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Original Research Article

Fish diversity and abundance in relation to water quality of Anjanapura reservoir, Karnataka, India

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Keywords

Anjanapura reservoir; fish fauna; biodiversity indices; water quality; Karnataka.

A B S T R A C T

Freshwater fish diversity, abundance and richness status of Anjanapura reservoir, Karnataka was studied monthly from November 2005 to October 2006 in three sampling sites. The present study has shown that Anjanapura reservoir supported 25 fish species belonging to 04 orders, 09 families and 18 genera. The order Cypriniformes was dominant with 14 fish species followed by order Siluriformes with 6 species, and the order Perciformes with 4 species and Osteoglossiformes with one species. Fish diversity was assessed by calculating the various diversity indices such as Shannon - Weiner index (H), Simpson's Dominance Index (D), Simpson's index of diversity (1-D), Pielous Evenness and Margalef index of species richness. As far as biodiversity status (IUCN-1994) is concerned, out of 25 species, 11 fish species are categorized into Lower risk Near threatened (LR-nt), 08 Not assessed, 03 Vulnerable, 01 each in respect of Endangered, Data Deficient, and Lower risk least concern (LR-lc) respectively. Seasonal water quality parameters such as water temperature, pH, electrical conductivity, free CO_2, DO, BOD, hardness, chloride, nitrate and phosphate has been recorded and were found suitable for fish population. It can be concluded that reservoir supported rich fish population. It needs proper management and utilization of this fish wealth and sustainable steps to monitor and conserve this fish health.

Introduction

Fish is sensitive to changes in water chemistry due to different anthropogenic activities from their catchments. Fish responses to environmental disturbances, including hydro-morphological factors are different in time and space in comparison to simpler organisms, as they tend to be integrated over larger intervals. Fish has been identified as suitable for biological assessment due to its easy identification

and economic value (Siligato & Bohmer. 2001). Fish assemblages have widely been used as ecological indicators to assess and evaluate the level of degradation and health of water bodies at various spatial scales (Zampella et al., 2006; Vijaylaxmi et al., 2010). Plafkin et al (1989) observed that there are many advantages of using fish assemblage as biological indicator. Many fish species have become highly endangered, particularly in rivers where heavy demand is placed on freshwater. However, the impact of the anthropogenic activities, habitat degradation, exotic species introduction, water diversions, pollution and global climate change are the main causative agents for the aquatic species rapid decline. Reservoirs play a very important role in the geochemical cycling of elements and influence the chemical composition and material transfer of the river system (Abhay et al., 2005). They are of high ecological, economic and recreational importance (Carol et al., 2006). They contribute significantly in fulfilling the basic human needs such as water for drinking and industrial use, irrigation, flood control, hydro power generation, inland navigation, fishing and recreation.

The objective of present investigation was to give recent data regarding fish diversity in relation to abundance, richness, relative abundance and diversity status of the reservoir system, aiming to contribute a better knowledge of the fish diversity profile of Anjanapura reservoir and a tool for conservation planning of aquatic environments in this region.

Materials and Methods

Study area

The study area Anjanapura reservoir lies in semi-malnad region of Shikaripura taluk, Shimoga district. It was constructed across the River Kumudvathi for irrigation and domestic purpose, but it is being used today for inland fish culture. The catchments area of reservoir consists of evergreen and semi evergreen forest types with deciduous (moist/dry) forest near Anjanapura reservoir area and lower basin consists of scrub forest. The average annual temperature is around 26^{o}C. The area receives good rainfall from south-west monsoon and the mean annual rainfall is 699.1 mm. The sampling sites selected for study are Site 1: Near left bank channel, Koppadakere Village (14^{o} 09.046' N, 75 ^{o} 22.555' E, Alt; 2023 ft), Site 2: Outlet near Dam wall, Anjanapura Village(14 ^{o} 09.462' N, 75 ^{o} 23.168' E, Alt; 2012 ft) and Site 3: Beyond Anjanapura Village, Shikaripura Road(14 ^{o} 09.249' N, 75 ^{o} 23.856' E, Alt; 2029 ft)

Fish samples collection

Fish samples were collected from different selected localities during the study period from November 2005 to October 2006 with the help of local fishermen using different types of nets namely gill nets, cast nets and dragnets. Immediately photographs were taken prior to preservation since formalin decolorizes the fish colour on long preservation. 10% formalin solution was prepared for preservation of fish samples. Fishes brought to the laboratory were fixed in this solution in separate jars according to the size of species. Smaller fishes were directly placed in the formalin solution while, larger fishes were given an incision on the abdomen before they were fixed.

