E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2024; 12(6): 103-106

www.fisheriesjournal.com
Received: 11-10-2024
Accepted: 18-11-2024

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A Review on fish diversity of freshwater ecosystems in India

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DOI: https://doi.org/10.22271/fish.2024.v12.i6b.3001

Abstract
Biodiversity is crucial for maintaining ecosystem stability, protecting overall environmental quality, recognizing the inherent value of all species on earth. Fish are the important biological resources used for ecological assessments at all levels of biological organization at the various levels of ecosystem. They can serve as bioindicators of water quality and environmental health and also used to monitor the water quality for toxic substances in aquatic ecosystems. Fish are considered as rich sources of protein and essential food for humans, providing fats, vitamins A and D, which are vital for daily life. Additionally, fish are also used in various medical treatments. Global freshwater biodiversity of fish is in decline due to various factors like alterations in water flow, pollution, unsustainable fishing practices, spread of invasive species, and the effects of climate change. The objective of this review work is to give better knowledge in understanding the fish diversity in relation to abundance, and richness of the fresh water aquatic ecosystems in India.

Keywords: Biodiversity, fish, bioindicators, climate change.

Introduction
Aquatic ecosystems are essential natural resources that support a variety of living organisms, including plants, insects, fish, invertebrates, and microorganisms. Particularly, freshwater fishes serve as bioindicators that are vulnerable to significant habitat changes. Consequently, periodic studies of water bodies are crucial for obtaining detailed information on biodiversity (Das *et al* 2023) [2]. Understanding the importance of biodiversity assessment is essential for making informed decisions on environmental management and conservation. (Dwivedi and De, 2024) [6]

Freshwater ecosystems occupy about 1% of the Earth's surface and support 51% of the world's fish diversity (Fricke *et al*, 2017) [8]. Fresh water ecosystems are highly dynamic in their physico-chemical and biological characteristics, which are significantly controlled by various natural and anthropogenic processes (Dudgeon 2019) [5].

Properly managed freshwater ecosystems can significantly support the achievement of Sustainable Development Goals, particularly those related to clean water and sanitation, responsible consumption and production, and life on land. This highlights the critical role of conservation and management of inland fishery resources in attaining these objectives. However, globally freshwater ecosystems face threats such as overexploitation, flow regulation, pollution, changes in land use and land cover, invasive species, and climate change (Kantharajan *et al* 2022) [10].

Fisheries are closely linked to a country's economy offering an alternative food source for a growing population. They also play a crucial role in health and commercial values, as they form a significant dietary component of many people in the world (Devi *et al*., 2014) (3). Fish has been recognized as suitable for biological assessment because of its ease of identification and economic importance (Siligato & Bohmer. 2001) [20].

Fishes serve as the important indicators of ecological health and abundance, play a key role in maintaining balance in the food chain by feeding on plankton and small animals and serve as a food source for many other species. This balance in the food chain can be disrupted by pollution in aquatic systems. Additionally, fish diversity faces numerous threats, including dam construction that blocks spawning migrations, the introduction of exotic species, and overfishing. Hence, understanding the status of fish fauna is essential to prevent the loss of specific species (Thirumala and Kiran, 2017) [22].

Irrational fishing practices, combined with environmental issues such as reduced water volume, increased sedimentation, water abstraction, and pollution over the years, have led to a decline in fish diversity. Several species have been lost from India's freshwater ecosystems, and mentioned as endemic, endangered, or threatened (Kantaraj *et al* 2011) [9].

Materials and Methods

This review is based on the available published literature collected from scientific publications, reports, and online databases focused on fish biodiversity in freshwater ecosystems. Relevant information was gathered from Peer-reviewed journals- Articles indexed in databases like Scopus, Web of Science, PubMed, and Google Scholar. The review considered studies of fish diversity of freshwater ecosystems in India "between 2009 to 2024".

