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A study on the seasonal fluctuation of water quality parameters and Ichthyofaunal diversity in determination of ecological health of Mathura Beel, A Flood plain Wetland of West Bengal

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ABSTRACT

Fish diversity and their correlation with seasonal fluctuation of water quality parameters of Mathura Beel was studied during the period 2015-16 to 2017-18. 39 species of fish belonging to 18 families under 8 orders were recorded from this floodplain wetland of North 24 Parganas district of West Bengal. The most dominant family was Cyprinidae with 13 species. The beel is alkaline in nature as the pH varies 7.7-10.5. The dissolved oxygen content is good. In this beel, Shannon-Weaver species diversity index (*H'*) has positive correlation with Free CO_2, DO, alkalinity and hardness whereas negative correlation with temperature, pH and BOD. Margalef's Species richness index (*D*) has positive correlation with temperature, pH and BOD while has negative correlation with Free CO_2, DO, alkalinity and hardness. Pielou's Species evenness index (*J'*) has positive correlation with Free CO_2, alkalinity, hardness and BOD whereas negative correlation with temperature, pH and DO. The overall ecological health of the beel was suitable for aquaculture.

Key words : *Floodplain wetlands, Beels, Physicochemical parameters, Fish, Diversity indices*

Introduction

Floodplain wetlands are formed from main stream of river when river meanders are cuts due to erosion and siltation of river banks. Some floodplain lakes are permanently cut offs from the river and forms closed ecosystem and others remains seasonally connected with river. These wetlands or lakes are known as beels or baurs or ox-bow lakes. (Jhingran and Jha, 1988). These beels houses many aquaculture industries in India particularly eastern part of the country and act as important source of inland fisheries also (Mondal and Kaviraj, 2009).

West Bengal, a state of eastern India, has more than 150 floodplain wetlands which covers almost 42,000 ha, constitutes 22% of state's total freshwater area (ICAR, 2006). These beels functions vitally in waste water treatment, water storage, ground water recharge and controlling flood. Not only that, beels acts as natural habitats of many common and rare fish species also. The diversity of fish and their occurrence in such type of beels are greatly influenced

by seasonal variation of physicochemical properties of the water bodies (Carol *et al.,* 2006).

However, in recent days, these natural water bodies becomes worst victims of environmental degradation like discharge of organic debris from human settlements, agricultural run-offs, eutrophication, indiscriminate jute retting which causes a serious threats to fish biodiversity and productivity of the beels (Mondal and Kaviraj, 2009). Beside these indiscriminate fish catching throughout the year also causes declination of fish biodiversity from the eastern part of India (Kar *et al.,* 2006; Mondal *et al.,* 2006).

For lack of sufficient literature, the present study, seasonal fluctuation of physicochemical properties in relation with fish diversity of an important floodplain wetland of West Bengal, 'Mathura beel' were undertaken.

Materials and Methods

The present study was carried out in Mathura beel (22^0 25' N - 23^0 55'N and 88^0 30' E - 88^0 50' E), falling under two districts of West Bengal namely North 24 Parganas and Nadia. The elevation of the area is 10 meter above sea level. The average annual rainfall is 1555 mm. The area of the beel is 184 ha. The length of the beel is 9 km and the width is 0.5 km. The beel is maintained by a local fishermen's cooperative society namely 'Kanchrapara Refugee Fishermen Society Ltd' which have 509 members which was constituted in 1950 at Kapachakla Gram Panchayet of Barrackpore-I block and Naihati assembly constituency. The occurrence of this wetland probably is cut off meander or offshore of River Ganga (Biswasroy *et al.,* 2011).

The study was done from March 2015 to February 2018. The study periods were grouped into three season viz. Pre-monsoon (March, April, May, June), Monsoon (July, August, September, October) and Post-monsoon (November, December, January, February).The water sample are collected from four different stations in 500 mL bottle for determination of physicochemical properties like pH, temperature, dissolved oxygen, free CO_2, alkalinity and hardness of the water following the method of APHA 2012.

For sampling of fish, random samples were taken by three netting from each station and pooled together to make 10 kg sample of fish for every month and thus 40 kg sample from each season. Fish samples are preserved in 10% formalin and identified by following standard literature (Talwar and Jhingran, 1991; Jayaram, 1999; Nelson, 1976). All the sampling was done in early morning in every month from March 2015 to February 2018.