Fish Identification

The fishes were identified by using Dutta Munshi and Shrivastava (1988); Talwar

and Jhingran (1991) and Jayaram (1999).

Diversity Indices

Species diversity can be measured separately either as species richness or evenness or diversity as a whole. Species richness was measured by Index of richness (denoted by R) given by Margalef (1958). Species evenness was measured with evenness index (denoted by E) given by Hill (1973). Diversity of the species calculated directly with a variety of indices, of which two commonly used are Shannon-Weiner Index or simply the Index of diversity or Shannon's index (denoted by H´; as given by Shannon and Weiner, 1963) and Index of dominance or Simpson's index given by Simpson (1949). Shannon's index has a direct relationship with the species diversity, whereas index of dominance has an inverse relationship.

Water Sample Collection for physico-chemical analysis

Surface water samples were collected in polythene cans from three sampling sites of the Anjanapura reservoir. Air and water temperature, pH, DO and free CO_2 were determined on the spot itself and for BOD determination water samples were collected in BOD bottles. For further analysis, samples were transported to laboratory and analyzed other parameters using standard procedures (APHA 2005).

Results and Discussion

The present investigation of fish fauna in Anjanapura reservoir showed that most of the fish species recorded were widely distributed in the lentic and lotic waterbodies of Western Ghats. A total of 25 species of fishes belongs to four orders and nine families were recorded. Among identified fishes, fishes belongs to order Cypriniformes was dominated with 14 species followed by order Siluriformes with 6 species, order Perciformes with 4 species and order Osteoglossiformes with only one species. Out of 25 fish species, 14 species belongs to family Cyprinidae, 3 species to Siluridae, and each species to Bagridae, Claridae, Heteropneustidae, Ambassidae, Gobidae, Channidae, Mastacembelidae and Notopteridae (Table 1). The percentage of fish population shown that order Cypriniformes was most dominant constituting 56% followed by order Siluriformes constituting 24%, order Perciformes constituting 16 %, and order Osteoglossiformes contributing 4 % of the total fish species recorded(Fig. 2). The economically important and cultivable fishes were also recorded and includes *Notopterus notopterus, Cyprinus carpio, Catla catla, Glossogobius giuiris, Labeo rohita, Cirrhinus mrigala, Sperata singhala, Sperata oar* and *Channa marulius* . Similarly,this reservoir is also inhabited by the ornamental fishes like *Puntius sp,, P. sarana sabnastus*, *Chanda nama* and *Rohtee ogilbii.* Some rare species which are confined to upstream and down streams stretch of the reservoir includes *Mastacembalus armatus, Cirrhinus cirrhosus, Labeo fimbriatus* and *Wallago attu.*

As far as biodiversity status (IUCN-1994) is concerned, out of 25 species, 11 fish species are categorized into Lower risk Near threatened (LR-nt), 08 Not assessed, 03 Vulnerable, 01 each in respect of Endangered, Data Deficient, and Lower risk least concern (LR-lc) respectively (Fig.1).Different diversity indices were calculated as per standard methods. The Shannon-Weiner fish diversity index of Anjanapura reservoir ranged from 2.4 to

3.0. The Simpson's dominance index values ranges between 0.08 and 0.2. Simpson's index of Diversity (1-D) also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In the present study, the Simpson's index of Diversity (1-D) values fluctuated between 0.89 and 0.95. However, Pielou's evenness values were ranges from 0.6 to 0.9. The Margalef index of species richness values revealed 1.48 to 2.4(Table 2).

