DOI: https://doi.org/10.36094/sc.v91.2025.A_Current_Status_and_Conservation_of_Freshwater.Wodeyar_K.400

ARTICLE

Sci. and Cult. 91 (7–8) : 400-404 (2025)

A CURRENT STATUS AND CONSERVATION OF FRESH WATER FISH DIVERSITY IN THE MIDDLE AND LOWER STRETCHES OF GANGA RIVER

ABHILASH WODEYAR K., ARCHISMAN RAY, BASANTA KUMAR DAS*, DEEPENDRA SINGH, DIBAKAR BHAKTA AND CANCIYAL JOHNSON

The present study evaluated the freshwater fish diversity across 13 stations in the middle and lower stretches of the Ganga River, recording 141 species from 99 genera. The middle stretch showed higher species richness, while the lower stretch exhibited greater diversity and evenness. NMDS analysis revealed distinct assemblages between stretches. Dominance of exotic species and decline of native taxa highlight ecological degradation. Conservation strategies such as habitat restoration, fish passages, and sustainable fisheries are essential to safeguard the Ganga's biodiversity and sustain the livelihoods of riparian communities.

Introduction

India's inland water resources span approximately 29,000 km of riverine ecosystems, supporting remarkable fish diversity and significant production potential. These river systems are broadly classified into five major groups: the Ganga, Brahmaputra, and Indus in the north, and the east and west coast river systems of peninsular India [1]. Indian rivers are among the world's richest reserves of freshwater fish biodiversity, playing a vital role in ensuring food and nutritional security, particularly for rural and economically disadvantaged communities[2]. The Ganga River, considered the most sacred river in India, originates from the Gangotri Glacier and flows through Uttarakhand, Uttar Pradesh, Bihar, and West Bengal before discharging into the Bay of Bengal. It supports a diverse and dynamic ecosystem with an abundance of fish species[3]. Freshwater fishes are of considerable value, contributing to income generation, nutrition, recreational fishing, and ornamental trade. Inland fisheries play a pivotal role in global food security and the sustenance of millions who depend on freshwater environments for their livelihoods. Riverine fisheries provide nutritional benefits and contribute significantly to local economies. The Ganga, one of Asia's largest and most productive river systems, has long sustained vibrant riparian communities and thriving fisheries. However, this system is increasingly threatened by various anthropogenic stressors, including unchecked pollution, climate change, flow regulation, habitat fragmentation, and the proliferation of invasive species [4, 5]. These stressors have collectively contributed to the deterioration of aquatic habitats and a noticeable decline in fish diversity and fishery yields. Given that the Ganga River serves as a critical lifeline for millions of fisherfolk who depend on it for their sustenance, the degradation of its aquatic resources has raised serious ecological and socio-economic concerns. Environmental perturbations have disrupted the river's ecological balance and significantly impacted its fisheries. Therefore, a comprehensive assessment of the current status of freshwater fish diversity and fisheries in the Ganga is urgently required. Such an evaluation is fundamental for guiding effective restoration efforts, developing conservation strategies, and ensuring the long-term sustainability of this vital riverine ecosystem.

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal

* Corresponding author: basantakumard@gmail.com

Methodology

The study was conducted across 13 stations along the middle and lower stretches of the Ganga River. The middle stretch included Bijnor, Narora, Farrukhabad, Kanpur, Prayagraj, and Varanasi, while the lower stretch comprised Buxar, Patna, Bhagalpur, Farakka, Berhampore, Balagarh, and Tribeni (Fig. 1). These sites span the states of Uttar Pradesh, Bihar, and West Bengal, covering diverse ecological conditions from freshwater-dominated upstream areas to downstream zones influenced by estuarine and tidal effects. A quarterly survey of fish assemblages was conducted from 2016 to 2023 across the sampling stations. Experimental fishing was carried out using various types of fishing gear to maximise species representation, including cast nets, dragnets, and other traditional indigenous nets. Diversity analysis and non-metric multidimensional scaling (NMDS) were performed using the vegan package[6] in R, while bar plots were generated using the ggplot2 package[7].

