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Fish diversity in relation to physico-chemical characteristics of Bhadra reservoir of Karnataka, India

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ABSTRACT

The fish community of the Bhadra reservoir in relation to physic-chemical parameters was studied by monthly samples taken from June-2004 to May-2005. This water body is situated at 13°42| N latitude and 75°38| E longitude located near Lakkavalli town of Chikmaglore district, Karnataka and the confluence of the Bhadra River. The water of the reservoir is used for producing electricity, fishery and tourism activities. Fish collections were done with gillnets of standardized dimensions with several mesh sizes. 33 fish fauna identified during the study belongs to Cyprinidae 18 species, Channidae 2 species, Bagridae and Siluridae with 3 species and a species each of Mastacembelidae, Ambassidae, Cichlidae, Claridae, Notopteridae, Cobitidae and Heteropneustidae. Besides identification, relative occurrence and economic importance of fishes are discussed. All fishes are useful as food fishes except Ambassis, Puntius and Gambusia, which are useful as ornamental and larvicidal fishes. The species diversity is peak in post monsoon, coinciding with favorable conditions such as sufficient water and ample food resources. The diversity was low in premonsoon probably due to the shrinkage of the water spread of the reservoir. The high value of dissolved oxygen coupled with low biochemical oxygen demand and other nutrient levels indicate that the water body is moderately oligotrophic in nature. The factors responsible for declining population of fish species is discussed in detail. To save this diversity and to develop a sustainable fishery practices and proper documentation leading to diversity information system is an urgent need.

Keywords : abundance, diversity indices, fish fauna, moderately oligotrophic, water quality.

Abbreviations: ***MSL***, *mean sea level;* ***TMC***, *thousand million cubic feet;* ***APHA***, *American public health association;* ***DO***, *dissolved oxygen;* ***EC***, *electrical conductivity;* ***COD***, *chemical oxygen demand;* ***WHO***, *world health organization;* ***NTU***, *Nephelometric turbidity unit.*

INTRODUCTION

Reservoirs present a good opportunity for studying the effect of scale on the relative importance of factors that determine diversity. On a broad scale, reservoirs are recent and their communities are a combination of species from the former riverine fish fauna as well as introduced species

(Fernando & Holcík 1991; Oliveira & Goulart 2000; Oliveira *et al.*2004). On a regional scale, reservoirs present longitudinal gradients (river-dam) and transversal gradients (upstream downstream of tributaries). Due to irrational fishing practices, environmental aberrations like reduction in water volume, increased sedimentation, water abstraction, and pollution over the years this diversity is on a decline and few species have been lost from the freshwater ecosystem of India and some are belonging under endemic, endangered and threatened category. The freshwaters of India have been viewed from a single perspective: that of economic production. They are to be sources of irrigation or urban-industrial water supply or of hydro power; they are to receive sewage and industrial waste; they may produce edible fish (Bhakta & Bandyopadhyay 2008).

The country is endowed with vast and varied resources possessing river ecological heritage and rich biodiversity. Freshwater fishery sites are varied like 45,000 Km. of rivers, 1, 26,334 Km. of canals, ponds and tanks 2.36 million ha and 2.05 million ha of reservoirs (Ayyapan 2004). About 21,730 species of fishes have been recorded in the world of which, about 11.7% are found in Indian waters. Out of the 2546 species so far listed (ICBD 1994), 73 (3.32%) belong to the cold freshwater regime, 544 (24.73%) to the warm fresh waters domain, 143 (6.50%) to the brackish waters and 1440 (65.45%) to the marine ecosystem. The Indian fish fauna is divided into two classes, viz., Chondrichthyes (cartilage fishes) and Osteichthyes (bony fishes). The endemic fish families form 2.21% of the total bony fish families of the Indian region. 223 endemic fish species are found in India, representing 8.75 % of the total fish species known from the Indian region.

The Western Ghats is the richest region in India with respect to endemic freshwater fishes. Northeastern India, which has a very high diversity among freshwater fish, does not have many endemic species within India because of its jagged political boundary. There are about 450 families of freshwater fishes globally. Roughly 40 are represented in India (warm freshwater species). About 25 of these families contain commercially important species. Number of endemic species in warm water is about 544. Freshwater fishes are a poorly studied group since information regarding distribution, population dynamics and threats is incomplete, and most of the information available is from a few well-studied locations only (Zooreach organization 2010; Sabuj Kumar Chaudhuri 2010).

India's inland water resources are diversified, as they are plentiful. Reservoirs contribute the single largest inland fishery resources both in terms of size and production potential. Fish fauna of a reservoir basically represents the fish diversity and their abundance. Indian reservoirs preserve a rich variety of fish species, which supports to the commercial fisheries. The objectives of the present study were to document the fish species in relation to physico-chemical characteristics of water and suggest appropriate conservation and management strategies.