Water quality parameters

The physico-chemical characteristics of water have an important role in supporting fish diversity freshwater ecosystems. The seasonal average values of physico-chemical parameters of the reservoir are depicted in the Table 3. In the present study, air temperature was recorded in the range of 28.00±2.16 during winter season to 33.50±0.58°C at Site 1. Water temperature was varied between 25.25±0.50°C at site 1 and 2 during winter season and 30.25±1.71°C at site 3 during summer season. pH was in the range of 7.40±0.22 at site 3 during rainy season and 7.66± 0.07 at site 3 during summer season. A minimum value of electrical conductivity was recorded at site 120.68±35.93 µmhos/cm during rainy season and a maximum of 169.50±9.75 µmhos/cm at site 3 during summer season. Free CO_2 was observed in the range of 1.41±0.52 at site 1 during summer season to 2.68±0.72 mg/L at site 3 during rainy season. DO level was varied between 6.19±1.16 mg/L at site 1 during summer season to 8.28±1.50 mg/L at site 3 during winter season. Biological oxygen demand for 3 days at 27°C was fluctuated between 0.83±0.04 mg/L at site 1 during rainy season and 2.48±1.41 mg/L at site 1 during summer season. Total hardness was registered in the range of 44.00±10.71 mg/L at site 1 during rainy season to 67.50±12.37 mg/L at site 3 during summer season. Nitrate concentration was observed in the range of 0.108±0.06 mg/L at site 1 during rainy season to 0.348±0.26 mg/L at site 2 during rainy season. Phosphate content was fluctuated between 0.004±0.002 mg/L at site 2 during winter season and 0.012±0.01 mg/L at site 2 & 3 during summer season.

The present study focuses on fish species richness and diversity of Anjanapura reservoir. In the present study order Cypriniformes was most dominant followed by order Siluriformes order Perciformes and order Osteoglossiformes. Sakhare (2001) reported the occurrence of 23 fish species belonging to 7 orders in Jawalgaov reservoir in Solapur district of Maharastra. The fishes belonging to order Cypriniformes were dominant with 11 species to be followed by fishes of order Siluriformes with 4 species, while orders like Osteoglssiformes, Perciformes and Channiformes were represented by 2 species and the rest of orders by single species. Similar observation has also made by Singh (2001), Pisca et al (2000), Salasker and Yeergi (2004) and Srikanth et al(2009). As per the species belongs to the family Cyprinidae shows dominance followed by the family Channidae, Notopteridae, Mastacembelidae, Bagridae and Siluridae. This indicates good correlation with overall species richness across the sites and could be utilized by the biodiversity conservation managers for prioritization of sites of conservation and habitat restoration (Bergerot et al., 2008). The economically important and cultivable fishes like *Notopterus notopterus,*

Table.1 Fish abundance and biodiversity status in Anjanapura reservoir, Shimoga, Karnataka

Sl No	Vernacular Name	Scientific Name	Abundance	Biodiversity	Habitat
		I. Order: Cypriniformes **I. Family: Cyprinidae** **I. Subfamily: Cyprininae**			
01	Agasagitti	*Barilius bendelisis* (Ham-Buch)	A-2	LR-nt	Lotic
02	Bilachi	*Barilius canarensis* (Jerdoni)	A-2	DD	Lotic
03	Arja	*Cirrhinus cirrhosus* (Bloch)	A-1	NA	Lentic & Lotic
04	Mrugala	*Cirrhinus mrigala* (Ham)	A-2	LR-nt	Lentic & Lotic
05	Kemminu	*Labeo calbasu* (Ham-Buch	A-2	LR-nt	Lentic & Lotic
06	Kemminu	*Labeo fimbriatus* (Bloch)	A-1	NA	Lotic & Lentic
07	Rohu	*Labeo rohita* (Ham-Buch)	A-2	LR-nt	Lentic&Lotic
08	Parake meenu	*Osteobrama cotio peninsularis* (Silas)	A-2	NA	Lotic
09	Harige	*Puntius pelchellus*	A-1	NA	Lotic
10	Gende meenu	*Puntius sarana sabnastus* (Valenciennes)	A-2	NA	Lentic&Lotic
11	Gende meenu	*Puntius* sp.*	A-(3-4)	LR-nt	Lentic&Lotic
12	Chachi	*Rohtee ogilbii* (Sykes)	A-2	NA	Lotic
13	Samanyagende	*Cyprinus carpio cummunis* (Linnaeus)	A-2	LR-lc	Lotic
14	Katla	*Catla catla* (Ham-Buch)*	A-2	VU	Lentic&Lotic
		II. Order: Siluriformes **II. Family: Bagridae**			
15	Giralu	*Mystus cavasius* (Ham-Buch)	A-(3-4)	LR-nt	Lentic&Lotic
		III. Family: Siluridae			
16	Gojale	*Ompok pabo* (Ham-Buch)	A-2	NA	Lentic&Lotic
17	Gojale	*Ompok bimaculatus* (Bloch)	A-2	EN	Lentic&Lotic
18	Balemeenu	*Wallago attu* (Schneider)	**A-1**	LR-nt	Lentic&Lotic
		IV. Family: Claridae			
19	Muragodu	*Clarias batrachus* (Linn)	**A-2**	VU	Lotic
		V. Family: Heteropneustidae			
20	Chelumeenu	*Heteropneustes fossili*s (Bloch)	A-(3-4)	VU	Lentic&Lotic
		III. Order: Perciformes **VI. Family: Ambassidae**			
21	Bachanikemeenu	*Chanda nama* (Ham-Buch)	**A-2**	NA	Lentic&Lotic
		VII. Family: Gobidae			
22	Bangisidda	*Glossogibius guiris* (Ham-Buch)	A-(3-4)	LR-nt	Lentic &Lotic
		VIII. Family: Channidae			
23	Avulu	*Channa marulius* (Ham-Buch)	**A-2**	LR-nt	Lentic &Lotic
		IX. Family: Mastacembelidae			
24	Havumeenu	*Mastacembelus armatus* (Lecepede)	**A-0**	LR-nt	Lentic &Lotic
		IV. Order: Osteoglossiformes **X. Family: Notopteridae**			
25	Chamari	*Notopterus notopterus* (Ham)	A-(3-4)	LR-nt	Lentic &Lotic

