Fish Fauna Distribution Pattern, Threats And Their Conservation Issues In Protected Areas: A Case Study From Vikramshila Gangetic Dolphin Sanctuary In Lower Ganga, Bihar, India

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Abstract :In the present investigation freshwater fish species diversity, distribution pattern, and their threats for conservation was carried out in three sampling zones keeping Vikramshila Gangetic Dolphin Sanctuary (VGDS) as center point in lower Ganga stretch during 2016-17. Totally 53 fish species from 21 families belonging to 10 orders have been recorded from all the three sites. Among them family Cyprinidae was dominated by representing 23 species (41%) and least was Clupidae (0.04%). According to the IUCN status, only 1 species was found vulnerable, 6 in low risk near threatened, one species in data deficient category, 43 in low risk least concern and 2 species were categorized in not evaluated category. Significant threats in means of disturbances, fishing pressure, destructive fishing practice (illegal net application) and habitat destruction have been reported. Protected part of the study stretch (VGDS) has supported substantial fish diversity which shows influence on catch of downstream. However, increasing percentage of small and trash fishes is alarming the conservation of fish resources in river Ganga. Furthermore, management strategies like awareness on sustainable harvesting, river pollution and destructive fishing may help in conservation of the native and endemic fish species in the mighty river of India.

Index Terms: Biodiversity, Destructive fishing, Fisheries, Fish distribution, Lower Ganga, Protected area, Vikramshila Gangetic Dolphin Sanctuary (VGDS)

1 INTRODUCTION

GLOBALLY, freshwater resources like streams and rivers are considered as harbors, landscapes and geographical regions that support variety of floral and faunal diversity. Freshwater biodiversity is most vulnerable than other terrestrial or marine biodiversity (Vijaylaxmi et al., 2010). Riverine habitats poses most threatened aquatic environments due to variety of anthropogenic impacts including fragmentation and other destruction in the riverine environment, rapid deterioration of water quality, and indiscriminate water abstraction (Zhao et al., 2011; Durham and Wilde, 2014). As a result, significant reductions in the distribution and abundance of many obligate riverine fishes have been documented in past few decades, especially in the rivers of high demand and aestheticism (Gido et al., 2010; Durham and Wilde, 2014). There has been a great concern among freshwater biologists about significant decline in the species diversity and abundance of riverine fishes. Among the most affected species has been a guild of riverine cyprinids that drift downstream as they pass their developmental stages (Durham and Wilde, 2009). The survival of this guild is reliant on unobstructed and adequate water flow that supports to suspend the eggs till hatching and allows for the successful growth of young larvae. The ongoing extensive habitat fragmentation, course change of river, development of new dry and side channels has resulted in poor adaptation of fishes to the lentic environments (Dudley and Platania, 2007) and dramatic declines in the abundance and distribution of fish fauna have occurred (Sarkar et al., 2012).

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River Ganga is the most sacred river in India ranked 5th in the world by basin area has covers one fourth of its water resource. The whole stretch of river Ganga is divided in to three stretches i.e., upper one covers in Uttarakhand State especially in Northern Himalayan area, where as middle stretch covers in the states of Uttar Pradesh and Bihar and lower stretch runs in some parts of Bihar and West Bengal (Sarkar et al., 2012). The Indian rivers like Ganga, is the richest in ichthyofaunal diversity in the world (Kumar et al., 2018). With the changing climatic conditions and increasing threats, riverine fish communities show seasonal variation in their community pattern, relative abundance and composition. Studies of freshwater fishes in the Indian subcontinent have been extensively done in river Ganga by several workers but limited to upper and middle stretches. Very few studies have been carrying out in lower Ganga river stretch covering in Bihar and even these studies have been largely restricted to some of the specific stations in the river. The present study is aimed to assess current status of fish biodiversity and threat in river Ganga in its lower stretch which is covering home ground of endangered Gangetic River Dolphin (*Platanista gangetica*). The findings from the study will benefit the planning and management of fisheries community structure and conservation of natural resources.

