

# 1 **Freshwater fish diversity in and around Vadodara district: A focus on** 2 **small indigenous species.**

3

## 4 **Abstract**

5 The present investigation aimed to document fish diversity in freshwater ecosystems located  
6 in and around the Vadodara region, based on surveys conducted from October 2020 to the  
7 June 2023. The study specifically examines Ichthyofaunal composition in freshwater lakes  
8 and reports a total of 31 fish species distributed across 10 orders, 16 families, and 29 genera.  
9 The assemblage was dominated by members of the family Cyprinidae, contributing the  
10 highest number of species, followed by Ambassidae, while several other families such as  
11 Xenocyprididae, Bagridae, Siluridae, and Cichlidae showed moderate representation, and the  
12 remaining families were represented by single species. Conservation assessment based on  
13 IUCN categories revealed that most species fall under the Least Concern category, with a  
14 smaller proportion classified as Near Threatened and Vulnerable, along with one Data  
15 Deficient species and a few yet to be evaluated. This study provides the first consolidated  
16 account of freshwater fish diversity in the Vadodara region and underscores the ecological  
17 and socio-economic importance of small indigenous fish species. These findings contribute  
18 valuable baseline information for biodiversity conservation, sustainable fisheries  
19 management, aquaculture development, and enhancement of nutritional security and  
20 livelihood opportunities for local communities.

21 **Keywords:** Cyprinidae, Ichthyofaunal diversity, Small Indigenous Fish species (SIF)

## 22 **Introduction**

23 India has been identified as a significant region of freshwater fish biodiversity with high  
24 levels of endemism, which contribute significantly to global biodiversity. The study of fish  
25 communities is vital for efficient management of ecosystems and rational utilization of these  
26 resources (Mogalekar *et al.*, 2017; Sarma *et al.*, 2017). Freshwater bodies, especially lakes,  
27 harbor rich fish communities, which are vital for inland fisheries as well as local economies.  
28 Efficient management of these resources depends on a proper understanding of species  
29 composition, distribution, and availability (Goswami and Mankodi, 2010). Fish act as  
30 efficient bio-indicators of environmental health, besides serving as a vital source of protein,

31 micronutrients, and livelihood support for rural communities (Niraj, 2012; Bera *et al.*, 2014;  
32 Delgado, 2003). India, identified as a megadiverse country (Nelson *et al.*, 2016), harbors over  
33 3,231 species of fish, with 800 species of freshwater fishes (Froese and Pauly, 2022; Gopi  
34 and Mishra, 2015; Bhattacharya *et al.*, 2020). Researchers have studied Ichthyofaunal  
35 diversity in numerous bodies of water around the nation (Jinghran *et al.*, 1969; Rema Devi,  
36 1996; Jayaram, 1999; Vijayalaxmi *et al.*, 2010; Murugan and Prabakaran, 2012;  
37 Silambarasan and Senthilkumaar, 2014).

38 Gujarat is situated on the western coast of India. The state is rich in fishery resources;  
39 however, the scientific study on the diversity of freshwater fish is still in the early stages due  
40 to the focus on marine fishery resources and lack of scientific information (Sharma *et al.*,  
41 2016; Sarma *et al.*, 2017). The information on the number of fish species is variable due to  
42 the complexity of the subject and lack of scientific information on the subject (Hoagland,  
43 1996). Previous studies on the subject have reported varying degrees of freshwater fish  
44 diversity in Gujarat state (Sen and Banerjee, 2000; Devi and Indra, 2012; Dholakia, 2004;  
45 Goswami and Mankodi, 2010; Gohil and Mankodi, 2010; Banyal *et al.*, 2019). Small  
46 Indigenous Fish species, measuring 25-30 cm in length, are found in all freshwater fish  
47 habitats. They are rich in nutritional value and play an important role in the food security of  
48 the people living in the region (Sarkar and Lakra, 2010; Mohanty *et al.*, 2013). Fish diversity  
49 is an indicator of the health of the ecosystem, hence an important parameter in the assessment  
50 of the environment (Hamzah, 2007).