MATERIALS AND METHODS

Description of the Study Area

Bhadra reservoir is located at Chikmagalore district of Tarikere taluk near Lakkavalli village, of Karnataka. The reservoir is situated at $13^0 42^{|} 00^{||}$ N latitude and $75^0 38^{|} 20^{||}$ E longitude. It is located at an elevation of 601 m above Mean sea level. The Bhadra River arises from Varsala hills (Ganga Moola). This is multipurpose project for power generation as well as for irrigation. The Bhadra basin gets the inflows from the south west monsoon (June-September) and North-east monsoon (October-December). The catchment area at site is about 1968 Sq.km. the average rainfall of that area is 117 cm to 513 cm. The depth of the reservoir is about 186 feet and total length is 1445 feet. Reservoir is designed to impound 61.70 TMC of water to irrigate an area of

1, 05,570 ha of land in Chikmagalore, Shivamogga, Chitradurga and Bellary district. The water of the reservoir is used for drinking, fisheries, irrigation and also for producing electricity. The climate of this area is moderately cool.

The fishes were collected from the Bhadra reservoir with the help of local fishermen during the year June 2004 to May 2005. The fishes were preserved in 10% formaldehyde solution for taxonomic analysis. Identification and economic importance of fishes was carried out with the help of standard literature (Day, 1951; Jayaram, 1981; Datta Munshi and Shrivastava, 1988; Talwar and Jhingran, 1991).

Fish diversity was subjected to diversity analysis using the index like Shannon-Weaver index (1949).

$$H^{!} = S/I = 1(\text{sum (pi) (Log 2 pi)}$$

Where $H^{!}$= Shannon-Weaver index, sum represents a capital epsilon
S=number of species, pi= proportion of individuals of the total sample belonging to the i^{th} species calculated as ni/N for each i^{th} species with ni being the number in species I and N, the number of individuals in the sample.

Water samples were collected between 8 Am to 11 Am and further transported to the laboratory immediately for further analysis. Water temperatures was measured at the time of sampling using mercury thermometer, pH was measured with standard pH meter (Global DPH 500), while other parameters were analyzed in the laboratory according to the methods suggested by Trivedy and Goel (1986) and APHA (1998).

RESULTS AND DISCUSSION

The diversity of the fishes mainly depends upon the biotic and abiotic factors and type of the ecosystem, age of the water body, mean depth, water level fluctuations, morph-metric features and bottom have great implications. The hydro-biological features of the collection centers also play an effective role in fisheries output to a greater extent. Among 33 species of fishes, the family Cyprinidae was the most dominant in the assemblage composition with 54.55% followed by Bagridae and Siluridae with 9.09%, Channidae with 6.06 %, Mastacembalidae, Ambassidae, Cichlidae, Claridae, Notopteridae, Cobitidae and Heteropneustidae each with 3.03 % respectively (**Fig.1**). The present results get support from other workers like Wakid and Biswas (2005) and Venkatshwarlu *et a*,(2007).

Percentage composition of various fish groups of Bhadra reservoir is showed in **Fig. 2.** Cat fish groups were the most dominant with 25 % followed by major carps and other fishes with 20.83 %. Murrels and carp minnows showed 8.33 % and rest of the groups with 4.17 % respectively.

Table 1 depicts biodiversity status, abundance and habitat of fishes of Bhadra reservoir. During the period of one year investigation (June 2004 to May 2005), 33 fish species belonging to 10 families were recorded of which cyprinidae was dominated by 18 species followed by Bagridae and Siluridae with 3 species, Channidae of 2 species and species each of Mastacembalidae, Ambassidae, Cichlidae, Claridae, Notopteridae, Cobitidae and Heteropneustidae **(Table 2)**

Lagler (1956) classified the fish species on the basis of their economic importance. However, **Table 3** shows the similar trend in Bhadra reservoir of Karnataka. Ahirrao and Mane (2000)

recorded 32 fish species belongs to 25 genera and 8 families belonging to 2 orders from fresh waters of Parbhani district of Marathwada region of Maharashtra state. Sakhare (2001) identified 23 fish species belonging to 7 orders in Jawalgaon reservoir in Solapur district. Hiware and Pawar (2006) recorded 43 fish species from Nath Sagar dam, Pathan, in Aurangabad district. In a study from neighboring state of Andhra Pradesh Savalla Murli Krishna and Piska (2006) recorded 31 fish species from secret lake Durgamcheruvu, Ranga Reddy district near Hyderabad.