The diversity and evenness index of fish were calculated according to Shannon-Weaver species diversity index (H') and Pielou's Species evenness index (J')

1. Shannon-Weaver species diversity index (**H**) = $-\sum_i^s \left(\frac{Ni}{N}\right) \ln \left(\frac{Ni}{N}\right)$

Where S is the total no. of species; N is the total no. of individual; Ni is the no. of specimens in each species.

2. Pielou's Species evenness index (**J**) = (H)/lnS

Where H is the Shannon-Weaver species diversity index; S is the total no. of species.

3. Margalef's Species richness index (**D**) = $\frac{S-1}{logN}$

Where S is the total no. of species; N is the total no. of individuals.

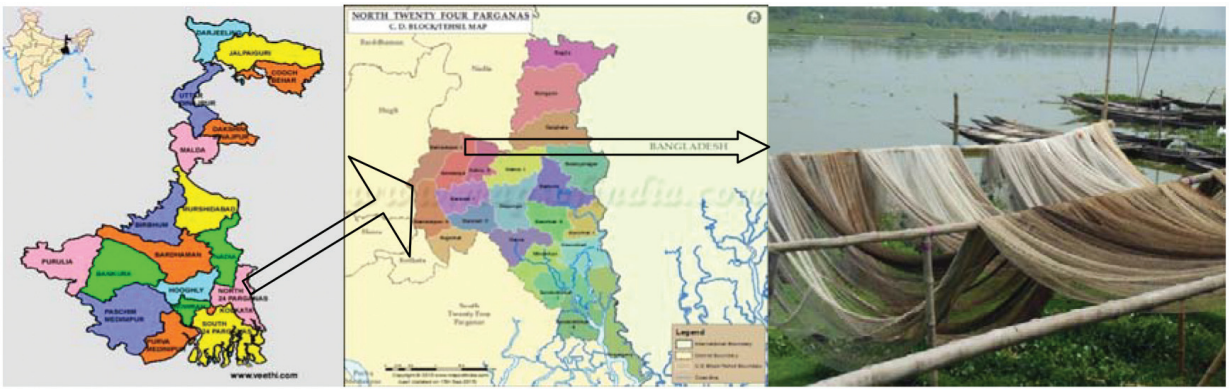

Fig. 1. Location of Mathura beel(Ref. www.beethi.com; mapsofindia.com)

4. Simpson's index of dominance (**ID**) = $(N_i/N)^2$

Where N is the total no. of individual; Ni is the no. of individuals in each species.

All results were statistically analysed by one-way ANOVA methods described by and R Development Core Team (2011) followed by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Method of Ghosh and Biswas (2018) was used for determination of correlation.

IUCN red list (2020) was followed for determination of threatened status of fishes.

Results and Discussion

The number of individuals belonging to 8 different orders of fish found per ten kilogram sample is represented graphically in Figure 4.

Physicochemical parameters of Mathura beel during three years of study period is shown in Table 2. Highest temperature (37^{0}C) recorded in pre mon-

Table 1. Technical details of the sampling stations of Mathura Beel:

Sl. No.	Properties	Station 1	Station 2	Station 3	Station 4
1.	Location	Nagdaha Khal (Sewage)	Dhankal Fishery Office ghat	Ramakrishna colony ghat	Dharampur hostel ghat
2.	Nearest Town	Kanchrapara	Kanchrapara	Kanchrapara	Kanchrapara
3.	District	North 24 Parganas	North 24 Parganas	North 24 Parganas	North 24 Parganas
4.	State	West Bengal	West Bengal	West Bengal	West Bengal
5.	Nearest Railway Station	Kanchrapara	Kanchrapara	Kanchrapara	Kanchrapara
6.	Nearest National Highway	NH 34	NH 34	NH 34	NH 34
7.	Source of Pollution	Khal sewage	Detergent, Pesticide	Detergent, Pesticide	Detergent, Pesticide
8.	Nearest River	Hooghly	Hooghly	Hooghly	Hooghly
9.	Controlling Authority	Kanchrapara Refugee Fishermen Society Ltd.	Kanchrapara Refugee Fishermen Society Ltd.	Kanchrapara Refugee Fishermen Society Ltd.	Kanchrapara Refugee Fishermen Society Ltd.
10.	Average Depth	1.3 ′	1.75 ′	1.9 ′	2.1 ′

