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A review of pattern of fish diversity & its management practices in several water body in India

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Abstract
Biodiversity is the concept of variety and variability of living organisms. Biodiversity includes not only the variety of species but also include genetic diversity, habitats, and ecological communities. Preserving biodiversity is crucial for protecting nature and ensuring a future for generations. Advancements in technologies as like remote sensing; robotic equipment improved our understanding of biodiversity on levels from genes to ecosystems. Biodiversity includes not the range of species but genetic diversity within species and diversity across ecosystems, such as various habitats, communities and ecological processes. One perspective on biodiversity focuses on its roles in ecosystems highlighting how different species contribute to functions like pollination, nutrient cycling and pest control. Fish Diversity many water bodies have been changed over the time due to the effects of climate change, anthropogenic activities, and human interference etc. Preserving biodiversity is the key to upholding these services from nature and safeguarding welfare, amidst adversities. It requires not only protecting individual species but also to preserving their habitats, promoting sustainable land use practices, restoring degraded ecosystems, and engaging local communities in conservation efforts.

Keywords: Biodiversity, conservation, ichthyofaunal, richness, fish abundance

Introduction

Biodiversity indeed encompasses a wide range of life forms and processes on Earth, as highlighted by Rathoure and Patel (2020) [41]. This comprehensive understanding of biodiversity is essential for addressing conservation challenges and promoting sustainable management of natural resources. By recognizing the interconnectedness of genes, species, ecosystems, and ecological processes, we can better appreciate the complexity and resilience of life on our planet. This holistic perspective guides efforts to conserve and restore biodiversity, ensuring its continued benefits for present and future generations. Alpha, beta, and gamma diversity are key concepts in the study of biodiversity, each representing different levels of diversity across spatial scales. Both habitat destruction and fragmentation disrupt ecosystems and ecological processes, leading to declines in biodiversity at local, regional, and global scales. These impacts are often exacerbated by other factors such as climate change, pollution, invasive species, and overexploitation of natural resources. Addressing habitat destruction and fragmentation is therefore essential for conserving biodiversity and maintaining the integrity of ecosystems. Conservation correlation to protecting and restoring habitats, establishing wildlife corridors to reconnect fragmented landscapes, and implementing land-use planning strategies that prioritize biodiversity conservation along with human development. Freshwater fish are among the most threatened taxonomic groups by globally. Several factors contribute to the declining of freshwater fish populations and the degradation of their habitat (Darwall and Vie 2005) [9]. Freshwater fish requires integrated and collaborative approaches, including habitat conservation and restoration, sustainable water management, pollution control measures, fisheries management, and climate change adaptation strategies, addressing the threats facing. Protecting of freshwater ecosystems and their biodiversity is essential for management of ecosystem services, supporting livelihoods, and ensuring the long-term health and resilience of freshwater ecosystems Cardinale *et al.* (2012) [18] highlighted that biodiversity loss can have profound impacts on the ability of ecosystems to provide essential goods and services that support human well-being.

India's tremendous biodiversity is indeed globally significant. The statistics they have provided demonstrate the richness and diversity of India's flora and fauna. These statistics decode India's importance as a biodiversity hotspot and highlight the need for effective conservation efforts to safeguard its rich biological heritage. Protecting of India's diverse ecosystems and the species is essential for maintaining ecosystem services, preserving genetic diversity, and ensuring the well-being of both wildlife and human communities.

Fishes are primarily cold blooded (ectotherms or poikilotherms), aquatic vertebrates which breathe by means of pharyngeal gills, compelling and compounding themselves by means of fins. They make up most of the abundant class of vertebrates, both terms, in number of species and individuals. Fishes have great significance in the life of humankind. They were the staple good protein source in diet of many consumers throughout the world. They comprise an important economy of world-wide and give incalculable recreational value to the naturalist, and home aquarist. They play an important role directly and indirectly in the heritage of human beings. At the same time, the outburst of human population and increased demand for water and its bio-resources had been resulting in further loss of stream habitat which had led to aquatic organisms becoming less abundant particularly the fisheries resources. Integrated and accelerated efforts were essential towards environmental restoration and conservation in order to stop further degradation of these fragile ecosystems (Kar *et al*., 2003; Kar, 2013) [29, 26]. Fishes were the most several of the vertebrate taxa and were distributed in a range of aquatic environments (Darwell *et al.*, 2007) [10]. The diversity of 39,900 vertebrate species known to exist so far, almost half i.e. 21,723 species are belonging to fishes species. Out of them, 8411 species are of freshwater fishes and the rest 11,650 are marine species. In the Indian region alone, of the 2,500 fish species, 930 are freshwater inhabitants and 1,570 are marine (Jayaram, 2010; Kar 2013) [23, 26]. North Eastern region of India, covering 262379 sq. km. area had been divided into two bio-geographic zones-Eastern Himalaya and North East India, based on floristic composition, the naturalness of the flora and the local climate (Rodgers and Panwar, 1988) [43].