The species of *Clarias* , *Channa* , *Mastacembelus* , *Heteropneustes* , etc, have air breathing organs and fetch good market value as live fish. *Puntius*, *Ambassis* and *Nemacheilus* species have ornamental value due to small size and bright colors and can are used as aquarium fishes. *Gambusia* sp is used as larvivorous fish. However, *Labio calbasu* found to be rare species in the present study. With the onset of Southwest monsoon, heavy influx of freshwater occurs in the reservoir in early July developing a freshwater isostatic habitat. Consequently, the high floods during monsoon changes the entire system. The human anthropogenic activities and over exploitation leads to rapid decline in the fish diversity. Though commercially important species are available they are not abundant to make fishery commercial and economical. Conservation measures require afforestation in catchment and awareness on illegal fishing and killing of brood fishes and juveniles.

The present study of fish fauna in Bhadra reservoir showed that most of the fish species recorded were widely distributed in the streams and rivers of Western Ghats. The fish species like *Cirrhinus fulungee, Salmostoma, Rasbora* and *Puntius* groups were more dominant. Therefore, the present investigation reveals that Cyprinid fishes are found to be the more dominant group than others which is supported by other studies also (singh *et al*., 2006).

The fish species recorded from Bhadra reservoir, the following are considered as economically important and cultivable fishes including *Notopterus notopterus, Cyprinus carpio, Oreochromis mossambica, Labeo rohita, Cirrhinus mrigala, Catla catla, Sperata seenghala, Sperata oar, Channa striatus and Channa marulius.* The current study has also shown that the reservoir inhabit the ornamental fishes like *Puntius sophore, Puntius deucanensis* and *Puntius filamentosus.*

Arya *et al*., (2001) have reported the presence of breeding grounds of some species viz., *Ompok bimaculatus* , *Labeo fimbriatus* , *Labeo calbasu* and major carps in the Indira sagar reservoir stretch. Which are likely to be disappeared due to dam construction. The loss of breeding grounds of these fishes would have a negative impact on the population of these fishes in reservoir area.

Wilson (1988) pointed out that changes in habitat caused due to dam formation often limit the lotic fish fauna to the upper unimpounded reaches of the river. This view indicated that the upstream river stretch and its tributaries could play an important role in survival of native fish fauna. Three exotic species viz., *Cyprinus carpio, Ctenopharyngodon idellus* and *Oreochromis mossambicus* recorded in the present study were not recorded in earlier surveys. This might be due to accidental entry from some fish farms in the basin during rainy season. Moreover, stocking of seed in the near by farm of the reservoir might be a source of the exotic species. However due attention should be paid to the presence of these species, as they may dominate and even eliminate the native fish fauna of the reservoir. An example of such domination has been witnessed in Gobindsagar where exotic carp has established itself as dominant species.

The study findings showed that fish diversity of the study area is reducing with the increase of water quality. The reduced fish diversity eventually decreases the fish production of native species and creates extinction of several species. These consequences eventually create instability in the socio-economic sector of the study area in terms of increased poverty of local fishermen. It reveals that, a rapid decline in fish diversity at discharged zone (polluted) of the Bhadra River. Such observation has also been confirmed by Koul (2000). In the polluted stretch of the Bhadra River tolerant species such as *Oreochromis mossambicus* is thriving well and commercially important and sensitive native species such as *Wallago attu*, *Labeo calbasu*, *Puntius* sp. etc, are considered to be threatened by increasing water pollution. This investigation would be used as a tool for controlling the water pollution at Bhadravathi town and conserving the fish species in the Bhadra River.

Fig. 3 depicted the Shannon-Weiner index for fish diversity in Bhadra reservoir. Its values are ranging from 2.2 to 4.10. Pereira (2000) used this same index to evaluate the diversity of Camaleao Lake, finding values varying from 3.9 to 4.1. In Central Amazonian lakes, Barthem (1981) found variation in the Shannon index of from 2.2 to 3.2.

The species diversity was at its peak in post monsoon ($H^{|}$ = 4.1) coinciding with the favorable post monsoon conditions such as sufficient water and ample food resources. The diversity was low in pre monsoon ($H^{|}$ = 2.2) probably due to the shrinkage of water spread of the reservoir. Species richness was at its best in the month of July while species evenness ($J^{|}$ = 0.99) was highest in late monsoon indicating on evenly distributed and rich fauna in the monsoon and post monsoon, respectively.

The water quality data is depicted in **Table 3**. Water temperature ranged from 26^{o}C to 28.9^{o}C throughout the study period. Highest water temperature was recorded during summer season (28.9^{o}C) whereas least was observed in winter season (26.10^{o}C). Turbidity is due to the presence of suspended matter, silt, clay, colloidal particles, plankton, and other microorganisms (Kataria *et al*. 1996). High turbidity was observed on an average of 7.33 NTU during winter season and least was noticed in summer season (6.00 NTU).The pH was observed in the range of 7.3 to 7.65 which indicates that water was slightly alkaline in nature. The total alkalinity ranged from 32 to 40 mg/l and it was highest during rainy season.

