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ORIGINAL RESEARCH ARTICLE

Fish Diversity In Relation To Physico-Chemical Characteristics of Kamala Basin of Darbhanga District, Bihar, India

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ABSTRACT

The fish community of the Kamala basin reservoir in relation to physico-chemical parameters was studied by quarterly samples collected from June-2010 to May-2011. The water of the reservoir is used for producing electricity, fishery and livestock activities. Fish collections were done with gillnets of standardized dimensions with several mesh sizes. 35 fish fauna identified during the study belongs to 22 family few includes Cyprinidae 31 species, Cobitidae 4 species, Ophiocephalidae 4 species, Bagridae 6 species etc. Besides identification, relative occurrence and economic importance of fishes are discussed. All fishes are useful as commercial, predatory food fishes, 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 pre-monsoon 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 and Water quality.

1. INTRODUCTION

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. 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, 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. Also 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 [1,2].

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. Reservoirs present a good opportunity for studying the effect of scale on the

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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 [3,4,5]. 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 [6]. 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.

Description of the Study Area

The reservoir is situated at latitude 260 27' 26.81 North and longitude 860 11' 20.98 East. It is located at an elevation of 601 m above msl. The kamala basin gets the inflows from the north east monsoon (June-September). The catchment area of the study site is about 1.6 km at a stretch. The average rainfall of that area is 105 cm. The water of the reservoir is used for fisheries, and irrigation. The climate of this area is extreme ends of both warm and cool. The water of the reservoir is used for drinking, fisheries, irrigation and also for producing electricity. The climate of this area is moderately cool.

2. METHODOLOGY

Fish collections were done during the year June 2010 to May 2011 from the Kamala reservoir with the help of local fishermen using gillnets of standardized dimensions with several mesh sizes. 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 [7,8,9,10].

Fish diversity was subjected to diversity analysis using the index like Shannon-Weaver index. $H^! = S/I = 1(\text{sum}(pi)(\text{Log } 2\ pi)$ 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 A.M to 11 A.M and 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)[11] and APHA (1998)[12].

3. RESULTS AND DISCUSSION

Species Diversity

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 35 species of fishes, the family Cyprinidae was the most dominant in the assemblage composition (**Table 1**) Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Catla (*Catla catla*), Big head (*Aristichthys nobilis*), Saura (*Channa maurulius),* Pothia (*Puntius chola*), Pothia (*Puntius savanna*), Gonch (*Bagariu bagarius*), Garai (*Channa straitus*), Mangur (*Clarias batrachus*), Chelwa (*Chelo at par*), Kauwa (*Xentodon concilla*), Rita (*Rita rita*), Boari (*M. Seenghata*), Boari (*M. aor)* Tetrodon cutcutia, Darhi (*Nandus nanduso*). In addition to fishes, other aquatic organism like Pryla, Tortoise, Snake, Crab, Unio, Garai, Kaua, *Ailia colia* were also found during the summer season.

The diversity of fishes and other aquatic organisms found during monsoon were Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Catla (*Catla catla*), Katri (*L. calbasu*), Saura, Garai (*C. punctatus*), Boari (*M.Seenghala*), Garai, Suhia, Chechra, Pothia,Tengra (*Mystus Tengara*), Boari, Colisa (*Colisa asiatus*), Reba (*Cirrhiunus reba*), Bata (*Labeo bata*), Gora (*Oxygastor gora*), Chenri (*Chanda nama*), Chenri (*Chanda ranga*), Darhi, Pyla, Tortoise large Snake, Bulla (*Glossogobius giuriso),*Unio *Pangesius pangeius*. Similarly the aquatic organisms of winter season were Rohu, Naini, Catla, Big head, Silver carp, Suhia (*Gudusia chopra*), Chechra (*Ompak bimatulam*), Boari (*Mystus seenghala*), Boari (*Mystus aor),* Pothia, Tengra, Boari, Chela (*Chela atpar*), Singhi (*Heteropneustus fossilis*), Jhinga (*Macrobrachium maleolmsonii*), Chonda (*Changa nama*), Chanda