51

## 52 **Methodology**

53 The study area comprises freshwater resources within Vadodara and its surrounding regions.  
54 Vadodara district (Fig. 1) is located in the central part of Gujarat, India, between 21°30' to  
55 22°30' N latitude and 72°45' to 74°30' E longitude. The district covers an area of  
56 approximately 7,548.50 km<sup>2</sup> (Vadodara District Report, 2001).

57 The collection of fish samples was carried out through systematic fishing activities, in order  
58 to determine species diversity. Three individuals of each species were collected in order to  
59 ensure proper identification of species. In this regard, preliminary identification of species  
60 was carried out in the field using standard taxonomic keys and identification guides. Later,  
61 these samples were subjected to further analysis in the laboratory. From three individuals of a  
62 particular species, one individual was preserved in 10% formalin, while two individuals were  
63 preserved at -20 °C for further molecular analysis. Detailed taxonomic identification was  
64 carried out using standard reference books, such as those written by Francis Day (1958),  
65 Jayaram (1999) and Rainer Froese and Daniel Pauly (2022). All species were preserved for  
66 future reference.

## 67 **Result**

68 The present study is based on a primary survey of commercially important freshwater lake  
69 fisheries in Vadodara, Gujarat. To date, no comprehensive documentation on fish diversity  
70 from this region has been reported. During the survey, all recorded species were identified  
71 using their common and scientific names, along with their respective order, family, and  
72 IUCN conservation status, as presented in Table 1. A total of 31 fish species belonging to 10  
73 orders, 16 families, and 29 genera were documented. The family Cyprinidae was the most  
74 dominant, comprising 10 species, which aligns with patterns commonly observed in inland  
75 freshwater ecosystems (Jhingran, 1991 and 1969; Talwar and Jhingran, 1991; Battul *et al.*,  
76 2007). This was followed by the family Ambassidae with three species. Families such as  
77 Xenocyprididae, Bagridae, Siluridae, and Cichlidae were each represented by two species. In  
78 contrast, Danionidae, Leuciscidae, Pangasiidae, Channidae, Gobiidae, Belonidae,  
79 Mastacembelidae, Notopteridae, Serrasalminidae, and Osphronemidae were represented by a  
80 single species each. The survey exclusively recorded bony fishes (Class: Osteichthyes),  
81 indicating their dominance in the freshwater lake ecosystems of the study area.

82 The graphs show the percentage distribution of the different fish species by taxonomic order,  
83 along with the IUCN status of each order. Of the total of 31 recorded species, 68% fall in the  
84 Least Concern category, followed by 13% Not Evaluated, 10% Near Threatened, 6%  
85 Vulnerable, and 3% Data Deficient (IUCN, 2022). The large representation of the order  
86 Cypriniformes, specifically the family Cyprinidae, emphasizes the ecological and economic  
87 value of the family in the area of interest. Fish such as the silver carp, grass carp, and other  
88 exotic carps are commonly cultivated depending on the aquaculture practices in the area  
89 (FAO, 2020; IUCN, 2022).

90 The wild species of fishes of the families Bagridae, Siluridae, Cichlidae, Channidae,  
91 Belonidae, Mastacembelidae, and Serrasalminidae are dominant in the water bodies. The small  
92 indigenous fish species (SIF) recorded in the study (Table 2), showed that the order  
93 Cypriniformes is dominant compared to other orders such as Ovalentaria, Siluriformes,  
94 Anabantiformes, Gobiiformes, and Osteoglossiformes. Small indigenous fish species (SIF),  
95 although less emphasized in most studies and practices, are of high nutritional and  
96 socioeconomic value. The nutritional value of small indigenous fish species is high due to the  
97 presence of high-grade protein, essential fatty acids, and vitamins and minerals. The  
98 consumption of these fishes is also advantageous since these are consumed whole (Sarkar and  
99 Lakra, 2010; Mohanty *et al.*, 2013; Thilsted, 2012). Small indigenous fish species are also of  
100 high socioeconomic value for food security (FAO, 2014).