Review of Literature

Devi Prasad *et al.*, (2009) [4] conducted a study on fish diversity in eight selected wetlands, including Doora and Kuduregundihalla lakes (Nanjangud Taluk), Devibudhi and Yennehole lakes (Mysore Taluk), Karigaladodda Kere and Paduvakote lakes (H.D. Kote Taluk), and Santhe Kere and Karimuddanahally lakes. The study identified 45 fish species belonging to 15 families and 31 genera, including four exotic species. The Cyprinidae family exhibited the highest species richness with 22 species, followed by Bagridae with 5 species, Channidae with 4 species, and Notopteridae and Siluridae with 2 species each, while other families were represented by single species.

The study highlighted a decline in fish diversity, with seven species identified as endangered and six as threatened. Tor khudree (Deccan mahseer) and seven other species were classified as vulnerable. Although 40 fish species were endemic to the region, their numbers decreased due to the introduction of exotic species and decline in diversity was attributed to increasing human activities.

Noman *et al.*, (2009) [15] investigated the fish diversity in Lakkavalli Lake, Shimoga, Karnataka, and identified 16 fish species. The study indicated that the distribution and abundance of fish species are significantly influenced by geographical and geological factors. The environmental conditions of the lake were particularly favourable for the Cyprinidae family, which exhibited higher growth and proliferation compared to other families. This dominance was attributed to the genetic traits of Cyprinidae species, which enhance their ability to tolerate environmental stress and adapt to changing conditions.

Shahnawaz and Venkateshwarlu (2009) [16] documented a high diversity of fish species in the Tunga and Bhadra rivers, identifying a total of 77 species under 5 orders, 18 families, and 44 genera. The order Cypriniformes represented by 62.3% of the assemblage composition of the 77 fish species, followed by the Siluriformes (18.18%), Perciformes (16.88%), Osteoglossiformes (1.29%), and Cyprinodontiformes (1.29%). The study emphasized the rich ichthyofaunal diversity of these rivers and highlighted the importance of developing sustainable strategies to further study and conserve the fish communities in the region.

Venkateshwarlu *et al.*, (2009) [23] conducted a study to evaluate fish diversity in the Sogane and Santhekadur tanks in Shimoga. The study identified a total of 17 fish species belonging to 4 orders, 9 families, and 14 genera, of which 3 species were exotic and 14 were indigenous. Among the 17 species, 8 were classified under the order Cypriniformes, 5 under Siluriformes, 3 under Perciformes, and 1 under Osteoglossiformes. In both the tanks, the fish fauna was predominantly represented by the Cyprinidae family.

Kantaraj. *et al.*, (2011) [9] investigated the fish community of the Bhadra Reservoir, located near Lakkavalli town in Chikkamagaluru district, in relation to physico-chemical parameters. A total of 33 fish species were identified during the study, with Cyprinidae contributing 18 species, Channidae 2 species, Bagridae and Siluridae 3 species each, and one species each from Mastacembelidae, Ambassidae, Cichlidae, Clariidae, Notopteridae, Cobitidae, and Heteropneustidae. Most of these species are food fishes, and *Ambassis*, *Puntius*, and *Gambusia*, are valued as ornamental and larvicidal fishes. The study concluded that fish diversity largely depends on biotic and abiotic factors, including nature of the ecosystem, the age of the water body, mean depth, water level fluctuations, morphometric features, and bottom characteristics. These factors have significant implications for the diversity of fish communities.

Basavaraja *et al.*, (2014) [1] studied the freshwater fish diversity, abundance, and richness of the Anjanapura Reservoir in Karnataka at three sampling sites and identified 25 fish species from 4 orders, 9 families, and 18 genera. The order Cypriniformes was the most dominant, with 14 species, followed by Siluriformes with 6 species, Perciformes with 4 species, and Osteoglossiformes with 1 species. The findings concluded that the reservoir supports a rich fish population, emphasizing the need for proper management, utilization, and effective conservation measures to preserve the aquatic biodiversity.

Shetty *et al.*, (2015) [17] conducted a study on fish assemblage and diversity in relation to water quality in three coastal rivers-Sita, Swarna, and Varahi located in Udupi District, Karnataka, India. The study collected 71 fish species, representing 7 orders, 20 families, and 41 genera, from 21 study sites along the three rivers. The Cypriniformes order was the most species rich, with the Cyprinidae family being the most abundant, followed by Bagridae (catfishes) and Balitoridae (loaches).