Electrical conductivity (EC) of an aqueous solution is a measure of the ability to carry out an electric current (Parashuram and Singh 2007). EC ranged between 59 to 71.60 µmhos/cm. High electrical conductivity was recorded during rainy season. This may be due to greater ionic concentration of the inlet flow (Prithwiraj Jha and Sudip Barat 2003). Total dissolved solids (TDS) test measures the amount of particles that are dissolved in water. The WHO standard is 1000 mg/l. TDS in excessive amounts may be unsuitable for aquatic life and crop irrigation. The TDS ranged from 36 to 43.67 mg/l. Seasonal analysis reveal that TDS values were low during winter and high during monsoon. Similar results were also reported by Narain and Chauhan (2002).

Dissolved oxygen (DO) is the most important parameter which can be used as an index of water quality, primary production and pollution. DO values ranged from 6.2 to 7.18 mg/l. Minimum values of DO were recorded during summer season and maximum during winter months. Minimum DO in months may be due to high metabolic rate of organisms. Maximum DO may be due to low atmospheric temperature. Similar trends were made by Adebisi (1981) and Deshmukh and Ambore (2006). The DO level (75 mg/l) of reservoir water may be favorable for aquatic organisms (Rajashekara *et al*. 2007).

Biochemical oxygen demand has been used as a measure of the amount of organic materials in aquatic solution, which support the growth of micro organisms. Biochemical oxygen demand values ranged from 0.5 to 2.75 mg/l. Maximum values during winter was probably due to presence of high amount of organic matter brought in by the surface run off of heavy rain (Rice 1938). During rainy season, Biochemical oxygen demand values were low; this is because the temperature retards the rate of reproduction of organisms. Similar observations were also made by Mane and Madlapure (2002) from Manar river district Nanded. Total hardness is a measure of the capacity to precipitate soap. It is the sum of the polyvalent cations present in water. The total hardness ranged from 25 to 33.83 mg/l. Maximum hardness was recorded during rainy season due to surface runoff. The total hardness values were within the permissible limits prescribed by WHO.

Chlorides are important in detecting the concentration of ground water by waste water. In the present study, the chloride value ranged between 9.0 and 14.03 mg/l. Similar results were observed by Damodharan and Suresh (2005). Chemical oxygen demand (COD) test is useful in pin pointing toxic conditions and presence of bio-chemical resistant substances. In the present investigation COD was maximum during summer season and minimum in rainy season indicate lower microbiological activities and presence of oxidisable matter in the water body. Nutrients like phosphate, nitrate, calcium, magnesium, and ammonia were in low level, indicates the moderately oligotrophic status of the water body.

Apart from agriculture, all other human activities are negligible considering pollution factor in the catchment area agriculture is the main activity with significant usage of fertilizers and pesticides. These pollutants ultimately reach the reservoir due to run off. Even though there is no possibility of a high pesticide level in the reservoir water, in the higher order organism like fishes it becomes significant due to bio magnification. Thus, it shows that there is a great need for measuring the effect of pesticide on aquatic species.

Threats to the fisheries

Without determining the carrying capacity and productivity of the reservoir enormous amount of fish seeds were introduced during the early 90s. In the absence of any baseline data on fisheries, it is hard to quantify the impact due to improper introduction. Even then by looking at the present condition it becomes clear that it has negatively affected the total fish fauna. Introduction of Tilapia (*Oreochromis mossambica)* is slowly gaining its phase in Bhadra reservoir. As per the local fishermen, the catch of *Tilapia* is increasing over the years. The catch starts at the post monsoon period and during November, it dominates the entire catch. Due to least demand for this fish in local market, fishermen treat this fish as an unwanted catch. Scientifically, this fish is regarded as a hardy, territorial and a powerful competitor in nature. Ecologically, these fishes have adverse effect on the indigenous fish species.

Fish conservation measures in the reservoir

Having a regulated fishing net mesh size which will only catch adults and exclude juveniles is recommended. This will ensure the full recruitment of the young to adult stage. A mesh size of above 17 cm is highly advocated. Regulation of the fishermen and prevention of over fishing will also enable the species to be conserved in the reservoir. Fish species are mostly caught in the dry season and found in the little vegetated food plain areas of reservoirs, it will be better if the vegetation of the areas is increased and protected from fishing activities (Crivelli 2002) reported that conservation of freshwater fishes would be better served by developing protected areas.

Intensive fishing of the species in the dry season should be discouraged or totally prohibited (Mustapha 2010).

