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Fish diversity and abundance in relation to water quality of Gaya reservoir, Bihar (India)

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Abstract : Freshwater fish diversity, abundance and richness status of Gaya reservoir (Bihar) was studied monthly from September 2017 to October 2018 in three sampling sites. The present study has shown that Gaya reservoir supported 3 fish species belonging the same class, order and family. 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 (I-D), Pielons Evenness and Margalef Index of species richness and 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 utilisation of these fish's wealth and sustainable steps to monitor and conserve these fish health. However, the present paper deals with fish diversity in the freshwater fishes of Gaya, as the water bodies harbour a large number of fish fauna. The survey is based on present observations and description of fishes as recorded in Systems Nature by Carls Linnaeus.

Key words: Freshwater fishes, water quality, biodiversity indices, Cyrinidae, Growth, Gaya, Bihar

INTRODUCTION

Fish perform all their body functions in water because it is totally dependent upon water to breathe, feed and grow, excrete wastes and reproduce understanding the physical and chemical qualities of water. Water has very unique density qualities. Most liquids become denser as they become cooler. However, water gets dense as it cools until it reaches a temperature of approximately 39°F. As it cools below this point, it becomes higher until it freezes (32°F). As ice develops, water increases in volume by 11 per cent. The increase in volume allows ice to float rather than sink, a characteristic that prevents ponds from freezing solid. It is the fact that water can dissolve more substances than any other liquid. This is why, it is called universal solvent. After oxygen, water temperature may be the single most important factor affecting the welfare of fish. Fishes are cold-blooded organisms and assume approximately the same temperature as their surroundings. The temperature of the water affects the activity, behaviour, feeding, growth and reproduction of all fishes. Metabolic rates in fish double for each 18°F rise in temperature. Temperature also determines the amount of dissolved gases (oxygen, carbondioxide, nitrogen etc.) in the water. The cooler the water the more soluble the gas. Water has its maximum density at 39.2°F. In spring season, water temperatures are nearly equal at all ponds depths. As a

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result, nutrients, dissolved gases, and fish wastes are evenly mixed throughout the pond. As the day become warmer, the surface water become warmer and lighter while the cooler-denser water forms a layer underneath. Circulation of the cooler bottom water is prevented because of the different densities between the two layers of water. Dissolved oxygen levels decrease in the bottom layer since photosynthesis and contact with the air reduced. The already low oxygen levels are further reduced through decomposition of waste products, which settle to the pond bottom. Localized dissolved oxygen depletion poses a very real problem to the fish culturists.

MATERIALS AND METHODS

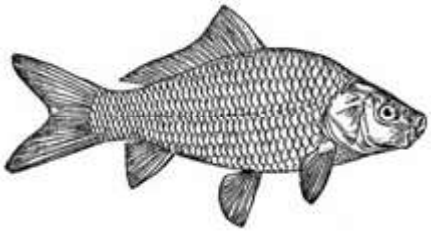

Fig. 1- *Labio rohita*

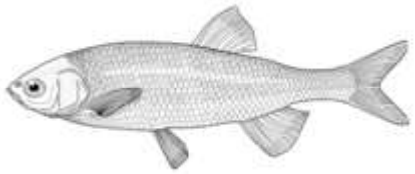

Fig. 2- *Catla catla*

Fig. 3- *Cirrhinus mrigala*

1. Study Area:

The study area is situated at Gaya (Bihar). Gaya is surrounded by hills on three sides and river on the fourth side. The climate of Gaya is seasonable. Its climate is characterised by relatively high temperature and evenly distributed rainfall throughout the year. The water bodies like ponds, lakes are very few in Gaya. There are few water bodies which contain water throughout the year and there are only source for supply of fishes in Gaya. The fishes feed on these biomass and mass efficiently convert them into animal protein in order to help farmers for fish culture in this area because of its high protein content. So a detail study is urgently required to correlate the growth of fish with respect to local environment that surround the water body and influence water quality. These works have immense significance for Bihar where large population depend on fishing not only as food source but also for their livelihood.