## 101 **Discussion**

102 Fish play a crucial role in both ecological balance and economic development, making the  
103 conservation and sustainable management of fish diversity essential. A comprehensive  
104 understanding of Ichthyofaunal diversity is fundamental for sustainable fisheries  
105 development, long-term resource utilization, and effective conservation planning (Goswami  
106 and Mankodi, 2010). Biodiversity documentation is equally important for assessing  
107 ecosystem structure and function (Gohil and Mankodi, 2010).

108 Field observations indicate that the order Cypriniformes dominates the study area,  
109 contributing 45% (14 species), followed by Siluriformes (16%) and Ovalentaria (10%). The  
110 family Cyprinidae emerges as the most abundant group, likely due to the availability of  
111 favorable freshwater habitats (Fig. 3). Additionally, an evaluation of the Ichthyofaunal  
112 diversity based on the IUCN conservation status (updated 2021) highlights the presence of

113 several threatened species in the region (Fig. 4; Table 1), emphasizing the urgent need for  
114 scientifically informed conservation strategies.

115 Existing literature suggests that studies on the status and utilization of small indigenous fish  
116 species (SIF) in India remain limited. However, previous research has demonstrated the  
117 potential of small-scale aquaculture involving species such as *Amblypharyngodon mola*,  
118 *Puntius sophore*, *Osteobrama cotio*, *Cirrhinus reba*, and *Labeo bata* (Roos *et al.*, 2003; Jena  
119 *et al.*, 2008; Sarkar and Lakra, 2010). Therefore, integrating SIF with Indian Major Carps  
120 (IMCs) through polyculture practices could enhance both productivity and sustainability.

## 121 **Conclusion**

122 Most of the species observed were common and widely distributed across the studied lakes,  
123 with Cypriniformes being the dominant order, indicating significant aquaculture potential,  
124 particularly for Indian major and exotic carps. In contrast, Small Indigenous Fish species  
125 (SIFs), though ecologically and nutritionally important, remain insufficiently explored and  
126 utilized. Additionally, there is a lack of comprehensive information on Ichthyofaunal  
127 diversity in both lotic and lentic ecosystems in the region. Hence, this study aims to  
128 document the Ichthyofaunal diversity of major freshwater resources in and around Vadodara  
129 district, with emphasis on species composition, abundance, and the prospects for culture and  
130 conservation of SIFs.

## 131 **Declarations**

### 132 **Funding statement**

133 The study was financially supported by the Government of Gujarat through the Scheme of  
134 Developing High Quality Research (SHODH) Scholarship.

### 135 **Conflict of interest**

136 The authors declare that there is no conflict of interest regarding the publication of this paper.

### 137 **Authors' Contribution**

138 GS: Data collection and Manuscript preparation; PM: Research guidance and supervision.

### 139 **Data Availability**

140 The above result is a part of doctoral research work. Hence the data is available with the  
141 corresponding author and will be presented as and when required.

142 **AI usage Statement**

143 Generative AI tools were used solely for language editing, including grammar correction,  
 144 paraphrasing, and improving clarity. No AI was used for data analysis, interpretation, or  
 145 generation of scientific content.