Table 2. Physicochemical parameters of Mathura beel

Parameters	Seasons	2015-16	2016-17	2017-18	Mean
Temperature (^{0}C)	Pre-Monsoon	35^{cn}±0.1	35^{cn}±0.11	37^{co}±0.1	35.67
	Monsoon	32^{bn}±0.21	31^{bm}±0.31	34^{bo}±0.34	32.33
	Post-Monsoon	26^{ao}±0.1	24.5^{am}±0.21	25^{an}±0.06	25.17
pH	Pre-Monsoon	10.5^{co}±0.11	9.9^{cn}±0.1	9.8^{cn}±0.06	10.07
	Monsoon	7.9^{ao}±0.06	7.9^{ao}±0.05	7.7^{an}±0.06	7.83
	Post-Monsoon	8.8^{bn}±0.06	8.8^{bn}±0.05	8.9^{bn}±0.06	8.83
Free CO_2 (mg/L)	Pre-Monsoon	0^{am}±0	0^{am}±0	0^{am}±0	00
	Monsoon	2.2^{bm}±0.1	2.2^{bm}±0.1	2.1^{bm}±0.1	2.2
	Post-Monsoon	0^{am}±0	0^{am}±0	0^{am}±0	00
DO (mg/l)	Pre-Monsoon	4.98^{an}±0.01	5.34^{bp}±0.02	5.21^{ao}±0.01	5.17
	Monsoon	5.09^{bo}±0.01	5.02^{an}±0.01	8.73^{cp}±0.03	6.28
	Post-Monsoon	6.04^{cn}±0.01	6.45^{co}±0.01	7.56^{bp}±0.02	6.68
Alkalinity (mg/l)	Pre-Monsoon	161^{am}±2.64	176^{an}±1.15	187^{ao}±0	174.67
	Monsoon	250^{cp}±0.58	230^{bo}±0	210^{bn}±0.58	230
	Post-Monsoon	235^{bo}±2	232^{bno}±3.46	211^{ba}±1	226
Hardness (mg/l)	Pre-Monsoon	89^{an}±1	77^{am}±0	78^{am}±2	81.33
	Monsoon	128^{bn}±1	124^{bm}±0.58	130^{bo}±0	127.33
	Post-Monsoon	145^{cn}±0.58	152^{co}±0.58	140^{cm}±2	145.67
Biochemical Oxygen Demand (mg/l)	Pre-Monsoon	1.57^{ao}±0.05	1.44^{an}±0.05	1.35^{bm}±0.03	1.45
	Monsoon	1.89^{cn}±0.03	1.65^{bm}±0.06	1.71^{cmn}±0.02	1.75
	Post-Monsoon	1.76^{bn}±0.05	1.80^{cn}±0.02	1.24^{am}±0.04	1.6

Table 3. Significance level of seasonal variation of the physicochemical parameters

Sr No.	Parameters	F-statistic value	P-value
1	Temperature	60.9609	0.0001
2	pH	70.3969	0.0001
3	Free CO_2	4230.2613	0
4	Dissolved Oxygen	1.062	0.4028
5	Alkalinity	11.5593	0.0087
6	Hardness	109.8486	0.00002
7	Biochemical Oxygen Demand	1.5792	0.2812

Table 4. Correlation between physicochemical parameters

Parameters	Temperature	pH	Free CO_2	Dissolved Oxygen	Alkalinity	Hardness	Biochemical Oxygen Demand
Temperature							
pH	0.3694						
Free CO_2	0.2056	-0.8335					
Dissolved Oxygen	-0.8906	-0.7516	0.2620				
Alkalinity	-0.6999	-0.9222	0.5551	0.9482			
Hardness	-0.9003	-0.7370	0.2409	0.9998	0.9410		
Biochemical Oxygen Demand	-0.3113	-0.9981	0.8660	0.7094	0.8966	0.6939	