Fish diversity in some prominent riverine systems

Johal and Rawal (2005) [24] did research on the management of Western Himalayan hill streams, particularly concerning fish species diversity and richness. The research aimed to understand the ecological dynamics of these streams across various environmental gradients. The study was done in 10 selected sites located within the Rivers Ghaggar, Yamuna, and Ganga watersheds. Over these sites, the researchers listed the presence of 26 fish species, which were classified into four orders: Cypriniformes, Siluriformes, Synbranchiformes, and Perciformes. Cypriniformes emerged as the dominant family, comprising 21 species. One key finding from their study was the deposition between stream characteristics and fish species richness. Streams situated at higher altitudes, characterized by steep gradients and boulder-dominated substrates, and exhibited lower fish species richness, typically ranging from 3 to 4 species. The Shannon and Weiner diversity index for these streams ranged from 0.55 to 0.99 that indicates relatively lower diversity. In comparison to hill streams at lower altitudes, characterized by gentler gradients and cobble-dominated substrates, along with several habitat types such as pools, riffles, runs, rapids, and cascades, showed higher fish species richness. The fish species richness index for these streams ranged from 6-14 species. Correspondingly, the Shannon-Weiner diversity index ranged from 1.67 to 2.35, indicating higher diversity in these habitats worked on the fish diversity in the Adan and Kathani Rivers of the Godavari basin, those are tributaries of the Painganga and Wainganga rivers, respectively. To estimate richness of species, he used the Jackknife-1 measure. Biodiversity Pro software was utilized for calculating richness estimates, diversity indices, and similarity measures, additionally. In the study they have identified total 47 fish species present in the rivers under investigation provided valuable insights into the fish diversity, distribution, abundance, and threats in the Gomti River, a tributary of the Ganga River in India. During the study period they identified a total of 56 fish species belonging to 42 genera and 20 families, that indicating a diverse fish fauna within the river ecosystem, variety of species reflects the ecological richness and complexity of the Gomti River and its associated habitats. Lakra *et al.* (2010) [37] worked on the Betwa River, which is part of the Ganga basin, provides important insights into fish diversity, habitat ecology, and threats to fish populations. During the study they identified a total of 63 fish species inhabiting the Betwa River, these species belong to 45 genera and 20 families that indicates a diverse fish fauna within the river ecosystem. The divers of listed species reflect the ecological richness and complexity of the Betwa River and its associated habitats studied on the fish diversity of the Bhadra River, located in the Western Ghats region. Their research aimed to examine the correlation between fish diversity and physicochemical variables in the river ecosystem. In their study period, they listed a total of 56 fish species, representing 31 genera and 15 families. The standard finding of their research was the positive relationship observed between fish species diversity and physico-chemical parameters of the river. The study concluded that the health and diversity of fish populations in the Bhadra River are influenced by factors such as water quality, temperature, and dissolved oxygen levels. They also mentioned a concerning aspect: the impact of industrial effluents on species richness. Rankhamb (2011) [44] did research on the fish fauna of the Godavari River at Mudgal, a sacred location situated on the riverbank. The study revealed the presence of 26 fish species belonging to 15 genera, 7 families, and 5 orders. Cypriniformes emerged as the dominant order (comprising 15 species) within the surveyed area. Jadhav *et al.* (2011) [25] conducted a study on the Koyna River, a tributary of the Krishna river system in western Maharashtra, which forms part of the East coast river system in India. During their research, they revealed the presence of 58 fish species belonging to 16 families and 35 genera in the Koyna River. They found that 22 fish species in the river were almost endemic at the Western Ghats region. This study highlights the unique biodiversity of the Koyna River within the context of the Western Ghats ecosystem and its importance, despite modest fishing pressure from tourism and pollution in certain stretches of the river. They concluded that the Koyna River harbors a rich diversity of fishes. The study suggested that the fish populations in the Koyna River were less threatened by anthropogenic stressors, indicating a relatively healthy ecosystem studied on the River Ganga and provides valuable insights into freshwater fish diversity, distribution, abundance, and threats in one of India's most important river systems. They enlist a total of 143 fish species in the River Ganga. Among these, 133 species were native to the region,