2 MATERIALS AND METHODS

2.1 Study area

The present study was carried out in the Vikramshila Gangetic Dolphin Sanctuary (VGDS), part of lower stretch of river Ganga covering in Bihar and adjacent 30 km up and downstream area. The sanctuary is lies in between 25° 15' 15" to 25° 16' 54" latitudes and 86° 44' 17" to 87° 13' 44" longitudes in the main course of river Ganga covering about 60 km distance starting from Sultanganj in upstream and ends at Kahalgaon in downstream. Total three sampling points i.e. 1) Munger as SI, about 30 km upstream from VGDS, 2)

Bhagalpur as SII in the center of VGDS and 3) Kursela as SIII, about 30 km downstream from the end of VGDS border at Kahalgaon. Unlike the other sanctuary, the river stretch including sanctuary is free for fishing to the local people. The river in this stretch is characterized with alluvial flood plains, meanders, side channels and islands and sandbars in all along the stretch. The river depth is declining continuously and sinuous shift mostly towards northern bank. The width of river varies from 500-2000 m during study period. The wide flood plain supports range of agriculture practice especially maize, wheat and some amount of lentils. The average rain fall of this zone was 1100 mm which brings major water in the river through runoffs from major cities like Munger, Khagaria, Sultanganj, Bhagalpur and Kahalgaon.

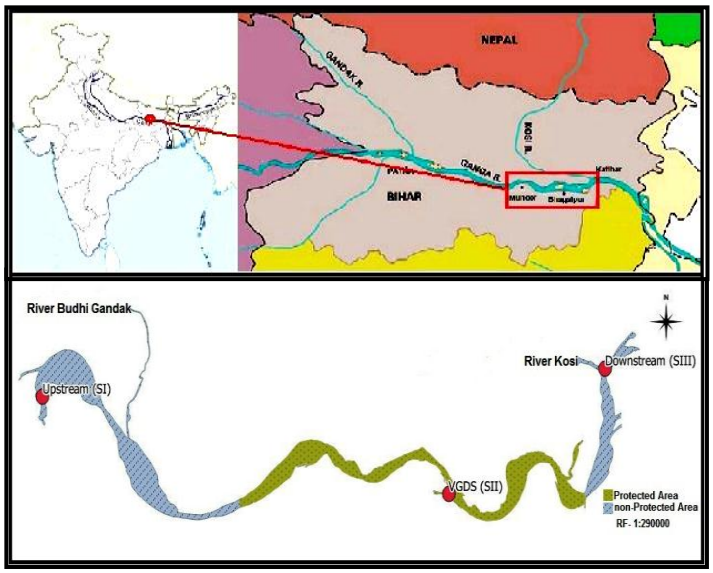

Figure -1: *Location map of sampling points in the lower stretch of river Ganga in Bihar*

2.2 Sampling

For All the samples were collected on seasonal basis from the local fish landings and fish markets between April, 2016 and March, 2017. A separate record was maintained for fishing gear and craft used for fishing by the fishermen. The collected fishes were identified with the help of key guide developed by Talwar and Jhingran (1991) and Jayaram, (1999). The samples were examined onsite in the morning catch at 5030 hrs and evening catch or landings at 1630 hrs.

2.3 Conservation Status

The data collected from different sites of fishes were categorized as per IUCN list of endangered (EN), vulnerable (VU), low risk least concern (LRlc), low risk near threatened (LRnt), data deficient (DD) and not evaluated (NE) species conservation status.

2.4 Data Analysis

The efforts were asked to fishermen and it was maintained equally 10 efforts per day for nets. The species richness was calculated following the standardize method by Lakra et al. (2010). Representative samples were kept in 10 % formaldehyde solution in jars and stored in laboratory. Data on threats encountered by the fish fauna were generated by primary survey in direct observations and interactions with local stakeholders and fishermen) and secondary (journal articles, reports and books).In biodiversity study relative abundance (RA) is a tool to know how commonly or contrary how rarely a species is relative to other species in a particular area or community. The relative abundance (percentage of catch) of fish across different sites was calculated by the following formula. RA of a species = (Number of individuals of a particular species/ Total number of individuals of all the species) x 100 The fish diversity indices were calculated as per standard method of Shannon and Wiener whereas, similarity of the species in all sampling sites were calculated by using Jacquard's index or JI coefficients of similarity method by using PAST software and MS office package version 2007.

