecology. *Journal of the North American Benthological Society*, **7**, 433-455.

Shaji, C.P. and Easa, P.S. (1998). Status and Distribution of endemic freshwater fishes in Kerala, Western Ghats, India. *Tigerpaper*, **25**, 21-24.

Shannon, C.E. and Weaver, W. 1949. *A Mathematical Model of Communication*. University of Illinois Press, Urbana.

Shaw, G.E. and Shebbeare, E.O. 1937. The fishes of North Bengal. *Journal of Royal Asiatic Society of Bengal*, III, 1-137.

Shinde, S.E., Pathan, T.S., Raut, K.S., Bhandare, R.Y. and Sonawane, D.I. (2009). Fish Biodiversity of Pravara River at Pravara Sangam District Ahmednagar, (M.S.) India. *World Journal of Zoology*,**4 (3)**: 176-179.

Silas,E.G. (1951). On a collection of fishes from Anamalai and Nelliampathi hill ranges (Western Ghats) with notes on its zoogeographical significances. *Journal of Bombay Natural History Society*, **49**, 670-681.

Sreekantha, M.D. Chandran, S., Mesta, D.K., Rao, G.R., Gururaja, K.V. and Ramchandra, T.V. (2007). Fish diversity in relation to landscape and vegetation in central Western Ghats, India. *Current Science*, **92 (11)**, 1592-1603.

Suzuki, C.D. and Cooke, S.I. (2006). Conservation of aquatic resources through the use of freshwater protected areas: opportunities and challenges. *Biodiversity Conservation*, DOI:10.1007/s10531-006-9060-7.

Talwar, P.K. and Jhingran, A. (1991). Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2 volumes: xix + 1158 pp.

Van Dyke, F. (2008). Conservation Biology: Foundations, Concepts and Applications. *Springer*, 478.

Warwick, R.M. and Clarke, K.R. (1995). New biodiversity measures reveal a decrease in taxonomic distinctness with increasing stress. *Marine Ecology Progress Series*, **129**, 301-305.

Warwick, R.M. and Clarke, K.R. (1998). Taxonomic distinctness and environmental assessment. *Journal of Applied Ecology*, **35**, 532-543.

Access this Article in Online	
	Website: www.ijarbs.com
Quick Response Code	Subject: Biodiversity
DOI:10.22192/ijarbs.2025.12.06.004	

How to cite this article:
Adwitiya Chaudhuri. (2025). Fish Diversity Patterns along River Murti: A Comparative Assessment Inside and Outside Protected Areas of Northern West Bengal, India. Int. J. Adv. Res. Biol. Sci. 12(6): 32-45.
DOI: http://dx.doi.org/10.22192/ijarbs.2025.12.06.004