while 10 species were exotic (or non-native). These fish species represent a diverse array of taxa, belonging to 11 orders, 72 genera, and 32 families. The presence of such a high diversity of fish species underscores the ecological richness and complexity of the Ganga River ecosystem. During the study they identified various anthropogenic activities, including hydrological alterations, dam construction, and overfishing, as significant factors contributing to alterations in fish diversity and community structure. These threats can disrupt habitat connectivity, alter flow regimes, degrade water quality, and lead to declines in fish populations and species richness. Dahanukar *et al.* (2012) [12] conducted a study on the Indrayani River, which is a northern tributary of the Krishna River system. In their research, they documented a total of 57 fish species belonging to 18 families and 39 genera within the Indrayani River. Among these 57 species, 12 were found to be endemic to the Western Ghats, additionally, 6 species were endemic to the Krishna River system itself. However, their study also brought attention to the threats facing the Indrayani River. They identified alien species and human-induced activities as significant threats to the river's ecosystem. These findings underscore the importance of conservation efforts to protect the native fish species and the overall health of the Indrayani River and its tributaries within the Krishna River system. Das *et al.* (2013) [13] conducted a comprehensive study on the Ichthyofaunal diversity, distribution, and community structure of the River Ganga, while also assessing the ecological integrity of its riverine reach. Their findings were revealing a rich diversity within the River ecosystem. During their research period they identified a total of 143 species, representing 40 families and 92 genera. The family Cyprinidae emerged as the most prevalent, constituting 38% of the observed species in the research. This dominance denotes the significance of this family within the Ganges River ecosystem. One notable observation from their study was the correlation between river depth and width with the abundance and distribution of fish fauna. Vyas and Vishwakarma (2013) [52] conducted a study focusing on the Jamner River, a tributary of the Narmada River, which is one of the main rivers of the west coast river systems in India. The research aimed to document the fish diversity present in this River system, providing a valuable insight into the aquatic ecosystems of the region. The study revealed the presence of 27 fish species within the Jamner River, representing a diverse array of aquatic life. These species were classified into four orders: Cypriniformes, Ophiocephaliformes, Perciformes, and Mastacembeliformes, reflecting the taxonomic diversity within the river ecosystem, among these orders Cypriniformes emerged as the most dominant, with 21 species recorded. Following Cypriniformes, Ophiocephaliformes were represented by 3 species, while Perciformes and Mastacembeliformes each had 2 and 1 species, respectively. This distribution highlights the significance of Cypriniformes in the fish diversity of the Jamner River, likely reflecting their ecological adaptability and abundance within the river system. The presence of diverse fish species across multiple orders decodes the ecological importance of the Jamner River and its role in supporting aquatic biodiversity within the broader Narmada River basin. Understanding the composition and distribution of fish communities in tributary rivers like the Jamner is essential for effective management and conservation of freshwater resources in the region studied on fish diversity of Tawa River and documented a total 57 species belonging to 6 orders, 13 families and 35 genera and among these Cypriniformes was the most dominant (59.64%) followed by Siluriformes (15.78%), Perciformes (15.78%), Synbrnchiformes (3.50%), Osteglossiformes (1.75%), Beloniformes (1.75%). The study also noted the presence of 25 ornamental fish species and 17 species commonly used in aquaculture practices, underscoring its significance for both recreational and economic purposes within the Tawa River. Sarkar *et al.* (2014) [45] conducted a survey that was focused on the fish diversity, distribution, and abundance patterns within the River Ken, a significant tributary of the River Yamuna. Their findings shed light on the ecological health and conservation status of this vital river system. The study revealed a total no. of 57 fish species present in the River Ken, representing 42 genera and 20 families. This diversity denotes the importance of the river as a habitat for a wide range of aquatic species. Vishwakarma *et al.* (2014) [53] studied on the fish fauna of the Barna River in Madhya Pradesh, employed various diversity indices to quantify the diversity of the fish assemblage. They utilized indices such as the Simpson dominance index, Simpson index of diversity, Shannon–Weiner index, Evenness index, and Margalef index. These indices were calculated using the software PAST (version 2.15). During the research they identified a total of 33 species of fish belonging to 5 orders, 9 families, and 21 genera in the Barna River. Among these families, the Cyprinidae family was the most abundant, comprising 75% of the individuals observed. After that, the Cobitidae family was the next most abundant, representing 10% of the individuals recorded in the study. This comprehensive assessment provides valuable insights into the diversity and abundance of fish species in the Barna River ecosystem, contributing to our understanding of freshwater biodiversity in the region. Joshi *et al.* (2016) [21] conducted a study focused on the Ichthyofaunal diversity, distribution patterns, and the invasion of exotic fish species within the Yamuna River, particularly in light of altered hydro-ecological conditions. Their research provided insights into the ecological dynamics and conservation status of fish populations within this important river system. They revealed a diverse array of fish species within the Yamuna River, with a total of 112 species identified. These species were belonging across 73 genera, 29 families, and 10 orders, highlighting the rich biodiversity present within the river ecosystem. However, it's concerning that out of these species; 6 species were identified as exotic, indicating the presence of non-native species that may pose threats to native species biodiversity. Assessment of the threat status of the fish species concerns conservation, 15 species were classified as threatened, while an additional 10 were categorized as near threatened. This suggests that a considerable portion of the fish fauna within the Yamuna River is at risk, likely due to various anthropogenic activities worked on Ichthyofaunal diversity of the Dudhi River, a tributary of the Narmada basin, during the study period they recorded total of 19 species categorized under 4 orders and 5 families during the study period. They also highlighted the significance of assessing Ichthyofaunal diversity in determining the water quality of rivers, as fishes are highly sensitive to even minor changes in the physico-chemical parameters of their habitat. They emphasized the crucial role of Ichthyofaunal diversity assessment in gauging the water quality of rivers. They also highlighted that fishes are highly sensitive organisms, capable of responding rapidly to even

