Exploring Ichthyofaunal Diversity and Water Quality in the Bhadar-II Reservoir, Gujarat, India

Abstract

The study was conducted to assess the fish diversity and water quality in the Bhadar-II reservoir, located in Rajkot district of Gujarat. Monthly sampling was carried out from September 2023 to April 2024. A total of 19 fish species were recorded during the study period. Cypriniformes was the dominant order in terms of species diversity (9 species), followed by Siluriformes (5 species), Anabantiformes (3 species), Osteoglossiformes (1 species) and Cichliformes (1 species). The dominant families were Cyprinidae (9 species), followed by Channidae (3 species), Siluridae (2 species), and 1 species each from Claridae, Heteropneustidae, Cichlidae, Pangasiidae, and Notopteridae. The catfish population was the most prevalent, accounting for 26% of the total fish population, followed by minor carp at 21%. Major carp, exotic fish, and murrels each contributed 16%, while featherback fish had the lowest at 5%. The fish data was subjected to species diversity analysis. The Shannon-Wiener Index values ranged from 1.776 to 2.546, indicating monthly fluctuations in diversity levels. This range suggests that the habitat structure was moderately stable. Pielou's Evenness Index values ranged from 0.8080 to 0.8880, showing a gradual increase in evenness over time. This increase can be attributed to a decline in the population of the dominant species. Species richness, as measured by the Margalef Richness Index, ranged from 1.278 to 2.477, with the highest species richness observed in November during the winter season. Monthly observations of physicochemical parameters showed the range of water temperature from 23.4°C to 30.1°C, dissolved oxygen levels from 6.7 to 8.9 mg/l, pH from 7.6 to 8.3, alkalinity between 139.4 to 156.2 mg/l, and total hardness from 94.2 to 133.1 mg/l.

Keywords: Ichthyofaunal, Diversity Indices, Water Quality, Reservoir.

1. Introduction

Biodiversity, encompassing species, ecosystem, and genetic diversity, reflects the vast variety of life forms on earth, with uneven distribution favouring tropical regions (Walker, 1992; Jana et al., 2015). Ichthyofaunal diversity, referring to the variety of fish in aquatic ecosystems, is crucial for ecological balance and food security. Globally, fish comprise over 50% of vertebrate species, with India contributing 7.7% of this diversity, including 1,673 marine and 994 freshwater species (Froese & Pauly, 2020). Freshwater ecosystems, covering

0.8% of India's land, support 9.7% of its fauna and provide key ecological services like flood control and water purification (Pathak &Lavudya, 2021).

Reservoirs, a vital component of India’s inland fisheries, span 3.15 million hectares across 19,370 water bodies (Desai, 2006). These reservoirs are classified into small, medium, and large categories, with small reservoirs playing a critical role in fisheries, offering higher yields. Despite their potential, reservoir fisheries face challenges such as poor management, overexploitation, and habitat disruption.Gujarat, home to 711 reservoirs, has significant aquaculture potential, although its fisheries are underdeveloped (Sugunan, 1995).The diversity of ichthyofauna within these ecosystems is vital for sustenance, economic benefits, and biodiversity. However, threats like pollution, overfishing, and river modifications jeopardize this diversity, with 20% of global freshwater fish species at risk (Postle, 2002). Advancing sustainable management practices is imperative to harness the full potential of India’s reservoirs and preserve ichthyofaunal diversity.

2. Materials and methods

2.1 Sampling site

The research was carried out in the Saurashtra region of Gujarat, India, specifically at the Bhadar-II reservoir (21°45′40″N, 70°25′22″E), located in Bhukhi village, Rajkot district, approximately 120 km from the College of Fisheries Science, Veraval. The Bhadar River, located in the Kathiawar (Saurashtra) peninsula, originates near Vaddi (Aniali Village), Rajkot district, Gujarat. The Bhadar-II reservoir, a medium reservoir with a capacity of 49 million cubic meters, plays a significant role in the region. Constructed in 2000, it covers an area of 850 hectares with an effective storage capacity of 41.85 million cubic meters and experiences an average annual rainfall of 586 mm.

2.2 Sampling methods

Data collection was conducted at the study location where water temperature was measured using a digital thermometer, and pH levels were determined in situ using a digital pH meter. Water samples were then carefully transported to the laboratory for further analysis. Dissolved oxygen (DO) levels were collected in glass stopper bottles to prevent exposure to air. Laboratory analysis of water samples included determining parameters such as total hardness (TH), dissolved oxygen (DO), and total alkalinity (TA), following standard laboratory protocols as outlined by the American Public Health Association (APHA, 2005).