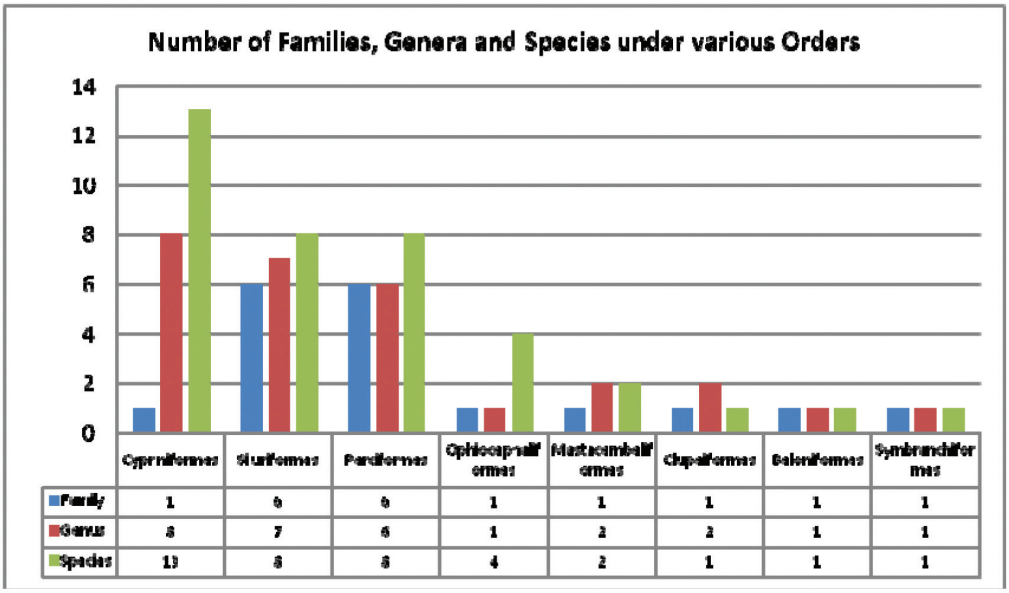

Fig. 2. Number of Families, Genera and Species under various Orders of fishes.

soon season of 2017-18 whereas lowest (24.5 ^{0}C) was recorded in post-monsoon season of 2016-17. It may be for the low water level and high solar radiation in summer season. pH was ranged between 10.5 at pre-monsoon season of 2015-16 to 7.7 at monsoon of 2017-18. Higher pH may be for the low water levels, excess nutrient contents and mixture of detergents during summer. Free CO_2 was recorded as Nil during pre and post monsoon seasons of each year whereas 2.2-2.1 mg/l in monsoon seasons. It may be for the increasement of decomposition of organic matter during monsoon. Highest value of Dissolved Oxygen was recorded in monsoon season of 2017-18 as 8.73 mg/l, whereas lowest in pre-monsoon sea-

Table 5. Fish species found in Mathura Beel during the study period of three years (2015-16 to 2017-18)