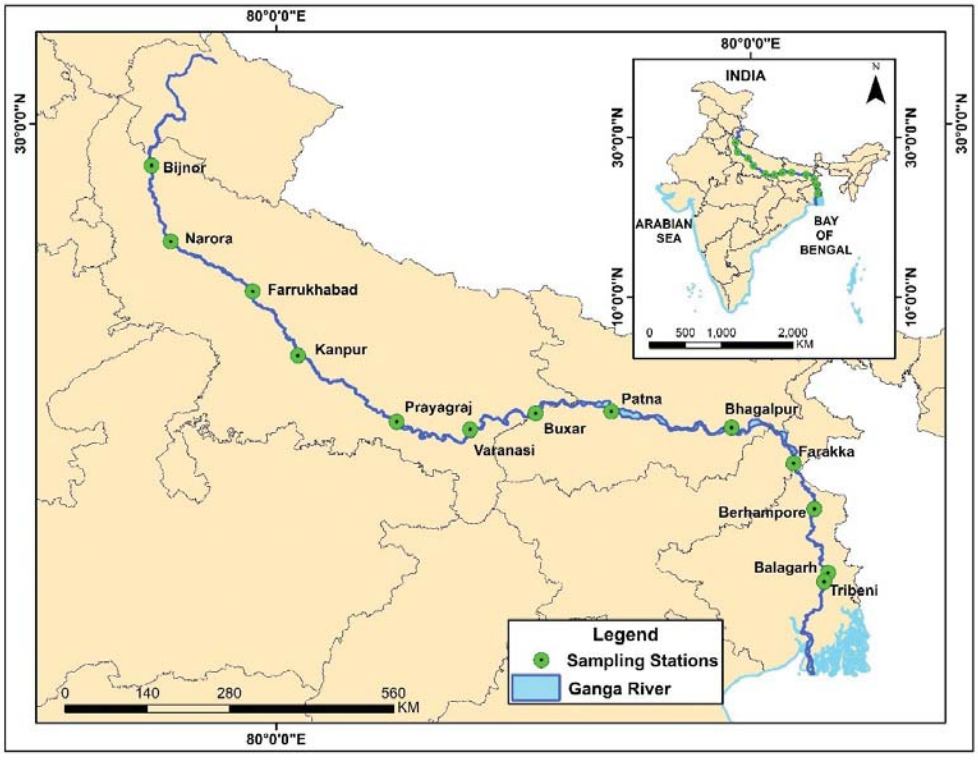

Fig. 1: Study area map of the Ganga River showing the 13 sampling stations

Results and Discussion

A total of 141 freshwater fish species, representing 99 genera and 44 families, were recorded across the 13 sampling stations along the middle and lower stretches of the Ganga River. The middle stretch (six stations) exhibited higher species richness (63–106 species) compared to the lower stretch (seven stations), with Bijnor (106 species), Narora (94 species), and Buxar (88 species) being the most diverse, while Tribeni (63 species) had the lowest richness. This difference in species numbers matches earlier research [8,9] that showed how different habitats, water quality, and human activities affect where species are found along the river. Hamilton[10] documented 272 species in the Ganga, while Sinha and Khan [8] reported 260 species. Sarkar [9], and Das [11], both recorded 143 species, suggesting a decline, particularly in the middle stretch. The present study recorded 141 species, which aligns with the previous studies indicating biodiversity loss due to dams, pollution, and invasive species. The bubble plot depicts the number of species recorded in the middle and lower stretches of the river Ganga (Fig. 2). The spatial variation in diversity indices was depicted in a bar plot (Fig. 3). The overall fish assemblage was dominated by family Danionidae (26.51%), Cyprinidae (20.72%), and Cichlidae (11.68%), consistent with earlier reports [11]. However, family dominance varied