Fish specimens were randomly collected using 8-12 gill nets, each measuring 8-10 meters in length and 3-5 meters in width, with mesh sizes ranging from 6 to 9 cm. These nets were deployed for 14 to 16 hours. After collection, fish specimens were identified and photographed on-site before being transported to the College of Fisheries Science, Veraval, for further examination, measurement, and identification. Upon arrival at the lab, the specimens were preserved. Fish samples were preserved using a 10% formalin solution (40% commercial solution) in separate containers based on size. Small fish were directly submerged, while larger specimens were dissected before preservation. Species identification and confirmation were conducted using available literature (Day, 1878; Talwar &Jhingran, 1991; Jayaram, 1999). Valid species nomenclature was referenced from the Catalogue of Fishes of the California Academy of Sciences (Eschmeyer & Fricke, 2024), and fish conservation status was cross-verified using the IUCN Red List (IUCN, 2024). Fish species diversity was analyzed using various indices, including species richness (Margalef, 1958), Shannon-Wiener diversity index (1963), and species evenness index (Pielou's, 1977), analysis was performed using freely available statistical software, PAST.

3. Result and Discussion

A total of 19 fish species were documented (Plate1), categorized into 5 orders (Cypriniformes, Siluriformes, Cichliformes, Anabantiformes, and Osteoglossiformes), 8 families, and 13 genera (Table.1). The dominant order was Cypriniformes, accounting for 48% of the total species, with 9 species such as *Puntius sarana*, *Labeocatla*, *Labeorohita, Labeoboggut, Labeofimbriatus, Labeocalbasu, Ctenopharyngodonidella,* and *Cyprinus carpio*and *Cirrhinusmrigala*. Other orders observed included Siluriformes (26%), Anabantiformes (16%), and Osteoglossiformes and Cichliformes (5% each) (Figure.1). The Cyprinidae family was most prevalent, aligning with Vyas et al. (2020), who also recorded a strong presence of Cyprinidae in their study. Other families, such as Channidae (3 species), Siluridae (2 species), and Cichlidae (1 species), contributed to the ichthyofaunal diversity (Figure.2).

Comparative studies reveal variation in species composition across regions. For instance, Battul et al. (2007) documented 18 species in Maharashtra, while Raja et al. (2015) recorded 48 species in Tamil Nadu, highlighting geographical and hydrological influences. The dominance of Cypriniformes is consistent with findings by Rao & Rao (2023), who observed a similar trend in Andhra Pradesh, whereas Niyazi et al. (2020) reported even higher dominance in Chhattisgarh.Environmental factors, including water quality and physico-chemical conditions, play a significant role in species distribution and diversity. Stressful conditions reduce diversity, often leading to dominance by a few species (Plafkin et al., 1989). This study emphasizes the unique characteristics and biodiversity of the reservoir, contributing to the understanding of regional ichthyofaunal patterns.

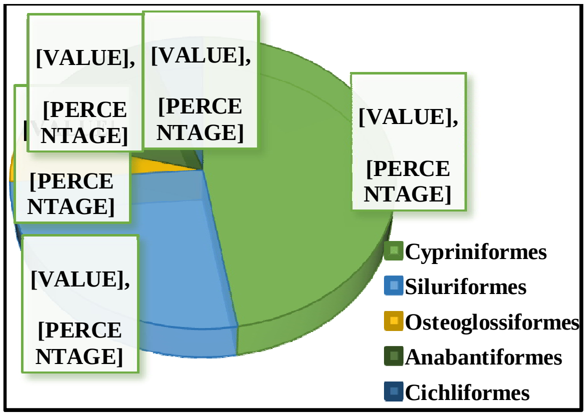

Figure 1.Order-wise species composition of fishdiversity of Bhadar-II reservoir

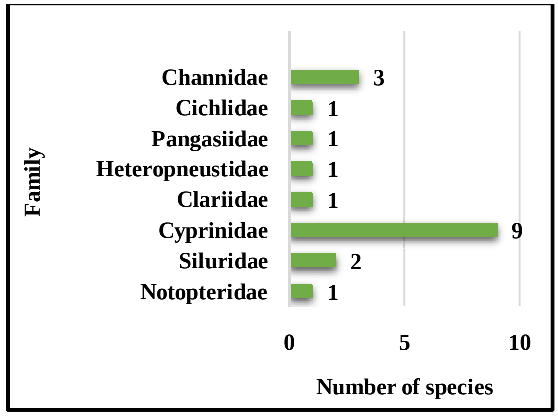

Figure 2. Family-wise species composition of fish diversity of Bhadar -II reservoir