Order	Family	Species	Common name	IUCN status	Population trend	Occurrence		
						PM	M	PoM
1. Cypriniformes	1. Cyprinidae	1. *Labeo rohita*	Rohu/Rui	Least Concern	Unknown	+++	+++	+++
		2. *Labeo bata*	Bata	Least Concern	Unknown	+++	+++	+++
		3. *Labeo calbasu*	Kalbose	Least Concern	Unknown	+++	+++	+++
		4. *Gibelion catla*	Katla	Not Evaluated		+++	+++	+++
		5. *Cirrhinus mrigala*	Mrigel	Least Concern	Stable	+++	+++	+++
		6. *Puntius sarana*	Sarpunti	Least Concern	Unknown	+++	+++	+++
		7. *Puntius sophore*	Punti	Least Concern	Unknown	+++	-	+
		8. *Puntius chola*	Punti	Least Concern	Unknown	+++	-	+
		9. *Puntius puntio*	Punti	Not Evaluated		++	+	++
		10. *Hypophthalmichthys molitrix*	Silver carp	Near Threatened	Decreasing	+++	+++	+++
		11. *Cyprinus carpio*	Common carp	Vulnerable	Unknown	+++	+++	+++
		12. *Ctenopharyngodon idella*	Grass carp	Not Evaluated		+++	+++	+++
		13. *Amblypharyngodon mola*	Mourola	Least Concern	Stable	-	+	+
2. Siluriformes	2. Notopteridae	14. *Notopterus notopterus*	Pholui	Least Concern	Stable	+++	+++	+++
		15. *Notopterus chitala*	Chital	Not Evaluated		++	++	++
	3. Bagridae	16. *Mystus vittatus*	Tengra	Least Concern	Decreasing	+++	+++	+++
		17. *Aorichthys (Sperata) aor*	Aar tengra	Least Concern	Stable	+	-	-
	4. Siluridae	18. *Wallago attu*	Boal	Vulnerable	Decreasing	+++	+++	+++
	5. Schilbeidae	19. *Eutropiichthys vacha*	Vacha	Least Concern	Decreasing	+	-	+
	6. Clariidae	20. *Clarias batrachus*	Magur	Least Concern	Stable	+++	++	++
	7. Saccobranchidae	21. *Heteropneustes fossilis*	Singhi	Least Concern	Stable	+++	++	++
3. Perciformes	8. Gobiidae	22. *Glossogibius giuris*	Bele	Not Evaluated		-	++	++
	9. Anabantidae	23. *Anabas testudineus*	Koi	Least Concern	Stable	+	++	++
	10. Nandidae	24. *Nandus nandus*	Bheda/Roina	Least Concern	Unknown	-	++	++
	11. Cichlidae	25. *Oreochromis niloticus*	Nilontica	Least Concern	Stable	+	+++	+++
		26. *Oreochromis mossambicus*	Tilapia	Vulnerable	Decreasing	+	++	++
	12. Ambassidae	27. *Chanda nama*	Chanda	Least Concern	Decreasing	++	++	++
		28. *Parambassis ranga*	Chanda	Least Concern	Stable	++	+	++
	13. Belontiidae	29. *Trichogaster fasciata*	Kholisa	Least Concern	Unknown	++	++	+++
4. Ophiocephaliformes	14. Ophiocephalidae	30. *Channa marulius*	Shal/Gajal	Least Concern	Unknown	+++	++	++
		31. *Channa striata*	Shol	Least Concern	Stable	+++	++	++
		32. *Channa orientalis*	Cheng	Vulnerable	Decreasing	+	+	+
		33. *Channa punctata*	Lata	Least Concern	Stable	+++	+++	+++
5. Mastacembeliformes	15. Mastacembelidae	34. *Mastacembelus pancalus*	Pankal	Not Evaluated		+	+	+
		35. *Macrognathus aculeatus*	Guchi	Not Evaluated		+++	++	++
6. Clupeiformes	16. Clupeidae	36. *Gudusia chapra*	Khoira	Least Concern	Decreasing	++	++	++
		37. *Corica soborna*	Kanchki	Least Concern	Unknown	+	+	++
7. Beloniformes	17. Belonidae	38. *Xenentodon cancila*	Kankle	Least Concern	Unknown	++	++	++
8. Symbranchiformes	18. Symbranchidae	39. *Monopterus cuchia*	Ban/Cuche	Least Concern	Unknown	+++	+++	++

Table 6. Number and Percent Composition of Families, Genera and Species under various Orders

Sl No.	Order	Families	Genera	Species	% of Families in an Order	% of Genera in an Order	% of Species in an Order
1	Cypriniformes	01	08	13	5.56%	28.57%	33.33%
2	Siluriformes	06	07	08	33.33%	25%	20.51%
3	Perciformes	06	06	08	33.33%	21.43%	20.51%
4	Ophiocephaliformes	01	01	04	5.56%	3.57%	10.26%
5	Mastacembeliformes	01	02	02	5.56%	7.14%	5.13%
6	Clupeiformes	01	02	02	5.56%	7.14%	5.13%
7	Beloniformes	01	01	01	5.56%	3.57%	2.56%
8	Symbranchiformes	01	01	01	5.56%	3.57%	2.56%
	Total	18	28	39			

Table 7. Percentage occurrence of fishes of Mathurabeel under the conservation status IUCN (2020)

	EN	VU	NT	LC	LR	DD	NE	Total
Number of species	00	04	01	27	00	00	07	39
Percent contribution	00%	10.26%	2.56%	69.23%	00%	00%	17.95%	100%

EN=Endangered
VU=Vulnerable
NT=Near Threatened
NE=Not Evaluated
LC=Least Concerned
LR=Lower Risk
DD=Data Deficient

Table 8. Various species diversity indices for fish of Mathura Beel at pre-monsoon, monsoon and post-monsoon period of 2015-16, 2016-17, 2017-18 (Values within columns indicated by different superscript letter (a,b,c) and values within rows indicated by different superscript letter (m, n, o) are significantly different at 5% level determined by Duncan's Multiple Range Test).