Fisheries laws and policies which prohibit obnoxious fishing practices, overexploitation of the species, detrimental human impacts on the watershed and water body, introduction of exotic fishes and other habitat degradation and stock decimation activities should be enacted and enforced. Provision of better spawning ground, shallow habitat and prevention of flood will greatly ensure the conservation of fish species in the reservoir. This is appropriately applicable because of the lapses in the recruitment of the species as noted by Lewis, *et al.*, (1996). Conservation of the species could be done by stocking of the species juveniles and culturing of the species in the reservoir. This will ensure the abundance of the species, protect its genetic variability, improve yield, rehabilitate the decimated stock and help to maintain a balanced population of the species. According to (Quiros 1999), stocking improves, maintains and conserves stocks. Although this method could be difficult to enforce, it is one method that could be emphasized to fishermen to release caught species back in to the water in order to save the species from extinction. Though non-native or alien fish species have been recorded in the reservoir, it will be desirable to control the accidental or deliberate introduction of non-native species in the reservoir (Mustapha 2010).

The best approach to the conservation of the species is to disseminate conservation information, education and practices to fishermen and other stakeholders about the danger of extinction of the species and the need for its conservation. This will go a long way towards protecting and preserving the species. Prevention now is not only better, but also cheaper than looking for ways of recalling the lost species. Once extinction occurs, it could not be easily reserved or recalled. To this, fish biologists, limnologists, aquatic ecologist and conservationists have a major role to play in creating public awareness and support for the conservation mechanisms for the species (Cambray and Pister 2002) pointed out the need for scientists to generate awareness for the conservation of fish species. This study highlighted the need for stake holders to watchful of autogenic and anthropogenic threats, activities and harmful practices which may cause the extinction of fish species in the Bhadra reservoir as well as in the freshwater system of Karnataka and the effects of this extinction, and the ways by which it could be prevented. A holistic approach to the conservation of fish species in the reservoir would be to integrate its conservation management strategies in to its water quality and production management programs. This would enable the evaluation of the present and future conditions of the species in the reservoir and its ability to sustain present and future exploitation. A picture is beginning to emerge in the reservoir where multi interest use of the reservoir for drinking water supply and fish production will become inevitable.

With the rapid increase in the human population and the increasing dependence on aquatic fishery resources including water and the continuing introduction of exotic species in natural water bodies, the loss of aquatic fish diversity is likely to increase further unless proper conservation measures are implemented. Detailed investigations should be initiated to locate the impact of all the introduced species in the present water body, followed by steps to eradicate the deleterious species (Bijukumar 2000). Any deviation would lead to further erosion of biodiversity that would be detrimental for fisheries and environment as a whole.