subtle changes in the physico-chemical parameters of their habitat. Therefore, monitoring fish diversity can serve as an effective tool for evaluating the overall health and quality of river ecosystems. Khade *et al.* (2017) [26] conducted a study on the fish diversity of Wan River, a tributary of the Tapti River. Their research unveiled a higher diversity, with 21 species identified belonging to 8 families and 5 orders and they observed a significant dominance of the Cyprinidae family (constituting 55%). Bhattacharjya *et al.* (2017) [6] conducted a study on the Ichthyofaunal diversity of the Brahmaputra River and its tributaries in Assam. Their research recorded a total of 141 fin fish species from 84 genera and 29 families within the studied area. This study provides valuable acuteness into the fish diversity present in the Brahmaputra River and its tributaries in Assam. Das *et al.* (2017) [14] conducted a study on the fish diversity of the Siang River, the largest river in the Brahmaputra River system. The research revealed the presence of 82 fish species categorized under 8 orders, 24 families, and 53 genera within the Siang River basin. Cypriniformes emerged as the most dominant order among the recorded species. The study also revealed the conservation status of the fish species identified in their study. They have found that the majority of the fish species were classified under the "least concern" status, indicating that they are not currently facing significant conservation threats. This information provides important insights into the ecological health and conservation status of fish populations in the Siang River ecosystem. Kaur *et al.* (2017) [27] worked on the fish diversity in the Harrick wetlands, which are formed at the confluence of the Beas and Sutlej Rivers. In their research they recorded a total of 37 fish species belonging to 25 genera and 14 families within the Harrick wetlands. Among the observed families, Cyprinidae was the most dominant, with 16 species recorded, followed by Bagridae (4 species), Siluridae (3 species), and others. The study provided a valuable insight into the fish diversity present in the Harrick wetland's ecosystem, highlighting the importance of this habitat for various fish species conducted a study on the ornamental fish fauna of the Beas, Sutlej, Ravi rivers and their tributaries in Himachal Pradesh. Their research listed a total of 58 ornamental fish species belonging to 13 different families and 36 genera within the studied area. Among these species, 42 were identified as native to the region, while 16 were imported for the aquarium trade. The Cyprinidae family emerged as the most dominant among the native Ichthyofaunal species diversity observed in the rivers and tributaries of Himachal Pradesh. This study highlighted on the diversity of ornamental fish species present in the rivers of Himachal Pradesh, as well as the importance of conservation of native fish populations in the region.