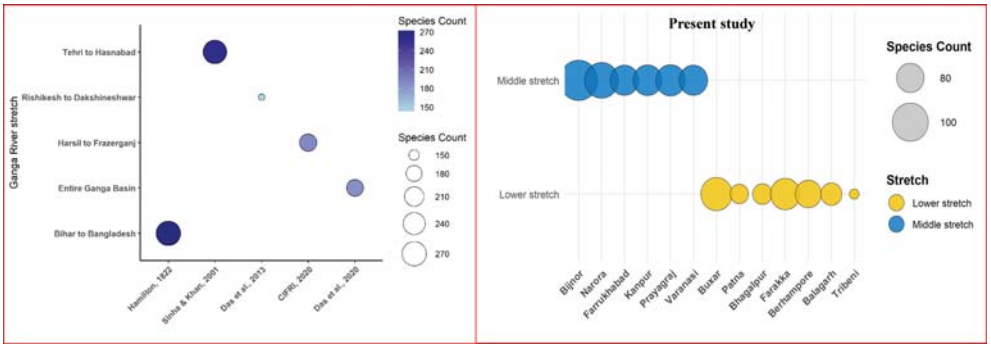

Fig. 2. Comparison of species richness recorded by previous studies in different stretches of the Ganga River

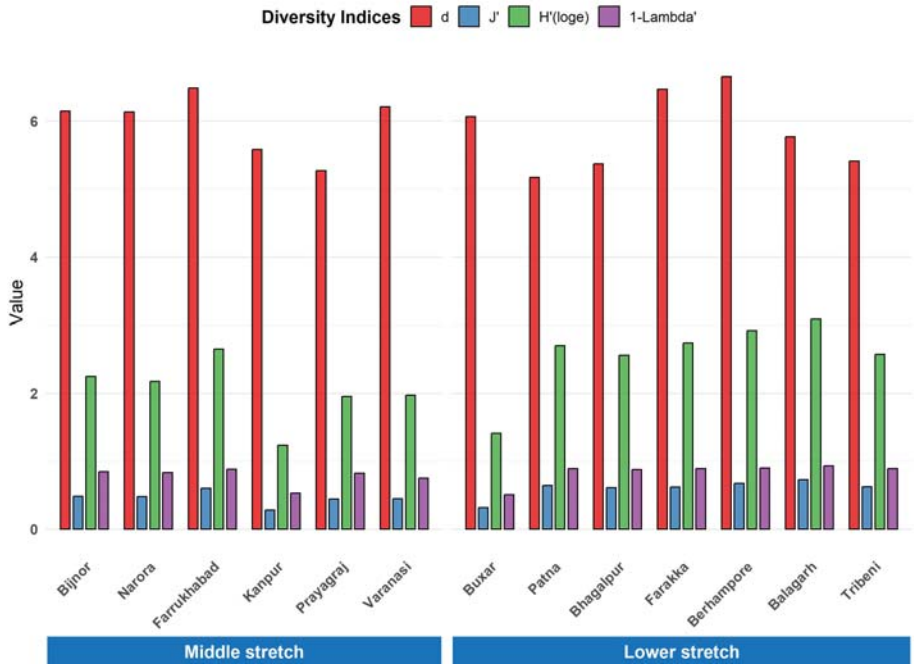

Fig. 3. Spatial variation of diversity indices across sampling stations in the Ganga River, showing (a) species richness, (b) Shannon diversity, (c) Pielou's evenness, and (d) Simpson's index values

spatially: Danionidae dominated at Bijnor (66.27%) and Narora (79.65%), while Cichlidae prevailed in Kanpur (66.4%) and Varanasi (45.94%). This shift suggests increasing pollution or habitat alteration that favours invasive or tolerant species. Cyprinidae dominated at Buxar (71.97%), while Ailiidae and Sciaenidae became prominent in Patna, Bhagalpur, and Farakka. Gobiidae dominated at Balagarh (27.76%) and Tribeni (40.02%), indicating brackish water intrusion. Table 1 presents the relative abundance of fish families recorded across sampling stations in the Ganga River.