(*Chanda ranga*), Bhunna (*Noropterus notopterus*), Bhu chatti (*Notopknus chitala*), Bata, Reba, Nandius nandus, Pyla, Tortoise, Snake, Crab, Unio, *Glossogobius giuris.*

Cat fish groups were the most dominant with 35 % followed by major carps and other fishes with 22%. Murrels and carp minnows showed 9 % and rest of the groups with 5% respectively. The present study of fish fauna in Kamala reservoir showed that most of the fish species recorded were widely distributed in the streams and rivers. 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 [13]. The fish species recorded from Kamala reservoir, the following are considered as economically important and cultivable fishes including Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Catla (*Catla catla*), Big head (*Aristichthys nobilis*), Saura (*Channa maurulius).* The current study has also shown that the reservoir inhabit the ornamental fishes like Pothia (*Puntius chola*), Pothia (*Puntius savanna).* Arya *et al*. (2001)[14] have reported the presence of breeding grounds of some species *viz*., *Ompok bimaculatus* , *Labeo fimbriatus* , *Labeo calbasu* and major carps in the reservoir stretch which are likely to be disappeared. The loss of breeding grounds of these fishes would have a negative impact on the population of these fishes in reservoir area.

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 Kamala River. Such observation has also been confirmed by Koul (2000)[15]. In the polluted stretch of the Kamala 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 and conserving the fish species in the Kamala River.

Shannon-Weiner index for fish diversity in Kamala reservoir. Its values are ranging from 2.2 to 4.10. Pereira (2000)[16] 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)[17] 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.

Table 1: Fish diversity and its availability

Fish	Season	Catchment %			Economic importance		
		>20 - 30	>6 – 10	>5	C	F	Others
Labeo rohita	S,M,W	*			*	*	
Cirrhinus mrigala	S,M,W	*			*	*	
Catla catla	S,M,W	*			*	*	
Aristichthys nobilis	S,W	*					
Channa maurulius	S,M	*			*	*	LV,PF
Puntius chola	S		*				LV, AF
Puntius savanna	S,M,W		*				LV, AF
Bagariu bagarius	S	*	*				
Channa straitus	S	*	*		*	*	
Clarias batrachus	S	*	*			*	PF
Chelo atpar	S,W		*				
Xentodon concilla	S		*				
Rita rita	S		*				
Mystus seenghala	S,M,W	*	*		*	*	PF
M. aor	S,W	*	*				
Tetrodon cutcutia	S			*			
Nandus nanduso	S,M,W			*			
L. calbasu	M	*				*	
C. punctatus	M	*					
Mystus Tengara	M		*				
Colisa asiatus	M		*				

Cirrhiunus reba	M,W		*				
Labeo bata	M,W		*				
Oxygastor gora	M		*				
Chanda nama	M,W		*	*			
Chanda ranga	M,W		*	*			
Gudusia chopra	M,W	*					
Ompak bimatulam	M,W	*					
Heteropneustus fossilis	W		*		*	*	PF
Noropterus notopterus	W		*				MD
Notopknus chitala	W		*				
Cyprinus carpio	W	*			*		

C-Commercial, F-Food, S-Summer, M-Monsoon, W-Winter, LV-Larvivorous fish, MD-Medicinal, PF-Predatory food fish

Physico -chemical characteristics

The water quality data is depicted in (**Table 2**) shows that stretch of river Kamala visually appeared to normal light green during summer season that turned into deep green during monsoon and winter season in spite of swelling due to monsoon rains. The water temperature ranged between 22.2^{0}C and 31.4^{0}C. The maximum temperature was recorded during summer while minimum was recorded during January of the winter season.