146 **Tables and Figures**

SN	Family	Scientific Name	Common Name	IUCN Status	Level of Abundance
<b>Order: Cypriniformes</b>					
1.	Cyprinidae	<i>Catla catla</i> (Hamilton, 1822)	Catla	LC	+++
2.		<i>Labeo rohita</i> (Hamilton, 1822)	Rohu	LC	+++
3.		<i>Cirrhinus mrigala</i> (Hamilton, 1822)	Mrigal carp	LC	+++
4.		<i>Hypophthalmichthys molitrix</i> (Valenciennes, 1844)	Silver carp	NT	++
5.		<i>Barbonymus gonionotus</i> (Bleeker, 1849)	Silver barb	LC	++
6.		<i>Puntius sophore</i> (Hamilton, 1822)	Pool barb	LC	+++
7.		<i>Osteobrama cotio</i> (Hamilton, 1822)	-	LC	+++
8.		<i>Vimba vimba</i> (Linnaeus, 1758)	Vimba bream	LC	+++
9.		<i>Tor tor</i> (Hamilton, 1822)	Tor barb	DD	-
10.		<i>Pethia ticto</i> (Hamilton, 1822)	Ticto barb	LC	-
11.	Danionidae	<i>Rasbora daniconius</i> (Hamilton, 1822)	Slender rasbora	LC	+
12.	Leuciscidae	<i>Alburnus alburnus</i> (Linnaeus, 1758)	Bleak	LC	++
13.	Xenocyprididae	<i>Ctenopharyngodon idella</i> (Valenciennes, 1844)	Grass carp	NE	+
14.		<i>Culter alburnus</i> (Basilewsky, 185)	-	NE	++
<b>Order: Siluriformes</b>					
15.	Bagridae	<i>Mystus cavasius</i> (Hamilton, 1822)	Gangetic mystus	LC	-
16.		<i>Sperata seenghala</i> (Sykes, 1839)	Giant river-catfish	LC	+
17.	Siluridae	<i>Wallago attu</i> (Bloch and Schneider, 1801)	Wallago	VU	+
18.		<i>Ompok bimaculatus</i> (Bloch, 1794)	Butter catfish	NT	+++
19.	Pangasiidae	<i>Pangasius pangasius</i> (Hamilton, 1822)	Pangus catfish	LC	++
<b>Order: Cichliformes</b>					
20.	Cichlidae	<i>Oreochromis mossambicus</i> (Peters, 1852)	Mozambique tilapia	VU	+++
21.		<i>Oreochromis niloticus</i> (Linnaeus, 1758)	Nile tilapia	LC	-

<b>Order: Ovalentaria</b>					
22.	Ambassidae	<i>Chanda nama</i> (Hamilton, 1822)	Elongate glass-perchlet	LC	+++
23.		<i>Parambassis ranga</i> (Hamilton, 1822)	Indian glassy fish	LC	+++
24.		<i>Parambassis lala</i> (Hamilton, 1822)	Highfin glassy perchlet	NT	-
<b>Order: Anabantiformes</b>					
25.	Channidae	<i>Channa striata</i> (Bloch, 1793)	Striped snakehead	LC	+++
26.	Osphronemidae	<i>Trichogaster lalius</i> (Hamilton, 1822)	Dwarf gourami	LC	-
<b>Order: Gobiiformes</b>					
27.	Gobiidae	<i>Glossogobius giuris</i> (Hamilton, 1822)	Tank goby	LC	+
<b>Order: Beloniformes</b>					
28.	Belonidae	<i>Xenentodon cancila</i> (Hamilton, 1822)	Freshwater garfish	LC	+++
<b>Order: Synbranchiformes</b>					
29.	Mastacembelidae	<i>Macrogathus aculeatus</i> (Bloch, 1786)	Lesser spiny eel	NE	++
<b>Order: Osteoglossiformes</b>					
30.	Notopteridae	<i>Notopterus notopterus</i> (Pallas, 1769)	Bronze featherback	LC	++
<b>Order: Characiformes</b>					
31.	Serrasalminidae	<i>Piaractus brachipomus</i> (Cuvier, 1818)	Pirapitinga (Paca)	NE	+