Margalef's richness index was highest at Berhampore (6.65) and Farakka (6.47), indicating diverse fish assemblages, possibly due to favourable ecological conditions or reduced anthropogenic stress. In contrast, Shannon-Weiner diversity was lowest at Kanpur (1.2) and highest at Balagarh (3.08), reflecting degraded habitat conditions in the middle stretch and more stable ecosystems downstream. Pielou's evenness followed a similar trend, with Kanpur (0.28) showing low evenness, likely due to dominance by a few species (e.g., Cichlidae at 66.4%), while Balagarh (0.73) exhibited a balanced community. Simpson's index further supported this, with the highest value at Balagarh (0.93), indicating high diversity and stability. Non-metric multidimensional scaling (NMDS) showed a clear difference between the middle and lower stretch stations (stress = 0.07), with middle stretch sites (Bijnor-Varanasi) grouped on one side and lower stretch sites (Buxar–Tribeni) on the other side (Fig. 4). This distinction reflects differing ecological conditions, such as salinity gradients, sediment load, and anthropogenic impacts (e.g., dams, pollution). Similar findings were reported by Sarkar [9], who noted shifts in fish communities due to hydrological modifications. Most species (77.22%) were classified as Least Concern (LC), but 9.4% were Not Evaluated (NE), and 5.56% were Near Threatened (NT). Endangered (1.11%) and Vulnerable (1.67%) species were rare, mirroring historical declines in key taxa like Indian major carps (IMC) and *Tenualosa ilisha*[11]. The increasing dominance of exotic species, such as *Cyprinus carpio* and *Oreochromis niloticus*, underscores significant ecological degradation within the river system, as they contribute approximately 38–41% to

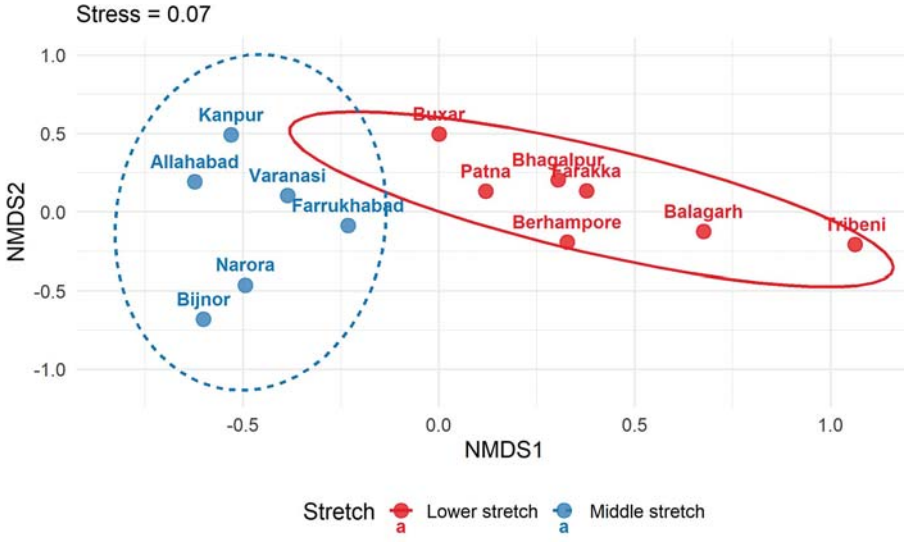

Fig. 4. Non-metric multidimensional scaling (NMDS) ordination of fish assemblage structure across sampling stations in the Ganga River

Table 1. Presents the relative abundance (%) of fish families recorded across sampling stations in the Ganga River