2. Fish Samples Collection

Fish samples were collected from different selected localities during the study period from September 2017 to October 2018 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 formation decolorises the fish colour on the long preservation. 10% formalin solution was prepared for preservation of fish samples. Fish 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 large fishes were given an incision on the abdomen before they were fixed.

3. Fish Identification

The fishes were identified by using Datta Munsi & Srivastava (1988) Talwar and Jhingran (1991) and Jayaram (1999).

4. Diversity Indices

Species diversity can be managed 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 (denote 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 as given by Shannon and Weiner, 1963) and Index of dominance given by Simpson (1949). Shannon's index has a direct relationship with the species diversity, whereas Index of dominance has an inverse relationship.

5. Water sample collection for physico-chemical analysis

Surface water samples were collected in polythene cans from different sampling sites of the Gaya 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, 1985, 2005).

Periodical estimates of fish growth and yield in relation to water samples were collected and analysed for computation of fish population dynamics and impact of physico-chemical complexes on fish yield of the water bodies. The whole exercise also involved network analysis and rendering of food chains/food web of the existing ecosystems.

Analytical studies in the selected water bodies were carried out two years 2016-2018 in different seasons such as prebreeding, breeding and post breeding. Mean values are presented here. However, methodology of APHA, 1985, 2005 used for experimental work. Three different seasons have been considered to determine that water condition affect the body of fishes, physiology taking growth index as measurement.

RESULTS AND DISCUSSIONS

The present investigation of fish fauna in Gaya reservoir showed that most of the fishes recorded were widely distributed in the lentic and lotic water bodies of Gaya. The members of Cyprinidae family dominate the fish population. The economically important and cultivated fishes were also recorded and include *Labio rohita, Cirrhinus mrigala, Catla catla*. The economically important and cultivable above fishes and reservoir can exploit for commercial production of fishes for better improvement of socio-economic condition of local people.

Table – 1 : Fish abundance and biodiversity status in Gaya reservoir, Gaya

Sl.No.	Name of Bony fish	Zoological Name	Abundance	Biodiversity	Habitat
1	Rohu	*Labio rohita* (Ham)	A-2	LR-nt	Lentic and Lotic
2	Mrigala (Naini)	*Cirrhinus mrigala*	A-2	LR-nt	Do
3	Katla	*Catla catla*	A-2	VU	Do

A – 2 : Common
VU : Vulnerable
LR-nt : Lower risk near threatened

As far as biodiversity status (IUCN-1994) is concerned different diversity indices were calculated as per standard methods. The Shannon-Weiner fish diversity index of Gaya 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 &1 but now the greater the value the greater the sample of 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 - 2.4 (Table 2).

Table – 2 : Fish diversity indices of Gaya, Bihar

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 (I-D)	0.89- 0.95
Pielou's evenness	0.6- 0.9
Margalef index	1.48 -2.4

Table 3: Seasonal variation of physico-chemical parameters in the water samples of Gaya reservoir during 2017-2018

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 ± 4.45	S6.13 ± 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	I 9.5 ± 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.l5	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 ± I 0.70	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 (^oC) turbidity (NTU), pH, electrical conductivity (μmhos/cm)

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^{o}C at Site 1. Water temperature was varied between 25.25±0.50^{o}C at Site 1 and 2 during winter season and 30.251.71^{o}C at the 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 mmhos/cm during rainy season and a maximum of 169.50±9.75 mmhos/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^{o}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 isn the range of 44.00±10.71 mg/L at site 1 during rainy season to 67.50±121.37 mg/L at site 3 during summer season. Nitrate concentration was observed in the range of 0.108±0.06 mg/L at site 2 during rainy season. Phosphate content was fluctuated between 0.012±0.01 mg/L at site 2 & 3 during summer season.

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. 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 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. The overall 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. 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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