In terms of species richness across the rivers, Sita River recorded the highest with 64 species (7 orders, 18 families, and 38 genera), followed by Swarna River with 54 species (6 orders, 14 families, and 36 genera), and Varahi River with 52 species (5 orders, 14 families, and 33 genera).

Fatima *et al.*, (2015) [7] reported the presence of 11 fish species belonging to 4 orders from their investigation of various waterbeds in the Gulbarga District. The highest number of species was recorded under the order Cypriniformes, comprising eight species. The orders Mastacembeliformes, Osteoglossiformes, and Siluriformes were each represented by one species. The study highlights that environmental degradation significantly impacts on fish diversity. It recommends an urgent need for comprehensive surveys and diversity studies of fish fauna across various habitats. Additionally, industrialization and anthropogenic activities are identified as major contributors to the disturbance of the eco-physiology of aquatic ecosystems.

The study of Thirumala and Kiran (2017) [22] was aimed to assess fish diversity in Duglapura Lake, located in the Chikkamagaluru District of Karnataka. The findings revealed that the lake supports low fish diversity, with 12 species belonging to 4 orders, 6 families, and 11 genera. Among the families, Cyprinidae was the most dominant, constituting 58.33% of the assemblage, while the other families-Channidae, Cichlidae, Gobidae, Notopteridae, and Heteropneustidae, each accounted for 8.33%.

Naik and Kiran (2017) [13] investigated fish diversity and abundance in three lentic water bodies-Sogane Tank, Navule Tank, and Tunga Reservoir. The study documented 16 fish species from 5 orders, 8 families, and 11 genera in Sogane Tank; 13 species from 3 orders, 6 families, and 12 genera in Navule Tank; and 32 species from 6 orders, 11 families, and 18 genera in Tunga Reservoir. The Cyprinidae family was the most dominant among all water bodies. The study highlighted the diversity of fish species in the Sogane Tank and Tunga Reservoir, which included native species, cultivable and ornamental fish, and some rare species. Notably, some of the species were identified as naturally predatory. Fish diversity and abundance were particularly high in the Sogane Tank and Tunga Reservoir, with the greatest species richness observed in lowland areas. The study suggested that deep water bodies promote niche segregation, allowing fish to coexist with minimal intra- and inter-specific competition.

Shivaraju *et al.,* (2018) [18] documented ten fish species from two orders, three families, and nine genera in Durgada Halli Lake. The order Cypriniformes was dominant, accounting for 80% of the fish species with eight distinct species, while the order Perciformes represented 20% with two species. The study recorded both native and exotic fish species in the lake. The findings raised concerns about the impact of invasive species such as Grass Carp and Tilapia, which pose a significant threat to the diversity and abundance of native fish species. In particular, the introduction of exotic species like *Oreochromis* was identified as one of the greatest risks to the survival of native fish populations in the lake.

Nayaka (2018) [14] documented a total of 08 species of fishes belonging to 07 genera and 02 orders from Bugudana Halli Lake of Tumakuru and found the order Cypriniformes dominant among fishes and opined that the protection of the lake is mandatory for sustainable fisheries.

Muniya *et al.,* (2019) [12] investigated the fish diversity in the Kadana Reservoir, Gujarat, and documented 32 fish species under 6 orders, 13 families, and 22 genera. The Cypriniformes order exhibited the highest diversity with 12 species, followed by Siluriformes with 10 species, Perciformes with 6 species, Synbranchiformes with 2 species, and Osteoglossiformes and Beloniformes, each represented by one species. Among the families, Cyprinidae dominated with 12 species, while Bagridae included 4 species, and Siluridae and Channidae each had 3 species. Mastacembelidae was represented by 2 species, whereas Clariidae, Heteropneustidae, Schilbeidae, Cichlidae, Ambassidae, Gobidae, Belonidae, and Notopteridae were each represented by a single species. Conservation assessments revealed that one species is classified as vulnerable, with the majority (27 species) listed as least concern. The authors highlighted that the reservoir's significant size and depth create a suitable habitat, fostering high fish biodiversity. To sustain fish production and maintain ecological balance, they recommended minimizing human-induced disturbances and implementing conservation measures.