3 RESULTS

In India, totally 2,246 finfish variety have been recorded among which 765 species belongs to freshwater forms (Sarkar et al., 2012), out of which 265 species were recorded from river Ganga (NGRBA, 2011). On the basis of present study, total 53 species of fishes belonging to 21 families of 10 orders have been recorded from three sampling stations in the lower Ganga stretch. The present survey record is representing about 70% of the fish recorded in this zone and about 20% of the total fish reported from the river Ganga. The family Cyprinidae was the most abundant contributing highest (41%) followed by Bagridae (25%) and least by Pangasiidae and Clupidae (0.04%) each in the study area. The families were arranged in the sequence of highest coverage by Cyprinidae >Bagridae >Ambassidae >Schilbeidae >Siluridae >Belonidae >Mastacembelidae >Botidae >Channidae >Sisoridae >Anabantidae >Tetraodontidae >Engraulidae >Anguillidae >Notopteridae > Clariidae >Gobiidae >Amphipnoidae >Mugilidae >Pangasiidae and Clupeidae at the lowest. The compositional trend of fishes and fisheries are tabulated (Table -1) with IUCN status. The selected stretch of river is divided into three sampling points and further the sampling site I and III has been clumped together (Non-Protected area-NPA) for understanding the difference in comparison to Site II (Protected area-PA). Total 35 fish species were recorded from SI that is in upstream and 53 species from SII which is the sanctuary area (protected area) and 47 fish species in SIII which is downstream part of the study area. The small sized fish like *Cabdio morar* (21.6%), *Mystus vittatus* (17.1 %), *Chanda nama* (12.3%), *Puntius ticto* (8.9%) and *Mystus tengara* (5.8%) were most dominant in this stretch. However, the highly commercial fishes such as *Clupisoma garua* (4.8%), *Cirrhinus reba* (1.4%), *Gibelion catla* (1%), *Labeo rohita* (1%), *Cirrhinus mrigala* (0.7%) are less in catch or decreasing and replaced with the noncommercial and trash fishes.

Table -1

List of fish species distribution, Relative abundance and IUCN threat category status collected from lower Ganga stretch during 2016-17

Scientific name of fish	IUCN status	Regional status*	SI	SII	SIII	RA	
						PA	NPA
Ambassidae							
Chanda nama	LRlc	NE	+	+	+	11.4	12.3
Ambassis ranga	LRlc	NE	+	+	+	4.87	4.40
Amphipnoidae							
Monopterus (Amphipnous) cuchia	LRlc	LR	-	+	+	0.11	0.09
Anabantidae							
Anabas testudineus	DD	VU	-	+	-	0.20	0.00
Trichogaster (Colisa) fasciata	LRlc	NE	+	+	+	0.72	0.41
Anguillidae							
Anguilla bengalensis	LRnt	LR	+	+	+	0.39	0.33
Bagridae							
Mystus tengara	LRlc	NE	+	+	+	4.68	5.78
Mystus vittatus	LRlc	VU	+	+	+	10.16	17.1
Rita rita	LRlc	EN	+	+	+	1.75	2.96
Sperata aor	LRlc	VU	+	+	+	5.26	2.30
Belonidae							
Xenentodon cancila	LRlc	LR	+	+	+	2.41	1.74
Botidae							
Botia dario	LRlc	LC	+	+	-	0.48	0.13
Botia lohachata	NE	EN	+	+	+	1.18	0.63
Channidae							
Channa punctata	LRlc	LR	+	+	+	0.26	0.27
Channa marulius	LRlc	LR	-	+	-	0.22	0.00
Channa striata	LRlc	LR	+	+	+	0.48	0.23