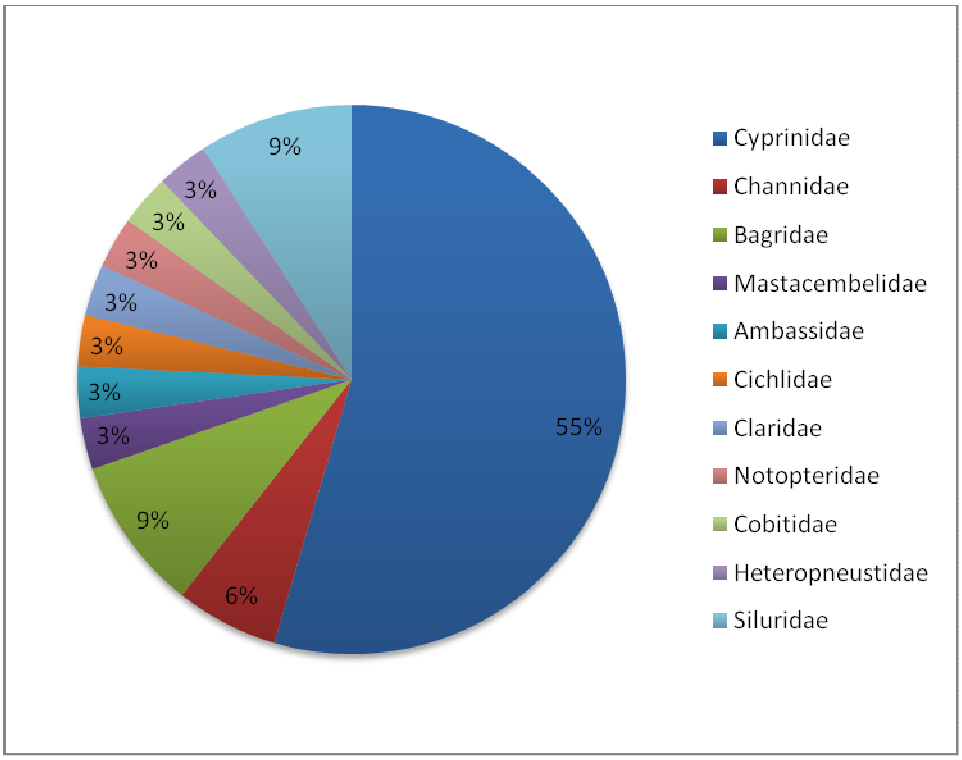

FIGURE 1. Percentage occurrence of fish families of Bhadra reservoir, India

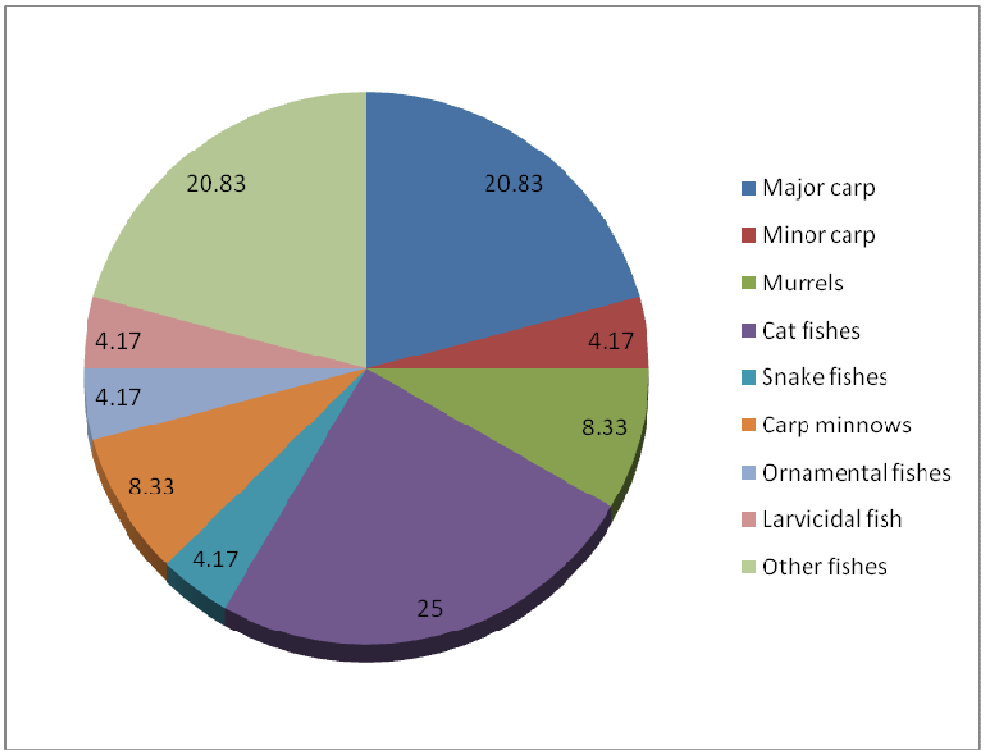

FIGURE 2. Percentage of various fish groups in Bhadra reservoir, India

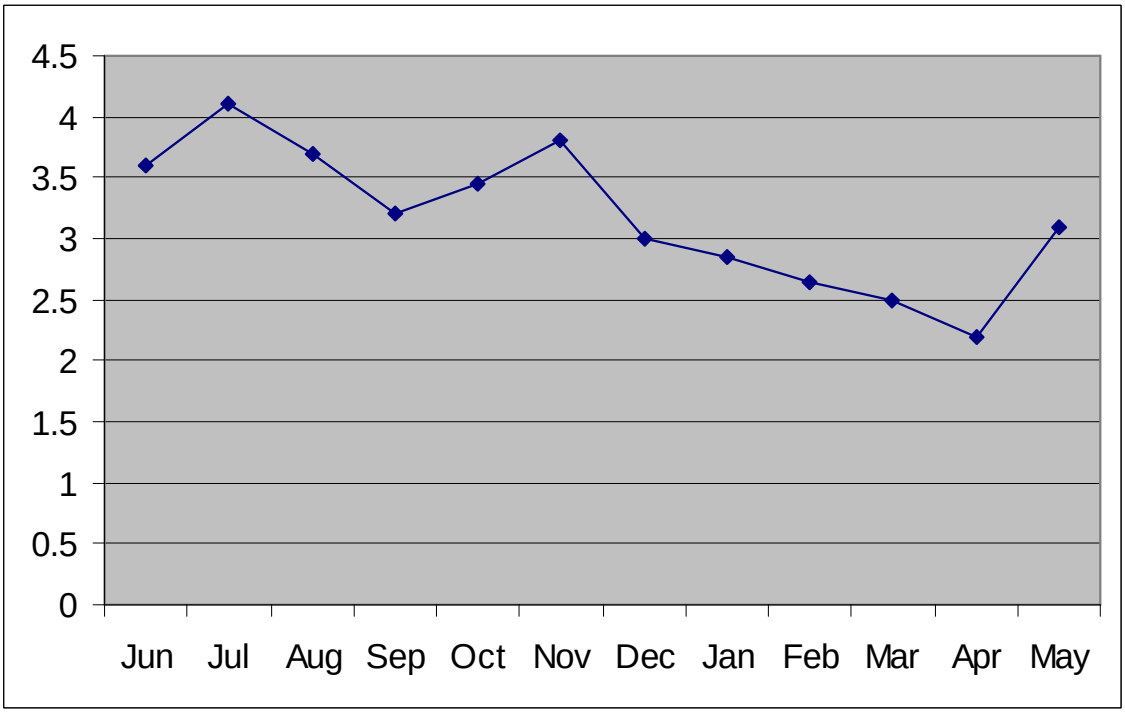

FIGURE 3. Monthly variations in diversity index (Shannon-Weiner index) of fish species in Bhadra reservoir