A-0- Very rare ; A1-rare ; A2-common ; A (3-4) - very common; VU-vulnerable ; NA-Not assessed; DD-Data deficient; LR-nt-Lower risk near threatened; LR-lc-Lower risk least concern

Table.2 Fish diversity indices of Anjanapura reservoir, Karnataka

Diversity indices	**Range**
Shannon – Weiner Index (H)	2.4- 3.0
Simpson's Dominance Index (D)	0.08-0.2
Simpson's Index of Diversity (1-D)	0.89- 0.95
Pielou's evenness	0.6- 0.9
Margalef index	1.48 -2.4

Cyprinus carpio, Catla catla, Glossogobius giuiris, Labeo rohita, Cirrhinus mrigala, Sperata singhala, Sperata oar and *Channa marulius* witnessed that reservoir can exploited for commercial production of fishes for better improvement of socio economic condition of local people.

The diversity index indicates good correlation with overall species richness across the sites and could be utilized by the biodiversity conservation managers for prioritization of sites of conservation and habitat restoration. Bergerot et al (2008) developed indices of fish biodiversity conservation concern, rarity index and fish magnitude values for prioritization of sites for large scale European freshwater basin in France. Lasne et al (2007) used fish zonation and identified indicator species for the evaluation of the ecological status of the Loire basin (France). They also carried out a discriminant analysis on environmental variables revealed that they could be mainly determined by the slope, temperature, and depth.

During study it was found that abundance and diversity of fishes were found to be very high in respect to extent of water body. The maximum numbers of species were recorded from low land areas. According to Shaikh et al (2011) in low and middle land areas fresh water fish diversity was found to be very high. It is due to deep water bodies allow niche segregation in order to enable the fishes to live without facing more intra and inter specific competitions. During summer when maximum level of water decreased due to hot air and high temperature most of fishes migrated toward low land for survival. But during winter season diversity of fish fauna abundant due to clear water, preference of maximum amount of phyto and zooplankton as complain to rainy season. The presence of exotic species in the reservoir may be due to carriage from nearby water bodies by flood water.