Clariidae							
Clarias batrachus	LRlc	VU	-	+	+	0.27	0.11
Clupeidae							
Gudusia chapra	LRlc	LC	-	+	+	0.06	0.02
Cyprinidae							
Labeo rohita	LRlc	LC	+	+	+	1.04	0.89
L. bata	LRlc	LC	+	+	+	1.32	1.24
L. calbasu	LRlc	LC	+	+	+	1.05	1.14
Puntius ticto	LRlc	LC	+	+	+	11.10	8.85
Systomus sarana	LRlc	VU	-	+	+	0.91	0.42
P. sophore	LRlc	LC	-	+	+	1.97	0.17
Pethia conchonius	LRlc	VU	+	+	+	5.26	2.72
Cirrhinus mrigala	LRlc	LR	+	+	+	0.70	0.67
C. reba	LRlc	VU	+	+	+	1.40	1.77
Gibelion catla	LRlc	VU	+	+	+	1.02	0.22
Cyprinus carpio	VU	NA	-	+	+	0.31	0.11
Ctenopharyngodon idella	NE	NA	-	+	-	0.10	0.00
Osteobrama cotio	LRlc	LC	+	+	+	0.66	0.43
Cabdio (Aspidoparia) morar	LRlc	LR	+	+	+	13.94	21.6
Salmostoma bacaila	LRlc	LR	+	+	+	0.57	0.57
Amblypharyngodon mola	LRlc	LC	-	+	+	0.22	0.26
Garra gotyla	LRlc	VU	-	+	+	0.03	0.06
Osteobrama cotio	LRlc	NT	+	+	+	0.37	0.32
Engraulidae							
Setipinna phasa	LRlc	NE	-	+	+	0.64	0.18
Gobiidae							

Glossogobius giuris	LRlc	LR	-	+	+	0.31	0.04
Mastacembelidae							
Mastacembelus armatus	LRlc	LC	+	+	+	0.53	0.98
Macrognathus pancalus	LRlc	LR	+	+	+	0.39	0.68
Mugilidae							
Rhinomugil corsula	LRlc	VU	-	+	+	0.11	0.07
Notopteridae							
Notopterus notopterus	LRlc	LC	+	+	+	0.15	0.18
Chitala chitala	LRnt	EN	+	+	+	0.20	0.08
Pangasiidae							
Pangasius pangasius	LRlc	VU	-	+	+	0.04	0.04
Schilbeidae							
Clupisoma garua	LRlc	VU	+	+	+	4.87	3.56
Eutropiichthys vacha	LRlc	EN	+	+	+	0.98	1.41
Alia colia	LRlc	LC	-	+	+	0.18	0.13
Siluridae							
Ompok pabda	LRnt	EN	-	+	-	0.32	0.00
Silonia silondia	LRlc	VU	-	+	+	0.22	0.10
Wallago attu	LRnt	LR	+	+	+	2.71	1.45
Sisoridae							
Bagarius bagarius	LRnt	VU	+	+	+	0.34	0.51
Bagarius yarrelli	LRnt	NT	-	+	-	0.59	0.00
Tetraodontidae							
Tetraodon cutcutia	LRlc	LR	+	+	+	0.54	0.33

IUCN status (2019); *Regional status opted from Lakra et al., 2010 and Sarkar et al., 2012; + = presence; - = absence of fish species; RA = Relative abundance; PA = Protected area and NPA = non Protected area (includes SI & SIII)

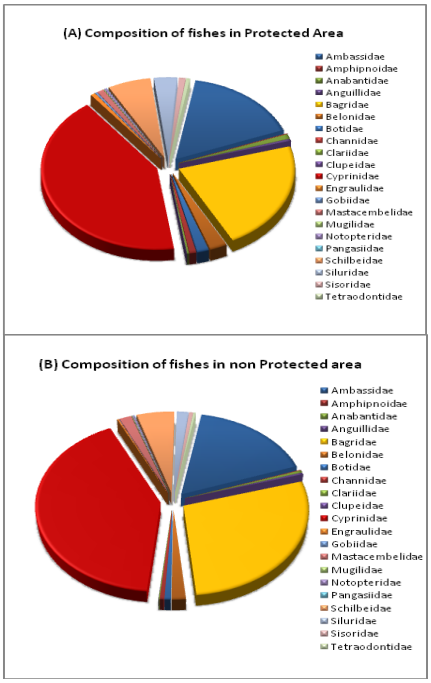

Figure -2: *Composition of fish families in (A) protected area i.e. SI and (B) non-protected area i.e. SI & SIII located in lower stretch of river Ganga.*

The diversity of fishes were found high at protected site and lowered in non-protected sites. The Shannon-Weiner index was high at SII (3.1) followed by SIII (2.8) and least at the SI (2.6). The other indices of diversity are statistically analyzed for all the three sites in the river and tabulated in Table -2. The dominance of species was low in SII (0.07) and higher in SI (0.13) and SIII (0.10). The richness of the species highly correlated with the Shannon-Weiner diversity index following the similar pattern. The richness was recorded high at SII (5.57) then SIII (5.24) and minimum at SI (3.88). The fish composition of the stretch including protected and non-protected area has not shown high level of dissimilarity. The equitability index was recorded little high at SII (0.77) then SI and SIII (0.72). The fish diversity is evenly distributed between sampling sites with less variations and followed the similar pattern as richness.