Shruthi and Ramakrishna (2020) [19] evaluated the ichthyofaunal diversity of the Boranakanive Reservoir in Tumakuru District, Karnataka, and identified a total of 13 fish species from ten genera, six families, and five orders. They concluded that the reservoir exhibited moderate ichthyofaunal diversity.

Kantharajan *et al.,* (2022) [10] recorded a total of 53 fish species, representing 11 orders, 16 families, and 36 genera in the Pranhita River. A higher number of species was observed during the non-monsoon season (52 species) compared to the monsoon season (24 species). Among the sampling sites, the orders Cypriniformes (24 species) and Siluriformes (14 species) were the most species rich in the river. Of the recorded species, six are listed under the threatened category, including one Endangered (EN) species, four Near Threatened (NT) species, and one Vulnerable (VU) species. Global population trends indicate that 13 species have stable populations, 14 have decreasing population, and one shows an increasing population trend. The study also highlights the presence of endemic species and their distribution along the river. The abundance of endemic species and the distribution of threatened species indicate the significant potential of River Pranhita for conserving fish genetic resources. This study emphasizes the Pranhita River should be considered a representative area for the conservation and protection of indigenous and endemic fish species.

Lalitha and Ramakrishna (2022) [11] investigated fish biodiversity in Kunigal Tank, Tumkur District, Karnataka, identifying 20 freshwater fish species belong to 15 genera, 8 families, and 6 orders. The order Cypriniformes was the most dominant, represented by 10 species, and followed by Perciformes and Channiformes with 3 species each, Siluriformes with 2 species, and Osteoglossiformes and Beloniformes with 1 species each. The study emphasized the need for proper management of the water body, effective utilization of fish resources, and sustainable measures to monitor and conserve fish fauna to maintain biodiversity.

Sincy *et al.,* (2022) [21] evaluated the water quality and documented the fish diversity in 36 lakes in the Bangalore region of Karnataka. The study recorded 18 fish species across 4 orders, 7 families, and 14 genera, with Cypriniformes emerging as the dominant order, constituting 41% of the ichthyofaunal population. This was followed by Perciformes (33%), Cyprinodontiformes (15%), and Siluriformes (11%). The decline in fish diversity in these lakes was attributed to various factors, including water pollution, habitat degradation, overfishing, the invasion of exotic species, and climate change. Notably, the introduction of exotic species has significantly reduced the abundance of native species. Moreover, Bangalore’s lakes are heavily polluted due to the continuous discharge of raw sewage and partially treated wastewater.

Das *et al.*, (2023) [2] recorded 190 fish species, 133 genera, 62 families, and 23 orders, from the entire stretch of the River Ganga in their study. Family Cyprinidae was most well represented with carps and minnows in all the sites. Out of the 62 families, Cyprinidae was found to be the most species rich with 28 species. The order cypriniformes contributing to 29% of the total fish species followed by Siluriformes with 22%.

Dwivedi and De (2024) [6] reported a total of 114 fish species under 66 genera from 59 sites along the Bhima River basin. Osteobrama cotio from 40 sites, Labeo rohita and Labeo calbasu were found from 36 and 35 sites, Parapsilorhynchus tentaculatus from 3 sites making it the least common species across the sites. The results concluded that the construction of dams and exhaustive irrigation development along the Bhima River has resulted in significant hydrologic changes, contributing to both periodic and prolonged water shortages in the river basin, and subsequently adversely impacting the native fish diversity. The findings also indicated that environmental conditions play an important role in shaping the ecological distinctiveness of fish assemblages.

Conclusion
Freshwater fish biodiversity plays a very crucial role in maintaining ecological balance and supporting human welfare. This review highlights the richness and abundance of freshwater fish species across various fresh water aquatic ecosystems in India. But, threats such as habitat destruction, pollution, overfishing, and climate change have severe impact on biodiversity. For the long-term sustainability of freshwater fish diversity, there is an urgent need for comprehensive conservation strategies, habitat restoration efforts, and implementation of environmental policies. Continuous monitoring and research on fish diversity are essential to combat emerging challenges and very much essential in preserving freshwater fish biodiversity for the future generations.

Conflict of Interest
The author has no conflict of interest.

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