Table 1. Biodiversity status, abundance and habitat of fishes of Bhadra reservoir, India

Species	Vernacular name/ Local Name	Biodiversity status IUCN-1990	Abundance	Habitat
Labeo rohita	Rohu	LR-nt	A-2	Lotic & Lentic
Notopterus notopterus	Chamari	LR-nt	A(3-4)	Lotic & Lentic
Catla catla	Catla	VU	A-2	Lotic
Cirrhinus mrigala	Mrigal	LR-nt	A-2	Lentic & Lotic
*Cirrhinus fulungee**	Arja	LR-nt	A(3-4)	Lentic & Lotic
Cyprinus carpio	Gowri	LR-IC	A-2	Lentic
*Salmostoma untrahi**	Bilachi	NA	A-2	Lotic
Puntius sophore	Gudda-pakke	LR-nt	A-(3-4)	Lentic & Lotic
Puntius filamentosus	Kijan	NA	A-2	Lotic & Lentic
Nemacheilus striatus.	Kallumullu meenu	DD	A-1	Lotic
Channa striatus	-	NA	A-2	Lentic & Lotic
Channa marulius	Avalu	LR-nt	A-2	Lotic & Lentic
Wallago attu	Balae	LR-nt	A-1	Lotic & Lentic
Mystus cavasius	Girlu	LR-nt	A-(3-4)	Lentic & Lotic
Labeo kawrus	-	NA	-	-
Labeo calbasu	Karae-Kolasa	LR-nt	A-2	Lotic & Lentic
Labeo fimbriatus	-	NA	A-1	Lentic & Lotic

Osteobrama neilli	Koona	EN	A-2	Lotic
Osteobrama cotiocunma	Parake	VU	A-2	Lotic
Puntius deucanensis	Smaal gende	NA	A-1	Lentic & Lotic
Hypophthalmichthys molitrix	Belli Gende	NA	A-2	Lentic
Ctenopharyngodon idella	Hullugende meenu	NA	A-1	Lentic & Lotic
Gambusia sp.		NA	A-1	Lentic
Clarias batrachus	Muragodu	VU	A-2	Lotic
Heteropneustes fossilis	Chaelu	VU	A-(3-4)	Muddy, Lotic & Lentic
Ompok pabo	Gogalae	EN	A-2	Lotic & Lentic
O.bimaculatus	Gogalae	EN	A-2	Lotic & Lentic
Mastacembalus armatus	Haavu Meenu	LR-nt	A-(3-4)	Lotic & Lentic
Ambassis kopsii	Bachanige meenu	NA	A-2	Lentic
*Oreochromis** mossambica*	Jilebi	NA	A-(3-4)	Lower reaches of Lotic & Lentic
Spectra oar	Kappu Suragi	VU	A-2	Lentic & Lotic
Sperata seenghala	Bili Suragi	NA	A-2	Lotic & inundated fields
Danio. Sp	Saslu	LR-nt	A-(3-4)	Lotic & Lentic

Abundance: A1-rare, A2-common, A (3-4) - very common; EN= Endangered; DD=Data deficient; LR- Ic=Lower risk least concern; LRnt = Lower risk-near threatened; VU= Vulnerable; NA = not assessed.

Table 2. Ichthyofauna collected from Bhadra reservoir of Karnataka

Classification	Scientific name of the fishes
Class : Pisces	*Notopterus notopterus*
Subclass : Teleostei	
Order : Clupeiformes	
Family : Notopteridae	
Order : Cypriniformes	*Cyprinus*
Family : Cyprinidae	*Catla catla*
	Cirrhinus mrigala
	Cirrhinus fulungee
	Labeo rohita
	L. kawrus
	L. calbasu
	Labeo fimbriatus
	Osteobrama neilli
	O. cotiocumma
	Puntius sophore
	P. filamentosus
	P.deucanensis
	Hypophthalmichthys molitris
	Ctenopharyngodon idella
	Salmostoma untrahi
	Danio sp.
Order : Cyprinodontiformes	*Gambusia sp.*
Family : Cobitidae	*Nemacheilus sp.*