Table -2

Diversity indices of fish community structure in lower Ganga stretch during 2016-17

Statistical Analysis	SI	SII	SIII
Species diversity	34	53	47
Diversity index (H')	2.55	3.07	2.77
Simpson index (D)	0.13	0.07	0.10
Evenness index	0.37	0.41	0.34
Margalef richness index	3.88	5.57	5.24
Equitability index (J)	0.72	0.77	0.72

The fishes recorded during study period have been assessed for threatened status following IUCN red list category (2019). Total four species namely *Anguilla bengalensis, Bagarius bagarius, Chitala chitala* and *Wallago attu* has recorded under LRnt category in upstream and downstream or combined non-protected area whereas, additional two species *Bagarius yarrelli* and *Ompok pabda* also reported within the protected area i.e. SII. Only one species (*Cyprinus carpio*) under VU category, one in DD (*Anabas testudineus*) and two species (*Botia lohachata, Ctenopharyngodon idella*) under NE category and rest 43 species grouped under LRlc category has been reported form whole studied stretch of river Ganga. But at the same time, some discrepancies have also been found in conservation status from old literatures (Lakra et al., 2010, Sarkar et al., 2012) which shows that many of the species such as *Anabas testudineus*, *Mystus vittatus, Rita rita, Sperata aor, Botia lohachata, Clarias batrachus, Pethia conchonius, Gibelion catla, Cirhinnus reba, Clupisoma garua and Rhinomugil corsula* has been in threatened category but in present status of IUCN red list 2019, they are in LRlc category. It clearly shows that the fish species improved in wild and clear effect of protected sites and success of conservation measures are shown.

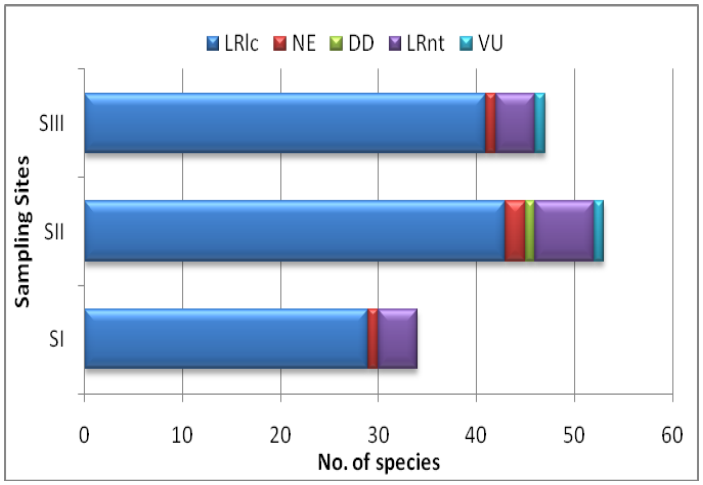

Figure -3*: IUCN conservation status of threatened species listed in lower Ganga stretch during 2016-17*

3.1 Threats Identification And Conservation Issues

Total 300 people (100 nos. of respondent from each zone i.e. Upstream non-protected area, VGDS protected area and Downstream non-protected area) were asked for the problems and consequences of fisheries activity reduction in the river. The major threat for fishing activity and fishermen are counted as siltation in the river> illegal and distractive fishing net operation> involvement of non-fishing community for fishing activity> population increase> anthropogenic load especially untreated sewage and effluent discharge the river. Apart of these problems, some issues like dredging of river for water ways development plan, shift of river course, formation of new channels and meanders, lack of coordination between fisheries and forest department officials for implication of fishing activity regulation and ownership contradiction were in prime importance.