Fish diversity of some prominent lakes and reservoirs

Jayaram (1999) [22] Recorded a total 852 freshwater species of fishes under 272 genera, 71 families and 16 orders, including primary and secondary freshwater fishes from India, Bangladesh, Pakistan, Myanmar, Nepal and Sri Lanka. Menon (1999) [2] Recorded 446 primary freshwater species under 33 families, 11 orders, from the Indian region, in the total fish species 68% were participating by the Cyprinoids, 18% are Siluroids and 14% are other groups. The present checklist of 667 species is being updated after a survey of 10 years includes several new species mostly Siluroids and a few Cyprinoids. New species discoveries can significantly contributed to our understanding of diversity. Chandrasekhar (2004) [7] studied on fish fauna of Hydrabad and its environs and the study noted that fish fauna of Hyderabad and its environment is an important endeavor for understanding of aquatic biodiversity of the region. Fish species play a vital role in ecosystem health and provide insights into the overall environment conditions. During the study it recorded total 65 numbers of fish species from the selected study site. Kar *et al.* (2005) [31-33] studied fish diversity and conservation aspects in an aquatic ecosystem in Northeastern India. The presence of 69 different fish species suggests that the aquatic ecosystem is relatively healthy and can support a wide range of fish species. These species belong to 49 different genera, 11 orders, and 24 families highlight the complexity and evolutionary history of the fish community. This diversity could be due to various ecological niches and habitats within the lake. The study revealed of 69 species of fishes in the lake belonging to 49 genera, 11 orders and 24 families studied on fish diversity and have mentioned 41 fish species belonging to 13 families and 25 genera. Tamot *et al.* (2012) [50] studied an approach to evaluate fish diversity and limnological status of sewage fed urban lake (Shahpura), Bhopal & revealed that due to expanded and development activities are concentrated around the lake that impact badly on water quality of the lake. In Shahpura lake receives some untreated domestic sewage water from around. Meena *et al.* (2013) [38] researched on Ichthyofaunal Diversity of District Bhopal (M.P.) and found a total 45 no of species belonging from 18 different families, 7 order and 32 genera from the water bodies of District Bhopal. In this study cypriniformes order was most dominant (19species) followed by Perciformes (10 species)> Siluriformes (8 species)> Synbranchiformes (2 species)> Osteoglossiformes (4species)> Beloniformes and Clupeiformes (1 species) each. Napit (2013) [40] worked on Threatened Ichthyofaunal of the Upper Lake Bhopal (M.P) and revealed that the Upper Lake was dominated by Cypriniformes > Ophiocephaliformes >Peciformes and others. In this study he also mentioned that many species from this lake are decline or have disappeared in compare to previously recorded data. According to his research the main significant factors contributing to the declining of the species habitat distribution, introduction of exotic species, pollution and over-fishing. This disappearance of highly conspicuous species is indeed worrying for ichthyologist. Conservation efforts are crucial to address this issue promptly and protect vulnerable fish population. Baliarsingh *et al.* (2013) [4] studied the diversity of freshwater fishes in the Similipal Biosphere Reserve, located in Odisha. They were recorded 66 species belonging from 42 genera and 19 families and 6 orders. Among these Cypriniformes have been the highest diversity followed by Perciformes> Synbranchiformes> Osteoglossiformes> Belongiformes. Studies like this are instrumental in understanding and conserving biodiversity within Biosphere reserve, the present Biosphere reserve of fish species included 42 species are least concern, 1 is endangered, 1 is vulnerable, 6 are near threatened and 3 species are data deficient. Bera *et al.* (2014) [5] worked on the ichthyodiversity in Kangsabati reservoir located at West Bengal, concerning physico-chemical parameters of water and they also evaluate the appropriateness of water to foster fishery activity. They also investigated that physicochemical parameters of the reservoir were compatible for 39 commercially important fish species and the study revealed that the aquatic environment and water quality parameters effect on the Ichthyofaunal diversity and development of fish