The mean air and water temperature values were similar and slightly high during summer season. Prakash et al (2007) have noticed similar observation in Thirparappu reservoir, Kanyakumari. pH is considered as an indicator of overall productivity that causes habitat diversity (Raj and Jayasekhar, 2007). The pH of most the natural water is varied between 6.0 and 8.5. In the present study, the seasonal mean pH was close to neutral. According to Goldman and Horne (1983), low pH < 5.0 can severely reduce aquatic species diversity. However, the range of water pH was reasonably good for fish population. The conductivity values were higher in the summer season due to decreases in the total volume of water, whereas; low in rainy season because of dilution factor(Alam et al., 2007). CO_2 has a great effect on photosynthesis which affect again on fish growth. There is no

Table.3 Seasonal variation of physico-chemical parameters in the water samples of Anjanapura reservoir during 2005-2006

Parameters	Site 1			Site 2			Site 3		
	Winter	**summer**	**Rainy**	**Winter**	**summer**	**Rainy**	**Winter**	**summer**	**Rainy**
Air Temp.	28±2.16	33±0.81	28.5±2.51	28±2.16	33.5±0.57	28.25±3.30	29±2.44	32.75±1.25	28.75±3.77
Water Temp.	25.25±0.5	29±2.16	26.75±1.70	25.25±0.5	29.75±1.89	26.5±1.91	26±0.81	30.25±1.71	27.25±2.87
Turbidity	30.82±22.35	21.75±10.37	52.62±29.23	15.35±3.92	28.7±10.83	49.82±30.57	15.5±4.20	26.25±6.34	56.5±28.38
pH	7.43±0.15	7.62±0.09	7.47±0.15	7.52±0.06	7.63±0.08	7.52±0.14	7.43±0.23	7.65±0.07	7.40±0.22
Alkalinity	51.11±6.61	59.25±2.27	42.78±14.45	56.13±8.33	61.45±1.47	42.58±13.41	55.03±5.92	61.50±2.08	40.08±13.21
EC	133.75±8.38	165.5±13.72	121.35±37.42	136.75±6.89	167±7.39	120.67±35.93	155.75±34.27	169.5±9.74	140.5±21.11
CO_2	2.47±0.74	1.4±0.52	2.55±0.92	2.54±0.91	1.45±0.58	2.63±0.83	2.31±0.47	1.49±0.53	2.68±0.72
DO	7.31±1.53	6.18±1.15	5.79±1.10	7.52±1.02	5.75±0.62	5.72±0.71	8.28±1.50	6.38±0.83	5.72±1.26
COD	8.8±6.34	16.1±9.46	4.50±1.73	12.5±2.88	12.25±6.94	11.5±5.51	10.22±9.25	15.5±9.98	14.75±9.28
BOD	1.01±0.68	2.47±1.40	0.83±0.04	1.17±0.47	1.31±0.67	1.21±0.44	1.18±0.84	2.20±1.39	1.77±1.23
Hardness	50.5±5.0	62.0±11.54	44.00±10.70	47±5.29	62.5±9	48±11.77	56.25±9.53	67.5±12.33	52.5±9.84
Chloride	21.98±0.81	26.59±4.68	20.27±3.00	21.45±2.19	26.57±5.12	21.62±4.81	24.89±1.71	27.65±5.37	23.04±1.36
NO_3	0.108±0.059	0.165±0.03	0.328±0.221	0.13±0.09	0.162±0.04	0.34±0.25	0.120±0.06	0.142±0.026	0.340±0.285
PO_4	0.011±0.008	0.012±0.007	0.009±0.005	0.004±0.002	0.012±0.006	0.007±0.004	0.006±0.003	0.013±0.006	0.009±0.004

All the parameters are expressed in mg/L except temperature (^{o}C), turbidity (NTU), pH, electrical conductivity (µmhos/cm)