Middle stretch	Lower stretch												
Family	Bijnor	Narora	Farru-khabad	Kan-pur	Allaha-bad	Vara-nasi	Buxar	Patna	Bhagal-pur	Fara-kka	Berham-pore	Bala garh	Tri-beni
Ailiidae	+	+	+	+	+	+	+	++	++	++	+	++	+
Ambassidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Amlyceptidae	+	+	-	-	-	-	+	+	+	+	-	-	-
Anabantidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Anguliidae	+	-	-	-	-	-	+	-	-	-	+	-	-
Aplochelidae	-	-	-	-	-	-	+	-	-	-	+	-	+
Badidae	+	+	-	-	-	-	-	-	-	-	+	+	+
Bagridae	+	+	+	+	+	+	+	+	+	+	+	+	+
Belonidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Botiidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Chacidae	+	-	-	-	-	-	-	-	-	-	+	-	+
Channidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Cichlidae	+	+	+	+++	++	++	++	-	-	-	-	-	-
Clariidae	+	+	+	+	+	+	+	-	-	-	-	-	-
Clupeidae	+	+	++	+	++	+	+	++	++	++	+	++	++
Cobitidae	+	+	-	+	+	+	+	+	+	+	+	+	+
Cynoglossidae	-	-	-	-	-	-	-	-	-	-	-	-	+
Cyprinidae	++	+	++	++	++	++	+++	++	+	++	+++	++	+
Danionidae	+++	+++	+++	+	++	++	+	++	++	++	++	+	+
Eleotridae	-	-	-	-	-	-	-	-	-	-	-	+	+
Engraulidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Gobiidae	+	+	+	+	+	+	+	+	+	+	+	++	++
Hemiramphidae	-	-	-	-	-	-	+	+	+	+	+	-	-
Heteropneustidae	++	+	+	+	+	+	+	+	+	+	+	+	+
Horabagridae	-	-	-	-	-	-	+	+	+	+	+	+	+
Latidae	-	-	-	-	-	-	-	-	-	-	-	-	+
Loriicaridae	-	-	-	-	-	-	-	-	-	+	-	+	-
Mastacembelidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Mugilidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Nandidae	+	+	+	+	+	+	+	+	+	+	+	+	+
Nemachaelidae	+	+	-	-	-	-	+	+	+	+	+	+	-
Notopteridae	+	+	+	+	+	+	+	+	+	+	+	+	+
Ophicthidae	+	-	-	-	-	-	+	+	-	+	+	+	++
Ospronemidae	+	+	+	+	+	+	+	+	+	+	+	+	-
Platycephalidae	-	-	-	-	-	-	-	-	-	-	-	-	+
Pristigasteridae	-	-	-	-	-	-	-	-	-	-	-	-	+
Sciaenidae	+	+	+	+	+	+	+	+	++	++	+	+	+
Siluridae	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 1. conted...

Sisoridae	+	+	+	+	+	+	+	+	+	+	+	+	+
Soleidae	-	-	-	-	-	-	-	-	-	-	-	-	+
Syngnathidae	-	-	-	-	-	-	-	-	-	-	-	+	+
Tetraodontidae	-	-	-	-	-	-	+	+	+	+	+	+	+
Xenocyprididae	+	+	+	+	+	+	+	-	-	-	-	-	-

Abundance symbols: + (<10%), ++ (10-50%), +++ (>50%)

the total fish abundance in the present study. This trend aligns with earlier observations by Singh and Johal (2009) in the Prayagraj stretch of the Ganga River.

Conclusion

Freshwater fishes currently face one of the highest extinction risks among vertebrate groups. In India, ichthyofaunal diversity demonstrates distinct spatial patterns; the middle stretch shows greater species richness, while the lower reaches exhibit higher diversity and evenness. This gradient is reflected in shifting family dominance from Danionidae and Cyprinidae upstream to Ailiidae, Sciaenidae, and Gobiidae downstream. The Ganga River system faces compounding threats including habitat fragmentation, invasive species proliferation, hydrological alterations, and pollution exacerbated by climate change and unsustainable fishing practices that have led to declining catches. Critical interventions should include the establishment of protected breeding refuges with constructed fish passages to maintain migratory routes, the implementation of scientifically monitored river ranching and ex situ breeding programs for genetic conservation, and comprehensive ecosystem impact assessments prior to any hydrological developments. Particularly crucial is restoring the river's longitudinal and lateral connectivity, especially with floodplain wetlands that serve as essential nurseries and feeding grounds. The holistic measures would not only preserve the Ganga's unique fish diversity but also enhance overall aquatic community structure and resilience.

Acknowledgment

The authors express their sincere gratitude to the National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India, for generously funding the experiments conducted in this study. They also extend their thanks to the ICAR-Central Inland Fisheries Research Institute for offering comprehensive research support and facilities. ❐

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