growth. Wani *et al.* (2015) [39] studied on Ichthyofaunal diversity of Sagar Lake, Madhya Pradesh and recorded a total 21 species belonging to 6 orders, 11 families and 17 genera from the study sites. According to CAMP (Conservation Assessment and Management Plan conservation status 5 are valunerable, 2 endangered, 10 lower risk- near threatened, 1 lower risk least concerned and 3 non-evaluated. Hussain *et al. (*2017) [18] worked on Ichthiofaunal Diversity of a Freshwater Lake and recoded total 35 species belonging to 5 orders, 11 families. Dubey *et al.* (2017) [16] studied on Ichthyofaunal diversity of Sarangpani Lake, Bhopal & recorded total 13 fish species belonging to 3 orders, 5 families and 10 genera during July – December, 2017. The study revealed that the Lake is rich in diversity but richness of diversity is to extinct due to discharges of pollutant so, the conservation of existed Ichthyofaunal is important for sustainable diversity. Mustafa *et al.* (2017) [39] worked on Ichthyofaunal diversity of Halali Reservoir, Vidisha during July- November, 2016 and recorded 23 fish species. And they found that the reservoir was dominated by Cuprinoformes> Siluriformes > Perciformes > Anguilliformes > Beloniformes > Osteoglossiformes. Singh *et al.* (2019) [46] studied conservation management and rehabilitation aspect on the diversity of Upper Lake, Bhopal and described about conservation and diversity play crucial roles in ensuring the sustainable use of resources. In their study period they recorded 27 species of fish belonging to 4 different orders 9 different families.

Current and future challenges of biodiversity

The challenges biodiversity conservation facing that is complex and interconnected, A urgently collaborative action from governments, businesses communities, and individuals worldwide to be included in further action plan of country. By addressing those issues is crucial for protecting biodiversity and ensuring a sustainable future. Each of those factors like, climate change, invasive species, overexploitation and illegal wildlife trade, pollution, lack of awareness, insufficient funding, and governance and policy issues pays a significant role in decline of species and ecosystem worldwide. Biodiversity loss has indeed accelerated over the past few decades, with significant declines observed across various taxonomic groups and ecosystems worldwide. This trend is supported by numerous scientific studies and assessments, including those mentioned by (Domisch *et al.* 2011) [11]. Biodiversity over the last decade due to the alarming rates of species extinction, driven by human activities such as habitat destruction, pollution, climate change, and overexploitation, have raised concerns about the loss of biodiversity and its potential consequences for ecosystem functioning and human well-being, that spurred increased research efforts to understand the drivers of extinction and develop strategies for conservation and restoration (Heydari *et al.,* 2020) [19]. To understanding the biodiversity of aquatic ecosystems, including riverine ecosystems, is crucial for assessing their health and functioning. Riverine ecosystems are highly progressive and variegated, supporting a wide variety of aquatic life, including fish species that play key roles in these ecosystems. These ecosystems are facing much anthropogenic pressures, leading to habitat degradation and loss, particularly for fish species.

Conclusion

In conclusion, we can say India contributes about to 7.7% of global fish diversity. Fish diversity along with distribution of fish fauna from various riverine systems and their tributaries, Lakes and reservoirs has been documented. Freshwater fishes face numerous threats from human activities, over fishing, dam construction, introducing exotic species, agricultural pesticides and herbicides, industrial wastage, all are contribute to declining of fish diversity. Ichthyofaunal diversity and distribution provide valuable information for design and implementing conservation strategies. Focusing on determination and management of protected areas within biodiversity hotspot is essential for addressing to the threats to biodiversity and promoting conservation of biodiversity.

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