Sl No	Diversity indices	Season	2015-16	2016-17	2017-18	Mean
1	Shannon-Weaver species diversity index (H')	Pre-monsoon	$3.1^{cm}\pm0.03$	$3.06^{bm}\pm0.04$	$2.986^{am}\pm0.01$	3.05
		Monsoon	$3.127^{cn}\pm0.02$	$3.105^{bo}\pm0.03$	$3.004^{an}\pm0.04$	3.08
		Post-monsoon	$3.1^{cm}\pm0.01$	$3.086^{bn}\pm0.06$	$3.002^{an}\pm0.02$	3.06
2	Margalef's Species richness index (D)	Pre-monsoon	$4.659^{bo}\pm0.15$	$4.701^{cn}\pm0.06$	$4.358^{ao}\pm0.14$	4.57
		Monsoon	$4.257^{bm}\pm0.24$	$4.304^{cm}\pm0.05$	$3.989^{am}\pm0.06$	4.18
		Post-monsoon	$4.393^{bn}\pm0.13$	$4.771^{co}\pm0.18$	$4.125^{an}\pm0.27$	4.43
3	Pielou's Species evenness index (J')	Pre-monsoon	$0.95^{bm}\pm0.01$	$0.938^{am}\pm0.02$	$0.939^{am}\pm0.05$	0.94
		Monsoon	$0.96^{cn}\pm0.03$	$0.9524^{bo}\pm0.04$	$0.945^{an}\pm0.06$	0.95
		Post-monsoon	$0.95^{cm}\pm0.02$	$0.9466^{bn}\pm0.03$	$0.9446^{an}\pm0.01$	0.95
4	Simpson's index of dominance (ID)	Pre-monsoon	$0.046^{am}\pm0.002$	$0.04892^{bn}\pm0.005$	$0.0539^{ao}\pm0.005$	0.05
		Monsoon	$0.0471^{bm}\pm0.005$	$0.0488^{an}\pm0.006$	$0.0563^{bo}\pm0.003$	0.05
		Post-monsoon	$0.0476^{cm}\pm0.004$	$0.0488^{an}\pm0.008$	$0.0543^{co}\pm0.002$	0.05

son of 2015-16 as 4.98 mg/l. Low DO value at summer season may be for the increased temperature and low water level. Alkalinity was ranged between 250-161 mg/l, monsoon and pre-monsoon season of 2015-16 respectively. Increase in alkalinity at summer season may be for the increased rate of organic decompositions. Highest value of hardness was recorded in post-monsoon season of 2016-17 as 152 mg/l, whereas lowest was 77 mg/l recorded in pre-monsoon of 2016-17. Biochemical Oxygen Demand was ranged between 1.89-1.24 mg/l at monsoon of 2015-16 and post-monsoon of 2017-18 respectively. Earlier workers like Mukherjee and Saha 2015, Dey et al. 2015 has also found these trends. The values of temperature, pH, Free CO_2, alkalinity, and hardness are varies significantly ($p<0.05$) between three sea-

sons. On the other hand the values of Dissolved Oxygen and Biochemical Oxygen Demand did not vary significantly ($p>0.05$) between three seasons of the study period (Table 3). Temperature has positive correlation with pH and Free CO_2 and shows negative correlation with DO, alkalinity, hardness and BOD. pH shows negative correlation with Free CO_2, DO, alkalinity, hardness and BOD. Free CO_2 is positively correlated with DO, alkalinity, hardness and BOD. DO have positive correlation with alkalinity, hardness and BOD. Alkalinity has positive correlation with hardness and BOD. Hardness is also found positively correlated with BOD (Table 4).

Overall **39** fish species belonging to 18 Families within 8 Orders were recorded during the study period of three years and are listed in Table 5. Out of 8 Orders, Order-Cypriniformes contains most number of species (13) followed by Siluriformes and Perciformes (8 each). Out of 39 fish species, 4 species (10.26%) are Vulnerable and 1 species (2.56%) is Near Threatened category of IUCN Red list (2020).