Identified Threats	SI	SII	SIII	Overall
Siltation in the river				
Illegal and distractive fishing net operation				
Motorized vessels or ferries				
Non-fishing community in fishing activity				
Increased number of boats for fishing				
Anthropogenic load (sewage pollution)				
Agricultural practices in diyara land				
Color represents threats	Low	Medium	High	

4 Discussion

Fishes are the cheap source of protein and one of the best indicators of river quality. They are the link chain between aquatic ecosystem and human life which display the trend of pollution status, biodiversity changes and their consequences when consumed. On the basis of present study, the results are revealed that the family Cyprinidae, Bagridae and Ambassidae were dominant and high valued fishes from family Mugilidae, Pangasiidae and Clupeidae were the lowest. The increasing numbers of cat fishes, non-commercial and weed fishes in the local catch may change the catch composition and per capita income of the fishermen. The high number of weed fishes in the natural environment indicating the alteration in fish diversity and adversely affects the indigenous and threatened category fishes. The present study was an attempt to focus a light on the fragmentation of river for localized level planning in aspect of biodiversity conservation and management. The data would help in decision making for the VGDS management plan and water ways development plan. The observations of the present study depicted that higher number of fish species in conserved area of the river Ganga (53 species) which is about 70 % of the total fish reported from this area by Choudhary et al. (2006). The fish diversity is also higher in this area compared to the adjacent area either upstream or downstream sampling sites. The fisheries activity is high and more number of boats was operated in this zone but due to the awareness and conservation steps proposed by VBREC team, the condition little improved. As this stretch of river is very crucial from both ecological and social point of view, it is always necessary to evaluate the fish diversity regularly. The river is planned for water ways and water supply projects in this area which will drastically change the habitat characteristics due to operation of heavy motorized boats and dredgers in the river course. During the construction and operation phase of the projects it may adversely affects on the sensitive population of dolphins, otters and their pray bases. Most important part of the study indicates the spatial change in fish diversity and importance of conserved regions in the river. Despite of heavy pressure of fishing by the local people apart from conventional fishermen, the population of fish was recorded higher within the sanctuary area. Contrary to the typical pattern of increasing fish richness and diversity form upstream to downstream (Lakra et al., 2010); the highest diversity was recorded in protected area. The contrast condition in the present study from the typical diversity pattern may be result of sampling variations, number of fishers attempted for fishing and spatial alterations (Habit et al., 2006). Although, the study shed light on conservation of habitat for sustenance of fishes to hatch and complete early developmental stages that flow downstream has indicatives of threats in the river. Illegal fishing activity in the sanctuary area may be one of the reasons to having high fish diversity. The fishermen practicing destructive fishing activities like barricading of meanderings, side channels, application of mosquito nets (fine mesh size nets), and purse seine kind of nets were help to show more fishery production of this area. Likewise, the indirect effect on abiotic factors by these activities ultimately degrades the biotic components of the river (Pokharel et al., 2018). It was endorsed many times in different aquatic conditions and geographical locations, habitat fragmentation and distractions are crucial in species composition or distributions than the species interactions (Peres-Neto, 2004) and the similar trends were recorded during the present study also. High numbers of threat category fishes were recorded from protected area (SII) that clearly indicates threat to the high valued fish group and creates opportunity to make strategic planning for conservation in selected zones. Higher composition of small sized fish indicates the unavailability of major carps and other large fishes (Montana et al., 2011) that will lead to additional pressure on riverine fishery and feed competition between aquatic organisms. The similar pattern of fishery has been noted by the pioneer researcher Bilgrami et al. (1991) and others also (Temple and Payne, 1995; Sinha and Khan, 2001; Choudhary et al., 2006). It is establishment that within sanctuary demarcation the pressure on fishery in river Ganga has high and increased (Kelkar et al., 2010). This trend may create difficult situation to sustain other species of high price and show greater demographic resilience.

5 Conclusion

The protected area in the river is difficult to manage and even critical when river is highly utilized by the stakeholders. The scenario of VGDS is very interesting due to high fishing pressure and high biodiversity than the adjacent areas. The fishery resources in this area depicted the health status of the river which indicates the importance and prioritization of taking steps towards conservation of river especially in this area. Each species has its own breeding and rearing adoptability which will insist them to be growing more in particular area. Strict regulation for fishing, generation of alternate livelihood opportunities, control on pollution and direct discharge to the river and develop a multicriterion management plan will help the river and fishery resources both to be conserved side by side.

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