The indices of fish species were calculated based on the abundance of species of fish diversity. The Shannon-Wiener diversity index (H') for fish in the Bhadar-II reservoir varied monthly. It peaked in December at 2.546 and dropped to 1.776 in September. Higher diversity in December was likely due to favorable environmental conditions, while lower diversity in September could reflect post-monsoon changes. These results align with Sharma et al. (2020), who reported similar seasonal trends in the Dilawara reservoir.Monthly variations in species evenness, measured by Pielou's Evenness Index(J’), ranged from 0.8080 to 0.8880. The highest evenness occurred in April, and the lowest in September. Higher evenness in April was associated with a decline in dominant species populations. The findings are consistent with Raja et al. (2015), who reported similar values from the Krishnagiri Reservoir. The Margalef Richness Index (d) for fish ranged from 1.278 in September to 2.477 in November, with November showing the highest species richness due to optimal environmental conditions. Conversely, September’s lower richness might be attributed to reduced post-monsoon activities. These findings are comparable to Mishra et al. (2014), though the biodiversity was lower than typically observed in healthy ecosystems (Table 1).

Table 1. Monthly variation in species diversity indices

Index	**Months**							
	Sep.	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**
Shannon-Wiener Diversity (H')	1.776	2.238	2.523	2.546	2.477	2.415	2.303	2.278
Pielou's Evenness (J')	0.8082	0.8480	0.8569	0.8646	0.8744	0.8711	0.8728	0.8880
Margalef Richness (d)	1.278	1.862	2.477	2.437	2.167	2.064	1.838	1.763

Water quality in India shows regional variation due to diverse geological and geographical factors. This study assessed key parameter- temperature, dissolved oxygen (DO), pH, alkalinity, and total hardness, using standard analytical methods. Water temperature, influenced by collection timing, season, and depth, directly affects aquatic ecosystems. The maximum temperature recorded was 30.1°C in April (summer), and the minimum was 23.4°C in December (winter). Similar patterns were observed by Chandravanshi et al. (2020) in the Hiran-II reservoir, Gujarat, and Lianthuamluaia et al. (2013) in the Savitri reservoir, Maharashtra. DO levels were highest in December (8.9 mg/L) and lowest in April (6.7 mg/L), reflecting seasonal variations. Winter solubility increases DO, while summer reduces it. Comparable trends were noted by Chaudhari et al. (2015) at Hatnur Reservoir, Maharashtra. The pH ranged from 7.6 in December to 8.3 in April, aligning with medium productivity (Jhingran et al., 1990). Summer increases in pH were due to higher photosynthetic activity. Similar findings were reported by Vyas (2020) in the Ozat-II reservoir. Alkalinity varied between 139.4 mg/L in December and 156.2 mg/L in April, influenced by runoff from agricultural areas. These results are consistent with Vyas (2020) and Verma et al. (2011). Total hardness ranged from 94.2 mg/L in December to 133.1 mg/L in April, categorizing the water as moderately hard (Kannan, 1991). Higher hardness during summer correlates with evaporation. This aligns with Vyas et al. (2019) (Table 2).