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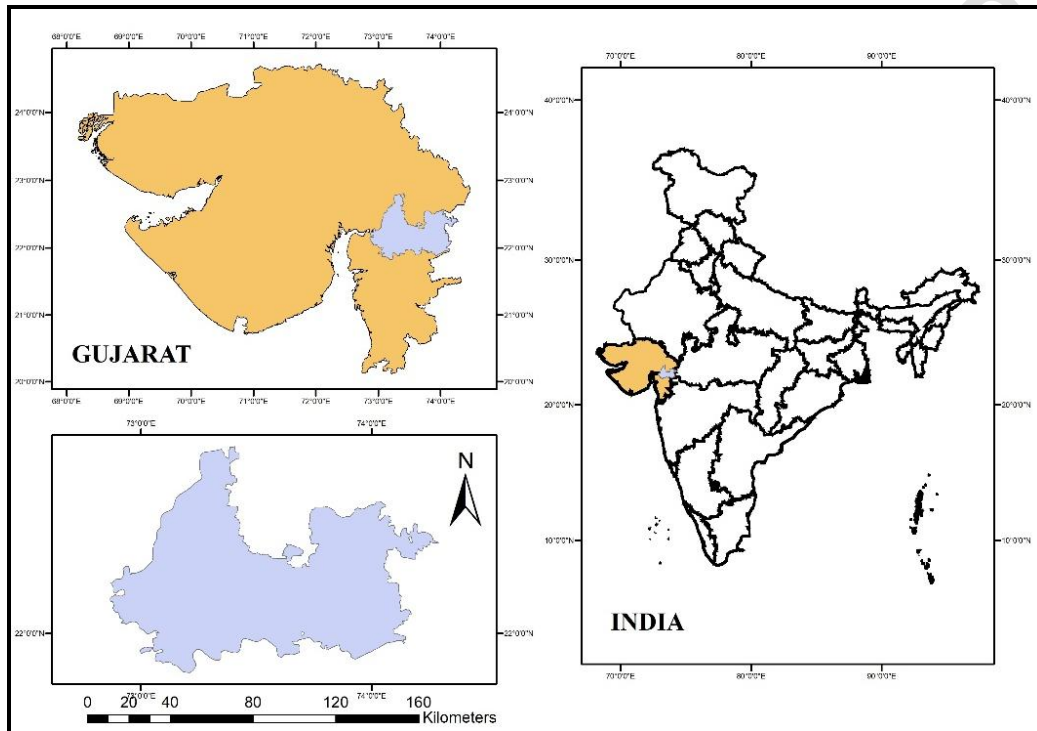
**Table 1.** List of freshwater fishes with their order, family, scientific name, common name, IUCN status and level of abundance (+ = Present, ++ = Common, +++ = Abundant, - = Rare; VU- Vulnerable; LC- Least concern; DD-Data Deficit; NE- Not evaluated, NT-Near threaten)

S. N.	Order	Family	Species
1.	Cypriniformes	Cyprinidae	<i>Puntius sophore</i> (Hamilton, 1822)
2.			<i>Osteobrama cotio</i> (Hamilton, 1822)
3.			<i>Pethia ticto</i> (Hamilton, 1822)
4.		Danionidae	<i>Rasbora daniconius</i> (Hamilton, 1822)
5.		Leuciscidae	<i>Alburnus alburnus</i> (Linnaeus, 1758)
6.		Xenocyprididae	<i>Culter alburnus</i> (Basilewsky, 185)
7.	Siluriformes	Bagridae	<i>Mystus cavasius</i> (Hamilton, 1822)
8.		Siluridae	<i>Ompok bimaculatus</i> (Bloch, 1794)
9.	Ovalentaria	Ambassidae	<i>Chanda nama</i> (Hamilton, 1822)

10.			<i>Parambassis ranga</i> (Hamilton, 1822)
11.			<i>Parambassis lala</i> (Hamilton, 1822)
12.	Anabantiformes	Osphronemidae	<i>Trichogaster lalius</i> (Hamilton, 1822)
13.	Gobiiformes	Gobiidae	<i>Glossogobius giuris</i> (Hamilton, 1822)
14.	Osteoglossiformes	Notopteridae	<i>Notopterus notopterus</i> (Pallas, 1769)