The pH of the water was recorded between a comfortable range of 6.1 – 7.6 being lowest during summer 6.1 and highest 7.6 during winter. Electrical conductivity (EC) of an aqueous solution is a measure of the ability to carry out an electric current [18]. The water conductivity (Redox potential) reflected a range of 180–240 mhos/cm. High electrical conductivity was recorded during rainy season. This may be due to greater ionic concentration of the inlet flow [19]. 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 5.4 to 6.6 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)[20] and Deshmukh and Ambore (2006)[21]. The DO level (75 mg/l) of reservoir water may be favorable for aquatic organisms [22]. The range of free carbon dioxide showed in the range of 2.6 – 4.8 mg/l. Similarly, the alkalinity, both in terms of carbonate and bicarbonate showed in the range of 5.8 – 26.4 mg/l and 93.0 – 110.0 mg/l respectively.

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 of river Kamala in the area studied was recorded to be 114.2 mg/l during summer, 76.4mg/l during monsoon and 64.1mg/l during winter season. Chlorides are important in detecting the concentration of ground water by waste water. In the present study, the chloride value ranged between 14.03 and 21.9 mg/l. similar results were observed by Damodharan and Suresh (2005)[23].

In chemical parameters, levels of calcium, magnesium, sodium, potassium, silicate, phosphate and nitrate were studied. Calcium concentration in the water body ranged from 17.36 mg/l to 38.4 mg/l being maximum during summer and minimum during winter season. During monsoon it was recorded to be 33.00 mg/l. The concentration of magnesium also followed the same trend as recorded in calcium. It was highest (10.2 mg/l) during summer and lowest during winter season (6.6 mg/l). In contrast, the level of sodium was recorded to be high during winter (16.4 mg/l) and low during summer (914.8 mg/l) season. Potassium and silicate were recorded in the range of 1.22mg/l – 1.46 mg/l and 4.76 mg/l –6.2 mg/l respectively. The level of phosphate and nitrate that determine the productivity level of the water body ranged between 0.0002 mg/l – 0.004 mg/l and 0.41 mg/l – 0.53 mg/l respectively.

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 becomes significant due to bio magnification. Thus, it shows that there is a great need for measuring the effect of pesticide on aquatic species.

Table 2: Seasonal variations of physico-chemical parameters of Kamala reservoir

Parameters	Summer	Monsoon	Winter	Range
Appearance	Normal	Normal	Normal	Normal
Water color	Light Green	Dark Green	Dark Green	Normal Green to Dark Green
Temp. (^{0}C)	31.4	28.6	22.2	22.2 – 31.4
pH	6.1	7.2	7.6	6.1 – 7.6
Conductivity (mhos/cm)	210	180	240	180 – 240
Dissolved O_2 (mg/l)	6.6	5.4	6.2	5.4 – 6.6
Free CO_2 (mg/l)	4.8	2.6	3.7	2.6 – 4.8
Carbonate alkalinity (mg/l)	26.4	18.6	5.8	5.8 – 26.4
Bicarbonate alkalinity (mg/l)	110.0	93.0	104.0	93.0 – 110.0
Chloride (mg/l)	9.6	12.0	10.8	9.6 – 12.0
Total hardness (mg/l)	114.2	76.4	64.1	64.1 – 114.2
Calcium (mg/l)	38.4	33.00	17.36	17.36 – 38.4
Magnesium (mg/l)	10.2	9.7	6.6	6.6 – 10.2
Sodium (mg/l)	14.8	16.2	16.4	14.8 – 16.4
Potassium (mg/l)	1.34	1.22	1.46	1.22 – 1.46
Silicate (mg/l)	6.2	4.76	5.2	4.76 – 6.2
Phosphate (mg/l)	0.004	0.002	0.002	0.002–0.004
Nitrate (mg/l)	0.42	0.53	0.41	0.41 – 0.53

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 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 [24] 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 [25].

Fisheries laws and policies which prohibit obnoxious fishing practices, over exploitation 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)[26].

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)[27], 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 [28].

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 [29] 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 Kamala reservoir as well as in the freshwater system of Bihar 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 [30]. Any deviation would lead to further erosion of biodiversity that would be detrimental for fisheries and environment as a whole.

4. 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 [31]. 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 [32, 33]. 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 [34]. 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 Kamala 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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