Table 2. Monthly recorded physicochemical parameters of Bhadar-II reservoir

	Physicochemical Parameters									
	Water Temperature (°C)		Dissolved Oxygen (mg/l)		pH		Alkalinity (mg/l)		Total Hardness (mg/l)	
	Mean ± SE	Range	Mean ±SE	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Sep.	27.3±0.12	27.1-27.5	7.0±0.05	6.95-7.11	7.9±0.03	7.85-7.93	145.1±0.2	144.8-145.5	104.0±0.15	103.8-104.3
Oct.	26.1±0.09	25.9-26.2	6.8±0.12	6.6-7.0	8.0±0.02	7.97-8.03	149.0±0.15	148.8-149.3	101.1±0.09	101.0-101.3
Nov.	24.0±0.12	23.8-24.2	8.6±0.05	8.55-8.7	7.8±0.02	7.76-7.82	143.0±0.15	142.7-143.2	98.0±0.15	97.7-98.2
Dec.	23.4±0.06	23.3-23.5	8.9±0.09	8.75-9.05	7.6±0.02	7.58-7.63	139.4±0.26	138.9-139.8	94.2±0.2	93.8-94.5
Jan.	24.0±0.02	23.93-24.01	8.0±0.05	7.95-8.12	7.7±0.02	7.67-7.72	142.0±0.05	141.9-142.1	98.0±0.15	97.7-98.2
Feb.	24.7±0.03	24.65-24.75	8.7±0.01	8.75-8.77	7.9±0.01	7.88-7.91	146.0±0.12	145.8-146.2	95.9±0.22	95.5-96.2
Mar.	27.8±0.12	27.6-28.0	6.9±0.06	6.8-7.0	8.0±0.02	7.96-8.03	152.2±0.2	151.8-152.5	129.0±0.12	128.8-129.2
Apr.	30.1±0.05	29.95-30.11	6.7±0.03	6.62-6.71	8.3±0.01	8.29-8.31	156.2±0.2	155.8-156.5	133.1±0.05	132.95-133.1

4. Conclusion

This study examined the monthly variations in fish diversity and water quality parameters—dissolved oxygen, temperature, alkalinity, pH, and total hardness—in the Bhadar-II reservoir, Gujarat. All recorded water quality parameters were within the permissible limits set by BIS standards. A total of 19 fish species were identified, representing five orders, eight families, and 13 genera. Among these, catfish dominated the fish population (26%), followed by minor carp (21%). Major carp, exotic fish, and murrels each accounted for 16%, while featherback fish had the lowest contribution at 5%. The fish community was predominantly composed of species from the Cypriniformes order, particularly the Cyprinidae family. Species diversity and richness indices revealed the highest fish diversity and richness during the winter season (November to February), followed by the summer (March and April) and post-monsoon seasons (September and October). The species evenness index showed the most even distribution of fish in April, attributed to a decline in dominant species, and the least even distribution in September due to uneven species distribution.The findings of this study are crucial for the conservation and sustainable management of the Bhadar-II reservoir. The documentation of fish diversity and seasonal trends provides a clear understanding of the ecological health of the reservoir and its capacity to support aquatic biodiversity. The observed dominance of specific species, such as catfish and Cyprinids, highlights the importance of maintaining balanced ecological conditions to prevent overpopulation or the decline of particular fish groups. Water quality parameters remaining within BIS standards suggest a relatively stable environment, but continuous monitoring is essential to mitigate potential anthropogenic impacts such as pollution or habitat degradation.Moreover, the data on species diversity and richness during different seasons can guide the development of seasonal fishing regulations, ensuring that overfishing during critical breeding periods is avoided. This will help maintain a sustainable fish population and ecosystem balance. The study's baseline data can also support initiatives for habitat restoration, such as reforestation of catchment areas and stocking of native fish species to enhance biodiversity. Additionally, the findings will aid policymakers, fishery managers, and local communities in implementing informed strategies for resource management and conservation.Overall, this research not only establishes a foundation for the scientific study of the reservoir's ichthyofauna but also contributes to preserving the ecological integrity of the Bhadar-II reservoir while promoting sustainable utilization of its fisheries resources.

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Plate1: Fish specimens collected from the Bhadar-II reservoir

Labeocatla **(WoRMS, 2023)**

Labeorohita **(Hamilton, 1822)**

***Labeocalbasu* (Hamilton, 1822)**

***Labeoboggut* (Sykes, 1839)**

***Cirrhinusmrigala* (Hamilton, 1822)**

***Ctenopharyngodonidella*(Valenciennes, 1844)**

***Cyprinus carpio* (Linnaeus, 1758)**

Puntius sarana

(Hamilton-Buchanan, 1822)

***Labeo fimbriatus* (Bloch, 1795)**

Oreochromis mossambicus
(Peters, 1852)

***Heteropneustesfossilis*(Bloch, 1794)**

***Clarias batrachus* (Linnaeus, 1758)**

***Ompokpabda* (Hamilton, 1822)**

Pangasius pangasius

(Hamilton, 1822)

***Wallago attu*(Bloch & Schneider, 1801)**

Notopterusnotopterus

(Pallas, 1769)

***Channa punctata* (Bloch, 1793)**

***Channa striata* (Bloch, 1793)**

***Channa marulius*(Hamilton, 1822)**