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**Table 2.** List of Small Indigenous Fish species (SIF) with their order, family, scientific name



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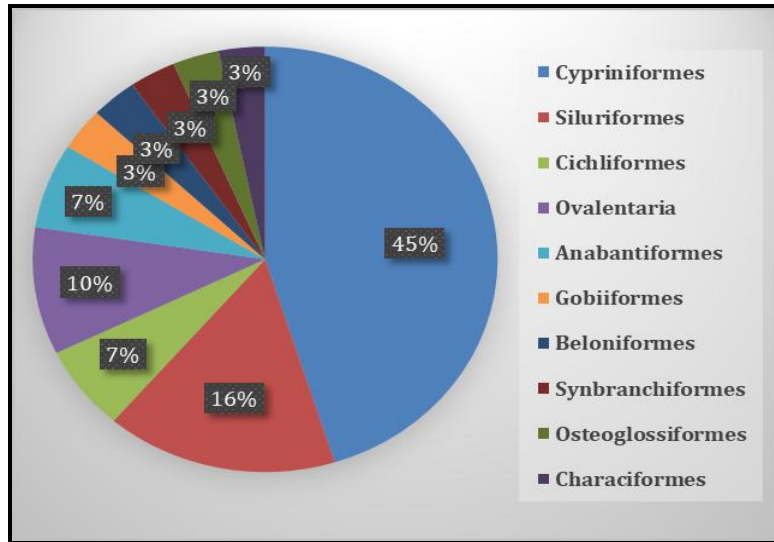
**Fig. 1.** Map of the study area



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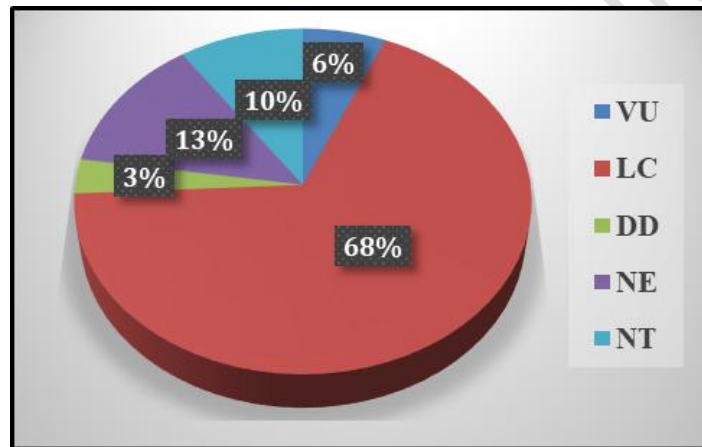
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**Fig. 2.** Illustrates the netting activity



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**Fig. 3.** Order wise percentage distribution of the species



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**Fig. 4.** Categorization of available fish species depending on IUCN-threatened status (Updated 2021)