Fig.2 Biodiversity status (IUCN-1994) of fishes of Anjanapura reservoir, India

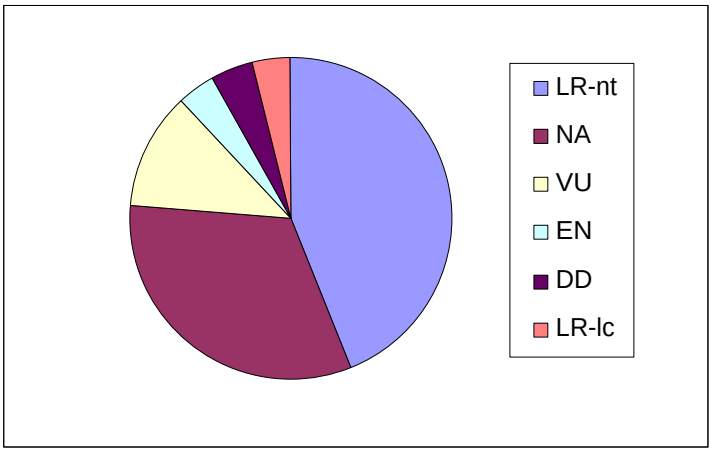
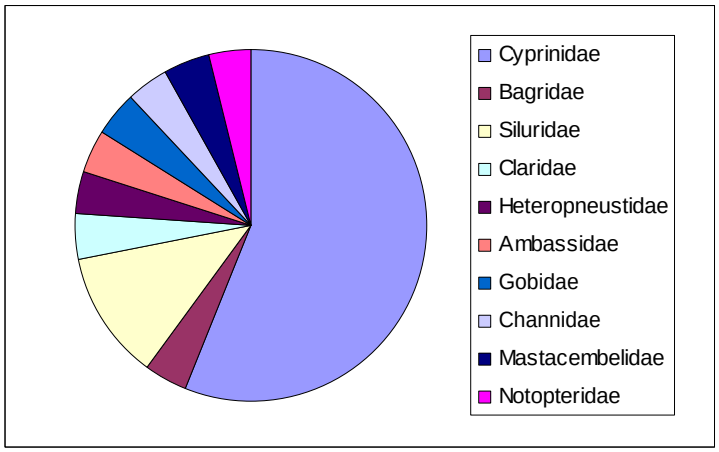


Fig.3 Percentage occurrence of fish families of Anjanapura reservoir, India



much variation in the concentration of free CO_2 throughout the study period. Fafioye et al (2005) have observed similar trend in Omi waterbody Ago Iwoye (Nigeria). Further, free CO_2 more than 20 mg/L is toxic to fish (Battul et al., 2007). The observed values were below 20 mg/L of free CO_2 hence, water is more suitable for fish diversity. Dissolved Oxygen is a primary and comprehensive indicator of water quality in surface water. The decline of dissolved oxygen level has a serious implication for the health of aquatic system. The optimum value for good water quality is 4 to 6 mg/l of DO, which ensures healthy aquatic life in a water body (Santosh and Shrihari, 2008). In the present study, DO level was more than 4 mg/L at all sites. Further, DO level was high in winter followed by summer and rainy season. The reason could be low temperature, turbulence of surface water by high wind action etc. And its level drops in summer due to high metabolic rate of organisms (Salve and Hiware, 2006) and limited turbulence in the reservoir (Mwaura, 2006). BOD value can be used as a measure the degree of water pollution and is useful in evaluating self-purification capacity of a water body.

The seasonal BOD values were slightly high in summer low during winter and rainy season. Higher values of BOD in summer season due to higher microbial activity and elevated temperature (Patel, 1999). As per the hardness values, water belonging to soft (0-60 mg/L) and moderate (60-120 mg/L) category. Seasonal variation of total hardness shows that its concentration was high in summer and more or less similar in other seasons. The high hardness during summer season could be due to reduced water level and increased salts content in water (Kemdirim, 2005). Nitrate (NO_3) is an essential nutrient for aquatic plants in natural waters. An excess concentration of nitrate tends to stimulate algal growth and leads to eutrophic conditions. Seasonal nitrate concentration was high during rainy season at all stations and remained similar in winter and summer season. The higher concentration of nitrate during rainy season could be due to leaching of nitrate from agricultural fields. Phosphorus concentrations above 0.02 mg/L in reservoirs tend to produce algal blooms. However, in the present study, phosphate was below 0.02 mg/L. Its concentration was high in rainy season than summer and winter season. Kemdirim (2005) also reported high nitrate and phosphate concentration in Kangimi reservoir during rainy season coincides with peak surface runoff. The over water quality parameters indicated that water is suitable for fish life in the reservoir.

This ichthyofaunal study indicates that this waterbody is rich in diversified fish fauna consists of native species, economical, cultivable, ornamental and rare species fishes. Changes in fish community, directly or indirectly affect other components of the reservoir ecosystem including physical, chemical and biological characteristics. Habitat loss and environmental degradation has seriously affected the fish fauna. Conservation of fish diversity assumes top most priority under changing circumstances of gradual habitat degradation. Therefore, a sustainable strategies needs to explore more fish species, utilization and save fish community of this reservoir. The study will provide future strategies for development and fish conservation.

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