Table 8 shows the various species diversity indices for fish of Mathura beel at pre-monsoon, monsoon and post-monsoon period during study period. Shannon-Weaver species diversity index (H') ranges between 2.986-3.127 which may be considered as good and was highest in monsoon period of 2015-16 whereas lowest at pre-monsoon period of 2017-18. Margalef's Species richness index (D) was highest (4.771) at post-monsoon period of 2016-17 and lowest (3.989) at monsoon of 2017-18. Pielou's Species evenness index (J') was ranged between 0.938-0.96 at pre-monsoon and monsoon periods of

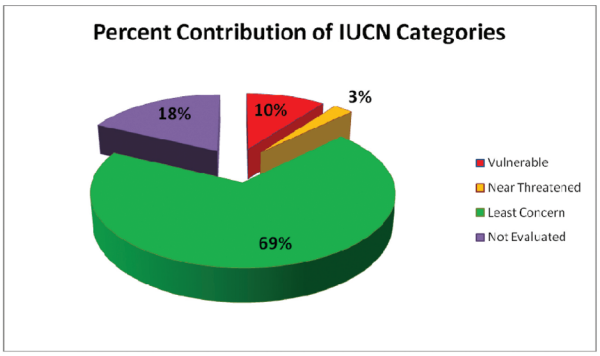

Fig. 3. Pi diagram showing the no. and percentage of species under various threat categories as per IUCN status.

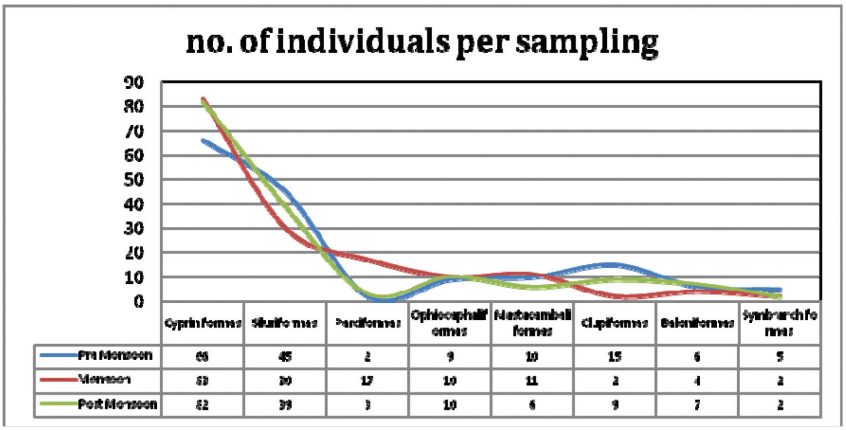

Fig. 4. Seasonal variation in number of individuals between 8 orders of fishes found /10 Kg sample.

Table 9. Correlations between Physicochemical parameters and species diversity indices

Parameters	Shannon-Weaver species diversity index (*H*)	Margalef's Species richness index (*D*)	Pielou's Species evenness index (*J*)	Simpson's index of dominance (ID)
Temperature	-0.1261	0.1545	-0.7448	-
pH	-0.9684	0.9752	-0.8952	-
Free CO_2	0.9449	-0.9351	0.5000	-
DO	0.4337	-0.4077	-0.2620	-
Alkalinity	0.7968	-0.8138	0.9979	-
Hardness	0.5453	-0.5691	0.9610	-
BOD	-0.6547	0.6327	0.0000	-

2016-17 and 2015-16 respectively. Simpson's index of dominance (**ID**) did not varies significantly between seasons.

Table 9 shows correlations between seasonal fluctuations of physicochemical parameters and species diversity indices of Mathura beel. Shannon-Weaver species diversity index (*H'*) has positive correlation with Free CO_2, DO, alkalinity and hardness whereas negative correlation with temperature, pH and BOD. Margalef's Species richness index (*D*) has positive correlation with temperature, pH and BOD while has negative correlation with Free CO_2, DO, alkalinity and hardness. Pielou's Species evenness index (*J'*) has positive correlation with Free CO_2, alkalinity, hardness and BOD whereas negative correlation with temperature, pH and DO. As there was no significant difference, the relationship between Simpson's index of dominance (ID) with seasonal changes of physicochemical parameters could not be determined.

The overall patterns of fish faunal diversity and seasonal fluctuations corresponds to earlier workers like Sharma1999, Khan 2002 and 2003, Dey *et al.* 2015, Mukherjee and Saha 2015 etc.

Conclusion

From the above study it can be clear the floodplain wetland Mathura beel contains a large number of fish species. The higher value (3.127) of Shannon-Weaver species diversity index (H') is the evidence of high icthyofaunal diversity. And it is also being concluded that temperature, pH and DO are very important factors for regulation of biodiversity of the wetland.

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