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165

166 **References**

- 167 Banyal, H. S., Kumar, S., & Raina, R. H. (2019). Exploration of fish diversity in the West  
168 Banas River, Banaskantha, Gujarat. *Records of the Zoological Survey of India*, 119(3), 282–  
169 288.
- 170 Battul, P. N., Rao, K. R., Navale, R. A., Bagale, M. B., & Shah, N. V. (2007). Fish diversity  
171 from Ekruk Lake near Solapur, Maharashtra. *Journal of Aquatic Biology*, 22(2), 68–72.
- 172 Bera, A., Bhattacharya, M., Patra, B. C., & Sar, U. K. (2014). Ichthyofaunal diversity and  
173 water quality in the Kangsabati Reservoir, West Bengal, India. *Advances in Zoology*, 2014,  
174 Article ID 539327. <https://doi.org/10.1155/2014/539327>
- 175 Bhattacharya, M., Chini, D. S., Kar, A., Patra, B. C., Malick, R. C., & Das, B. K. (2020).  
176 Assessment and modeling of fish diversity related to water bodies of Bankura district, West  
177 Bengal, India, for sustainable management of culture practices. *Environment, Development  
178 and Sustainability*, 22(2), 971–984. <https://doi.org/10.1007/s10668-018-0207-8>
- 179 Day, F. (1958). *The fishes of India*. William Dawson and Sons.
- 180 Delgado, C. L. (2003). *Fish to 2020: Supply and demand in changing global markets* (Vol.  
181 62). WorldFish.
- 182 Devi, R. K., & Indra, T. J. (2012). *Checklist of the native freshwater fishes of India*.  
183 Zoological Survey of India.
- 184 Dholakia, A. D. (2004). *Fisheries and aquatic resources of India*. Daya Publishing House.
- 185 Food and Agriculture Organization of the United Nations. (2014). *The state of world fisheries  
186 and aquaculture 2014: Opportunities and challenges*. FAO.
- 187 Food and Agriculture Organization of the United Nations. (2020). *The state of world fisheries  
188 and aquaculture 2020: Sustainability in action*. FAO. <https://doi.org/10.4060/ca9229en>
- 189 Froese, R., & Pauly, D. (Eds.). (2022). *FishBase*. <https://www.fishbase.se>
- 190 Gohil, M., & Mankodi, P. C. (2010). Diversity of fish fauna from downstream zone of River  
191 Mahisagar, Gujarat State, India. *Journal of Environmental Sciences*, 3, 23–26.

- 192 Gopi, K. C., & Mishra, S. S. (2015). *Diversity of marine fish of India*. In Venkataraman, K.,  
193 Sivaperuman, C., & Raghunathan, C. (Eds.), *Marine faunal diversity in India* (pp. 171–193).  
194 Academic Press.
- 195 Goswami, A. P., & Mankodi, P. C. (2010). Diversity of fishes from freshwater reservoir  
196 Nyari II of Rajkot district, Gujarat. *Electronic Journal of Environmental Sciences*, 3, 23–26.
- 197 Hamzah, N. (2007). Assessment on water quality and biodiversity within Sungai Batu Pahat  
198 (Doctoral dissertation, Universiti Teknologi Malaysia).
- 199 Hoagland, K. E. (1996). The taxonomic impediment and the convention on biological  
200 diversity. *ASC Newsletter*, 24(5), 61–62.
- 201 Jayaram, K. C. (1999). *The freshwater fishes of the Indian region*. Narendra Publishing  
202 House.
- 203 Jena, J., Das, P. C., Kar, S., & Singh, T. K. (2008). Olive barb (*Puntius sarana*) as a potential  
204 candidate species for polyculture. *Aquaculture*, 280(1–4), 154–157.  
205 <https://doi.org/10.1016/j.aquaculture.2008.04.040>
- 206 Jhingran, V. G. (1991). *Fish and fisheries of India* (3rd ed.). Hindustan Publishing  
207 Corporation.
- 208 Jhingran, V. G., Natarajan, A. V., Banerjea, S. M., & David, A. (1969). Methodology on  
209 reservoir fisheries investigations in India. *Bulletin*, 12, 109.
- 210 Mogalekar, H. S., Canciyal, J., Ansar, C. P., Bhakta, D., Biswas, I., & Kumar, D. (2017).  
211 Freshwater fish diversity of West Bengal, India. *Journal of Entomology and Zoology Studies*,  
212 5(2), 37–45.
- 213 Mohanty, B. P., Mahanty, A., Ganguly, S., Sankaranarayanan, A., Chakraborty, K., et al.  
214 (2013). Nutritional composition of food fishes and their importance in providing food and  
215 nutritional security. *Food Chemistry*, 140(4), 633–642.  
216 <https://doi.org/10.1016/j.foodchem.2012.10.039>
- 217 Mohanty, B. P., Pati, M. K., Bhattacharjee, S., Hajra, A., & Sharma, A. P. (2013). Small  
218 indigenous fishes and their importance in human health. *Advances in Fish Research*, 5, 257–  
219 278.