Family : Claridae	*Clarias batrachus*
Order : Siluriformes	*Sperata aor*
Family : Bagridae	*Mystus cavasius*
	S. *seenghala*
Family : Heteropneustidae	*Heteropneustes fossilis*
Family : Siluridae	*Wallago attu*
	Ompok pabo
	O. bimaculatus
Order : Channiformes	*Channa striatus*
Family : Channidae	*C. marulius*
Order : Mastacembaliformes	*Mastacembalus*
Family : Mastacembelidae	*armatus*
Order : Perciformes	
Family: Ambassidae	*Ambassis kopsii*
Family : Cichlidae	*Oreochromis mossambica*

Table 3: Economic importance of fishes recorded from Bhadra reservoir

Species	Commercial	Fine Food	Coarse Food	Aquarium Fishes	Others
Labeo rohita	✓	✓			
Notopterus notopterus			✓		MD
Catla catla	✓	✓			
Cirrhinus mrigala	✓	✓			
*Cirrhinus fulungee**		✓	✓		
Cyprinus carpio	✓				
*Salmostoma untrahi**		✓			
Puntius sophore			✓	✓	Bt,LV,WF
Puntius filamentosus			✓	✓	Bt,LV,WF
Nemacheilus sp.			✓	✓	
Channa striatus	✓	✓			LV, PF
Channa marulius	✓	✓			LV, PF
Wallago attu	✓	✓			PF
Sperata seenghala	✓	✓			PF
Mystus cavasius	✓	✓			PF
Labeo kawrus		✓			
Labeo calbasu		✓	✓		
Labeo fimbriatus		✓			
Osteobrama neilli		✓	✓		
Osteobrama cotiocunma		✓			
Puntius deucanensis			✓	✓	Bt, LV,WF
Hypophthalmichthys molitrix	✓	✓			
Ctenopharyngodon idella	✓	✓			
Gambusia sp.			✓	✓	LV
Clarias batrachus		✓			PF
Sperata aor	✓	✓			PF
Heteropneustes fossilis	✓	✓			PF
Ompok pabo	✓	✓			PF
O.bimaculatus	✓	✓			PF
Mastacembalus armatus	✓	✓			PF
Ambassis kopsii			✓	✓	WF
*Oreochromis** mossambica*		✓	✓		
Danio sp.		✓	✓		

*LV-Larvivorous fish, Bt-Bait, MD-Medicinal value, WF-Weed fishes, PF-Predatory food fishes, *- abundant species, **- Exotic species.*

Table 4 : Seasonal variations of physico-chemical parameters of Bhadra reservoir

Parameters	Rainy	Winter	Summer
Water temperature (^{0}C)	26.12	26.10	28.90
pH	7.65	7.47	7.34
Turbidity (NTU)	6.7	7.33	6.00
Electrical conductivity (µm hos/cm)	71.60	59.38	71.57
Total solids (mg/l)	290.83	337.00	223.00
Total suspended solids (mg/l)	247.15	300.55	170.16
Total dissolved solids (mg/l)	43.67	36.44	39.45
Chloride (mg/l)	12.89	9.05	14.03
Total hardness (mg/l)	33.83	25.50	27.00
Total alkalinity (mg/l)	40.00	32.75	37.25
Nitrite (mg/l)	0.11	0.19	0.37
Ammonia (mg/l)	0.0050	0.0085	0.0230
Dissolved oxygen (mg/l)	7.01	7.18	6.24
Bio chemical oxygen demand (mg/l)	0.55	2.75	1.00
Phosphate (mg/l)	0.0020	0.0010	0.0025
Calcium (mg/l)	6.86	5.70	5.30
Magnesium (mg/l)	6.36	4.44	6.56
Free carbon dioxide (mg/l)	7.25	12.25	7.50
Chemical oxygen demand (mg/l)	1.77	2.65	3.32

CONCLUSION

India is one of the mega diversity countries with respect to freshwater fish species (650+species). In freshwater fish diversity India is eighth in the world and third in Asia (Kottelat and Whitten 1996). There are plenty of cultivable species and any further introduction of exotic fish species is unnecessary. The need of the hour is to protect the existing indigenous fish stock and steps for enhancing the quality of the culturable species rather than go in for indiscriminate introduction of exotic species (Molur and Walker 1998; Bijukumar 2000).The indigenous fishes should also be incorporated into the value systems of the society (sport, biological control, aesthetic, etc) Fishes such as *Gambusia* sp. are effective in mosquito control. Similarly, there are several slanderously coloured native ornamental fishes (Harishankar and Bijukumar 1998). India has to develop baseline data on the natural population potential of the indigenous species. Extreme risk areas should be identified for effective monitoring and conservation programs. The water bodies harboring endangered fishes must be declared as fish sanctuaries or aquatic diversity management areas.

Presently, our freshwater fish diversity in Bhadra reservoir is in peril. Checking the entry of exotic species coupled with more awareness on the indigenous species would go a long way in preserving our rich reservoir fish diversity.

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