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ARTICLE

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INVASIVE FISH SPECIES IN THE GANGA RIVER: UNSEEN THREATS TO BIODIVERSITY

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The river Ganga, home to 190 fish species, is increasingly threatened by eight exotic fish species. Surveys at 20 stations reveal low invasion in upper stretches (0.37% at Bijnor) and high levels in middle and lower sections, peaking at Buxar (25.66%). Common carp (52.44%) and Nile tilapia (40.37%) dominate, making up 90% of exotics. Omnivorous invaders (62.5%) disrupt native food webs, impacting major carps and hilsa. The study highlights the need for stricter aquaculture regulation and habitat restoration to conserve biodiversity and fisheries.

Introduction

The River Ganga stands as one of the world's most significant freshwater ecosystems, renowned for its rich biodiversity and cultural importance. It supports a diverse assemblage of native fish species, with over 140 documented by Sarkar[1], including iconic species like *Tor putitora* and *Tenualosa ilisha*. More recently, Das[2] reported a total of 190 fish species in the river, underscoring its ecological richness and conservation value. However, this fragile ecological balance is increasingly threatened by the proliferation of invasive fish species growing and urgent concern.

Globally, aquatic ecosystems face unprecedented threats from habitat destruction, pollution, and species invasions [3]. The Ganga is no exception, with the introduction of exotic species emerging as a critical concern. In India, more than 300 exotic fish species have been introduced since the mid-20th century for various purposes, including aquaculture and mosquito control [4]. Notable among these are the African catfish (*Clarias gariepinus*) and tilapia (*Oreochromis niloticus*), which are fundamentally altering the river's ecological dynamics through competition, predation, and habitat modification. The ecological consequences of these introductions are both profound and multifaceted. Invasive fishes compete with native species for limited resources, introduce novel diseases, and often dominate trophic structures, leading to the decline of indigenous populations [5]. Beyond ecological implications, these changes jeopardize food security and economic stability for communities that depend on the river's resources[6]. Despite these threats, comprehensive assessments of invasive fish distribution and their ecological impacts in the Ganga remain lacking.

This study addresses these critical knowledge gaps by documenting the current status of invasive fish species throughout the Ganga basin, evaluating their ecological impacts on native fish communities and ecosystem functioning, and identifying priority areas for conservation intervention. The findings provide essential baseline data for developing science-based management strategies to protect the Ganga's unique biodiversity while addressing the socioeconomic realities of communities dependent on its resources. The results also underscore the pressing need for policy interventions to prevent further biological invasions and mitigate the existing impacts on this vital river ecosystem.

Materials and Methods

Study Area: The Ganga River stretches across northern India from west to east, spanning approximately

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2,525 kilometres. Geographically, it extends between longitudes 77°58'47.44" E to 88°30'37.89" E and latitudes 22°18'6.43" N to 31°2'49.31" N. This study focuses fish diversity and abundance observed at nineteen strategically selected sampling stations distributed along the river's course. The stations were categorized into four specific river segments: the top segment (Harshil to Haridwar), the middle segment (Bijnor to Varanasi), the lower segment (Buxar to Tribeni), and the estuarine segment (Godakhali to Fraserganj), as seen in Fig.1. Twelve locations, namely Harshil, Tehri, Haridwar, Bijnor, Narora, Farrukhabad, Kanpur, Prayagraj, Varanasi, Buxar, Farakka, and Balagarh, documented the occurrence of invasive fish species.

Sampling Methodology: Fish sampling in the River Ganga was conducted seasonally between 2021 and 2024 at selected stations along its course. Various locally available fishing gears with different mesh sizes were employed, including dragnets (1.0 mm), gill nets (10–40 mm), and cast nets (10–20 mm). To ensure standardized sampling and facilitate comparison across all locations, experimental fishing was conducted at each site using gill nets with mesh sizes ranging from 10 to 40 mm. Abundance indices were standardized using catch per unit effort (CPUE), calculated from standardized gill net deployments only, expressed as number of individuals per net per hour. This allowed for consistent comparison across gear types and stations. Fresh fish specimens were kept in ice as soon as they were captured and brought to the lab for taxonomic identification. Identification was performed up to the species level using standard taxonomic keys by Talwar and Jhingran [7], Jayaram [8], and Nelson [9]. The scientific names and taxonomic classification of fish species were further validated using the database of Eschmeyer [10] and FishBase [11].