- 220 Murugan, A. S., & Prabakaran, C. (2012). Fish diversity in relation to physico-chemical  
221 characteristics of Kamala Basin of Darbhanga District, Bihar, India. *International Journal of*  
222 *Pharmaceutical and Biological Archives*, 3(1), 211–217.
- 223 Nelson, J. S., Grande, T. C., & Wilson, M. V. (2016). *Fishes of the world* (5th ed.). Wiley.
- 224 Niraj, K. (2012). Study of Ichthyofaunal biodiversity of Turkaulia Lake, East-Champaran,  
225 Bihar, India. *International Research Journal of Environment Sciences*, 1, 71–73.
- 226 Rema Devi, K. (1996). Extension of distribution range of *Horadandia atukorali*. *Journal of*  
227 *the Bombay Natural History Society*, 93(2), 303–304.
- 228 Roos, N., Islam, M. M., & Thilsted, S. H. (2003). Small fish is an important dietary source of  
229 vitamin A and calcium in rural Bangladesh. *International Journal of Food Sciences and*  
230 *Nutrition*, 54(5), 329–339. <https://doi.org/10.1080/0963748031000136716>
- 231 Sarkar, U. K., & Lakra, W. S. (2010). Small indigenous freshwater fish species of India:  
232 Their role in nutrition, food security and livelihoods. *Journal of the Inland Fisheries Society*  
233 *of India*, 42(1), 1–12.
- 234 Sarkar, U. K., & Lakra, W. S. (2010). Small indigenous freshwater fish species of India:  
235 Significance, conservation and utilization. *Aquaculture Asia*, 15(3), 34–35.
- 236 Sarma, K. J., Prajapati, M., & Mankodi, P. C. (2017). Morphological description and  
237 taxonomic account of *Labeo* species from Gujarat, India. *Journal of Entomology and Zoology*  
238 *Studies*, 5(4), 1120–1125.
- 239 Sen, T. K., & Banerjee, P. K. (2000). *Freshwater fishes*. In Fauna of Gujarat (Vol. 8, pp.  
240 413–464). Zoological Survey of India.
- 241 Sharma, H., Swain, M., & Kalamkar, S. S. (2016). Evaluation and assessment of economic  
242 losses in fisheries sector in Gujarat State (Report No. 163). Agro-Economic Research Centre.
- 243 Silambarasan, K., & Senthilkumaar, P. (2014). Studies on Ichthyofaunal biodiversity of  
244 Kolavoi Lake, Tamil Nadu, India. *International Journal of Zoology Studies*, 3(5), 545–546.
- 245 Talwar, P. K., & Jhingran, A. G. (1991). *Inland fishes of India and adjacent countries* (Vols.  
246 1–2). Oxford & IBH Publishing.

- 247 Thilsted, S. H. (2012). The potential of nutrient-rich small fish species in aquaculture to  
248 improve human nutrition and health. *Food and Nutrition Bulletin*, 33(4), 341–353.  
249 <https://doi.org/10.1177/156482651203300404>
- 250 Vadodara District Report. (2001). *Central Ground Water Board*.  
251 [https://cgwb.gov.in/old\\_website/District\\_Profile/Gujarat/Vadodara.pdf](https://cgwb.gov.in/old_website/District_Profile/Gujarat/Vadodara.pdf)
- 252 Vijayalaxmi, C., Rajashekar, M., & Vijayakumar, K. (2010). Freshwater distribution and  
253 diversity status of Mullameri River. *International Journal of Systems Biology*, 2(2), 1–9.

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