Analysis of Biological Indices

a. Relative Abundance (RA)

$$RA = \frac{N}{S}$$

N represents the total number of individuals of a species, while S denotes the total number of fish.

b. Distribution Index (D)

$$D = \frac{Ni \cdot st}{N \cdot st} \times 100\%$$

Where, Ni. st = total number of locations where fish were found, N.st = total sampling sites

c. Abundance Index (AI)

$$AI = \frac{n(k) \times 100}{N}$$

Let n(k) represent the quantity of exotic fish captured at each research location, while N denotes the total number of fish species captured at that location.

d. Analysis of Trophic Niche

Various exotic fish species are classified into functional guilds based on their feeding habits (Karr[12]; OPEA,[13]. The feeding guilds include planktivores (PL), omnivores (OV), and herbivores (HR). Furthermore, the exotic species were divided into two broad groups according to their spatial orientation in the aquatic habitat: pelagic (P) and benthic (B), as described by Jhingran[14].

Result and Discussion

Status and Trends of Freshwater and Exotic Fishes in the River Ganga: **Native Fish Diversity and Threat Status:** The River Ganga, a vital lifeline for India's aquatic biodiversity, supports diverse freshwater fish species. Recent studies have documented 190 species, including 182 native and 8 exotic species. The family Cyprinidae is the most dominant, followed by Danionidae and Bagridae, reflecting the river's ecological richness and complexity. However, there has been a significant decline in several commercially important species, such as major carps (*Labeo rohita*, *Catla catla*) and large catfishes (*Sperata seenghala*, *Wallago attu*) attributed to overfishing, habitat degradation, and pollution. In contrast, small indigenous fishes (*Cabdio morar*, *Puntius sophore*) and invasive species like common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) are increasingly dominating catches. Conservation assessments based on IUCN criteria reveal that nearly 70% of freshwater fish species in India are threatened, highlighting an urgent need for their protection [15]. Further compounding the issue are hydrological alterations, dams, constructions and pollution, which have exacerbated the decline of migratory species like the Hilsa (*Tenualosa ilisha*) and Golden Mahseer (*Tor putitora*). Sustainable management, habitat restoration, and strict regulations on invasive species are critical to preserving the Ganga's fragile fish biodiversity.

Abundance of Exotic Fish Species: This study highlights a concerning rise in the abundance and spatial distribution of non-native fish species in the River Ganga, especially in its middle and lower sections. The abundance index of non-native fish species, evaluated across various sampling locations, indicated significant geographical

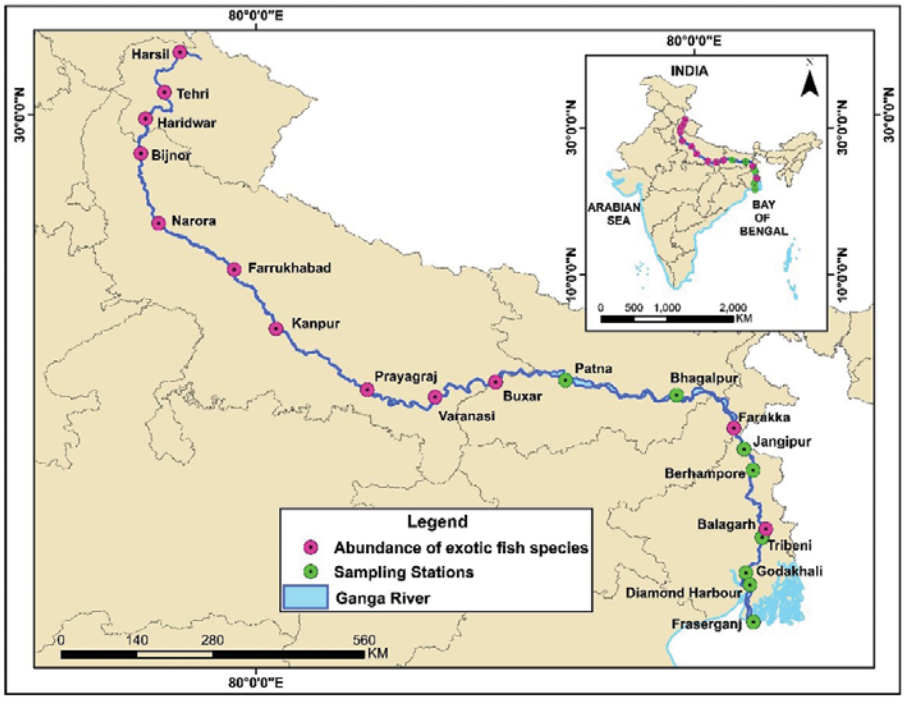

Fig. 1: Study Area and Sampling Sites for Exotic Fish Distribution in the River Ganga

variance (Fig. 2), ranging from a low of 0.37% in Bijnor to a high of 25.66% in Buxar. Upper stretch stations such as Harshil (0.62%), Bijnor (0.37%), and Narora (0.71%) exhibited markedly lower exotic fish abundance relative to middle and lower stretch sites. In contrast, the central Ganga region, including Kanpur (20.01%), Varanasi (19.38%), and Prayagraj (15.72%), demonstrated substantially higher proportions of alien species,

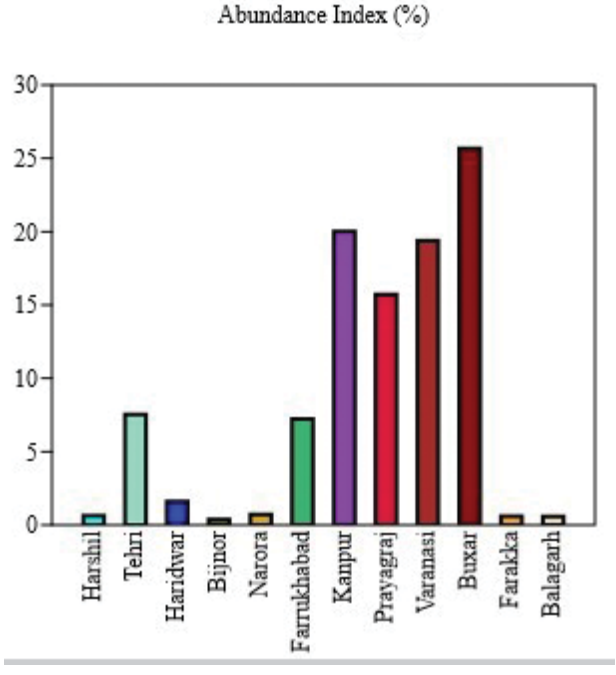

Fig. 2: Abundance index (AI%) of exotic fish species at different stations.

suggesting either ecological disruptions or favourable conditions for the proliferation of invasive taxa. The highest abundance index was recorded at Buxar (25.66%), indicating its potential role as a hotspot for invasive species establishment. These findings are aligned with earlier studies by Sarkar [1], who emphasized that upstream regions are generally less susceptible to biological invasions due to lower anthropogenic activity and environmental constraints. In contrast, middle and lower stretches, with higher pollution and aquaculture activity, provide more suitable environments for the spread and establishment of exotics.

Composition and Relative Abundance of Exotic Species: Eight alien fish species were documented in the River Ganga, with *Cyprinus carpio* var. *communis* constituting 52.44% of the exotic fish population and *Oreochromis niloticus* comprising 40.37% (Fig. 3). Together, these two species made up nearly 90% of the total alien fish population, indicating robust establishment in the river's ecology. Moderate relative abundance was observed for *Ctenopharyngodon idella* (2.51%) and *Cyprinus carpio* var. *specularis* (2.42%). Other species like *Pterygoplichthys disjunctivus*, *Hypophthalmichthys molitrix*, *H. nobilis*, and *Clarias gariepinus* were found in minimal quantities, each accounting for less than 1.1% to the exotic fish community. The predominance of *Cyprinus carpio* var. *communis* and *Oreochromis niloticus* is consistent with observations by Lakra [16], who classified these species as high-risk invaders

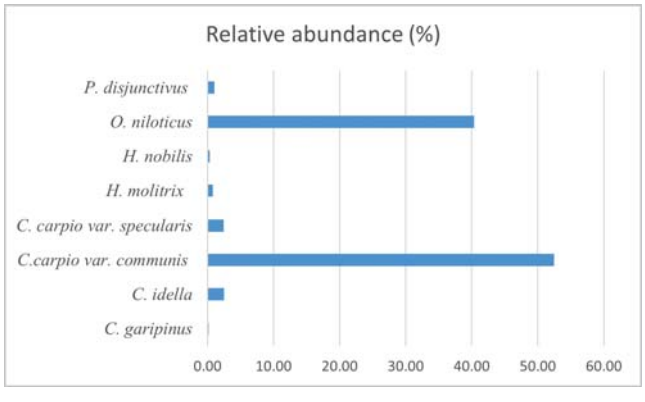

Fig. 3: Relative abundance of exotic fish species of the River Ganga.

due to their strong ecological adaptability, rapid reproduction and invasive potential. These species, widely introduced for aquaculture, pose threats to native biodiversity through competition, hybridization, potential hybridization with native taxa and habitat alteration.

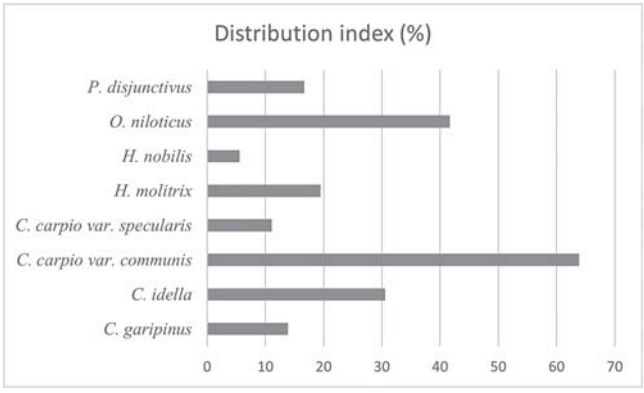

Fig. 4: Distribution index of exotic fish species of the River Ganga

Distribution Pattern of Exotic Fish: The distribution index of exotic species showed significant heterogeneity among sampling sites (Fig. 4). *Cyprinus carpio* var. *communis* exhibited the widest distribution, being recorded at 63.89% of the surveyed sites, followed by *Oreochromis niloticus* (41.67%) and *Ctenopharyngodon idella* (30.56%). Moderate distribution was observed for *Hypophthalmichthys molitrix* (19.44%) and *Pterygoplichthys disjunctivus* (16.67%). In contrast, *Clarias gariepinus* and *Cyprinus carpio* var. *specularis* had limited distribution indices of 13.89% and 11.11%, respectively. *Hypophthalmichthys nobilis* exhibited the lowest distribution, occurring at only 5.56% of the sites. These findings are mirror reports by Singh and Lakra [17], who highlighted the increasing presence of unauthorized introductions and their expanding footprint in Indian inland waters. The presence of *Hypophthalmichthys* spp., recorded in low relative abundance, also reflects potential future threats to planktonic communities and the overall trophic balance of the river ecosystem, as highlighted by Jena[18].

Habitat Orientation and Trophic Indices: The investigation of trophic niches among exotic fish species revealed that five were omnivorous, two planktivorous and one was herbivorous. Habitat orientation data (Table 1) indicated a predominance of pelagic exotic species, followed by benthic forms in the River Ganga. These ecological traits, broad dietary adaptability and flexible habitat use contribute significantly to the success of exotic species in the River Ganga and enhance their competitive advantage over native fauna.

Conclusion

The Ganga River is facing a major ecological crisis as invasive fish species, particularly common carp (52.4%) and Nile tilapia (40.4%), dominate catches in its middle and lower sections. These species are associated with reductions in indigenous fish populations, such as major carps and hilsa. Buxar, Kanpur, and Varanasi, identified as hotspots for invasion, exhibit a significant abundance of exotic species, primarily due to habitat loss and pollution. The prevalence of omnivorous invaders (62.5%) further indicates a disruption in the food web. Immediate actions encompass stringent aquaculture controls, focused habitat restoration, and comprehensive monitoring. This study underscores the urgent need for policy reform and

Table 1: List of freshwater exotic fish species sampled in the river Ganga

Sr. No.	Species	Date of Introduction	Home Country	Purpose	Invasive Status	Habitat	Trophic Guild
1	*Ctenopharyngodon idella*	1957	Japan	Culture	I	P	HR
2	*Hypophthalmichthys nobilis*	1980's	China	Aquaculture: control of plankton populations	NA	P	PL
3	*Hypophthalmichthys molitrix*	1959	Hong Kong	Experimental culture	I	P	PL
4	*Cyprinus carpio var. communis*	1939	Sri Lanka	Experimental culture	I	P	OM
5	*Cyprinus carpio var. specularis*	1939	Sri Lanka	Experimental culture	I	P	OM
6	*Oreochromis niloticus*	Unauthorized introduction	Africa (Nile Basin)	Aquaculture (Unauthorised introduction common)	I	P	OM
7	*Pterygoplicthys disjunctivus*	1990s (unofficial)	South America	Aquarium trade (later escaped)	I	B	OM
8	*Clarias garipinus*	Unauthorized introduction	Africa	Aquaculture (Unauthorised introduction common)	I	B	OM

Source: Sarkar[1]; Sandilyan[19]. ***I*** invasion, ***NA*** not assessed, ***P*** pelagic, ***B*** benthic, ***PL*** planktivore, ***OM*** omnivore

community engagement to protect biodiversity and ensure the sustainability of fisheries in the Ganga River.

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References

1. U.K. Sarkar, V.K Dubey, A.K. Singh, B.K. Gupta, A. Pandey, R.K. Sani and W.S. Lakra, *The Environmentalist,* **32**, pp.476-484 (2012).
2. B.K. Das, A. Ray, C. Johnson, S.K. Verma, A. Alam, R. Baitha, R.K. Manna, S. Roy, and U.K. Sarkar, *Acta Ecologica Sinica,* **43**(2), pp.307-332 (2023).
3. P.B. Moyle and P.R. Moyle, *Environ Biol. Fish*, **43**:29-37 (1995).
4. A. Biju Kumar, *Zoos' Print J.,***15**:363-367 (2000).
5. E. García-Berthou, *J. Fish Biol.,* **71**:33–55 (2007).
6. D.P. Philipp, J.M. Epifanio, J.E. Mardsen, J.E. Claussen, Proceedings of the World Fisheries Congress, Theme 3, Oxford and IBH Publ. Co., New Delhi (1995).
7. P.K. Talwar, A.G. Jhingran, Inland Fishes of India and Adjacent Countries, Oxford and IBH Publishing Co, New Delhi (1991).
8. K.C. Jayaram, The Freshwater Fishes of The Indian Region, Narendra Publ. House, New Delhi, p 551 (1999).
9. J.S. Nelson, T.C. Grande and M.V. Wilson, *Fishes of the World*, John Wiley & Sons (2016).
10. W. Eschmeyer, R. Fricke and R. Van der Laan, *Catalog of Fishes: Genera, Species, References*, California Academy of Sciences, California, (2023).
11. R. Froese, D. Pauly, FishBase. Available: https://www.fishbase.se/search.php. Accessed 13 Nov 2024.
12. J.R. Karr, D. Fausch, P.L. Angermeier, P.R. Yant, I.J. Schlosser, Illinois Natural History Survey Special Publication 5, Urbana (1986).
13. OPEA, *Biological Criteria for the Protection of Aquatic Life*, Vol. III, Ecological Assessment Section, Division Water Quality, Planning and Assessment, State of Ohio, Environmental Assessment Agency, (1987).
14. A.G. Jhingran, *Fish and Fisheries of India*, 2nd edn., Hindustan Publ. Corp., Delhi, (1997).
15. E. Somanathan, Oxford Companion to Economics in India (Ed. Kaushik Basu). Oxford University Press, pp. 32-35 (2007).
16. W.S. Lakra, U.K. Sarkar, A. Gopalakrishnan, A.K. Pandian, Threatened Freshwater Fishes of India, NBFGR Publication, Lucknow (2010).
17. A.K. Singh, and W.S. Lakra, *Aquacult. Asia,* **16**, 23–25 (2011).
18. J.K. Jena, S. Ayyappan, P.K. Aravindakshan, B.C. Mohapatra, P. Jayasankar and S. Chandra, *J. Inland Fish. Soc. India*, **40**(1), 1–19, (2008)
19. S. Sandilyan, *Wetl. Ecol. Manag.,* **30**(2), 423–437, (2022).