



Diversity and Distribution of Fish Fauna of Indus River at Taunsa Barrage in Punjab, Pakistan

Haji Muhammad, Zafar Iqbal* and Saira Saleemi

Department of the Zoology, University of the Punjab, Quaid-i-Azam Campus, Lahore, Pakistan



ABSTRACT

The present study was conducted to determine the fish fauna of Indus River at Taunsa Barrage, situated in South Punjab Pakistan. The survey was conducted from September 2013 to August, 2014 at eight sampling sites to ascertain fish diversity and their distribution pattern. A total 2249 fish specimen were collected using a variety of fish nets and identifications of these fishes were made by using standard taxonomic keys on the basis of morphometric characters. Seventy species belonging to 43 genera and 17 families were recorded from the study area of Indus River. Thirty two species were commercially important. Alpha Diversity Indices study showed that fish diversity of the River was quite rich (species richness, 70) and diverse, (Shannon's index=3.66), (Simpson-D=0.96), Evenness was also high (Evenness (H/S) =0.55) and Chao-1 (70.75). The Quadrate diversity Indices were applied to the data and Bootstrap replicates mean values of the following indices were recorded as Chao 2 (70.8), Jackknife 1 (72.9), Jackknife 2 (71.9) and Bootstrap (70.17). The study further indicated that the population of many endemic and commercially important fish species has declined while the exotic family Cichlidae representative of three species (*Oreochromis mossambicus*, *Oreochromis aureus* and *Oreochromis niloticus*) has become well established in the study area. Similarly the population of exotic common carp (*Cyprinus carpio*) also seems to be established in the Indus River.

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Authors' Contributions

ZI conceived, designed and supervised the study. HM performed Lab work, analyzed the data and wrote the article. SS assisted in lab work and writing of manuscript.

Key words

Indus River, Quadrate Diversity indices, Shannon's index jackknife, Bootstrap and evenness.

INTRODUCTION

The worlds' largest earth and rock filled dam, Tarbala dam and six barrages (Jinnah, Chasma, Taunsa, Guddu, Sukkur and Kotri) are constructed on Indus River in Pakistan. Froese and Pauly (2015) reported freshwater fish species in different countries; such as 951 in India, 1643 in China, 277 in Iran, 250 in Bangladesh and 128 in Afghanistan. There are not less than 193 freshwater fish species in Pakistan (Rafique and Khan, 2012). But more than 180 fish species are found in Indus River in Pakistan (Mirza and Mirza, 2014). Many scientists have studied the fish fauna of Indus and its tributaries. The complete description of this work seems difficult to refer. However, work includes Mirza (1975, 1978, 1980, 1990 and 1993), Talwar and Jhingram (1991), Jayaram (1981, 1999), Rafique (2000) and Iqbal *et al.* (2013). Complete picture of the fish diversity and distribution pattern in Indus River and its drainage system still need our attention. Moreover, there are serious threats to the fish biodiversity of Indus River due to industrial pollution, illegal hunting of fish, extensive deforestation, global warming and westward shifting of its course.

Fish populations of both fresh and marine habitat in many parts of the world is continuously decreasing due to many factors including, loss of habitat, agricultural and industrial development, overexploitation, pollution, alteration in water flow through diversion and damming. Diversity and distribution of fish of a habitat is closely associated with different factors such as, depth, food availability, breeding sites, topography, water current and water physicochemical properties. Hence, it was essential to study fish diversity continuously in different

ecosystem of the country. Present study was designed to investigate the fish diversity of Indus River at Taunsa barrage to supplement more data and information regarding fish diversity and population.

MATERIALS AND METHODS

Sampling sites

Fish sampling was carried out in Indus River at Head Taunsa Barrage from September 2013 to August 2014 for a period of one year. Taunsa Barrage provides a huge and diverse macro-habitat in the form of off shoots, side streams, shallow waters, deep waters, clear stagnant water in hands, fast flowing water with high oxygen content, side water with low oxygen due to vegetation decomposition, shallow water with submerged vegetation, side pockets with lotus and typha and seepage water on sides to variety of fish fauna.

Sampling was carried out at eight sites namely Nose Jheel (NJ), Sipur No.1 Jheel (S1), Tall Jheel (TJ), Hockey Jheel (HJ), Kali Jheel (KJ), Chetti Jheel (CJ), Muzaffar Garh Canal (MGC) and Head Taunsa Bridge (HB), respectively (Table I). Fish specimen were randomly collected from the study area by using variety of fish nets like gill nets, cast nets, drag nets and hand nets in every month for the period of one year. Smaller specimens were stored in 10% formalin directly while larger specimens were first given intra-peritoneal injection and then stored in 10% formalin and transported to Fish Disease and Health Management Lab, Department of the Zoology, University of the Punjab Lahore for further analysis. Samples from each site were separately packed in labeled plastics jars according to date, site, time, and locality. Each specimen was tagged by a specific number manually; classification and taxonomic identification of the sampled specimens completed using standard keys (Mirza and Sharif, 1996; Mirza and

* Corresponding author: dr.zafariqbal.pu@gmail.com

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Sandhu, 2007) on the basis of morphometric characters.

Table I.- Sampling sites at Taunsa barrage of Indus river.

Sampling Site	Site Code	Distance from Head Taunsa Bridge (km)	Location
Nose Jheel (East bank upstream)	NJ	1.38	30°31'8.9" N, 70°51'47.07" E
Sipur No.1 Jheel (East bank upstream)	S1	1.60	30°30'31.5" N, 70°51'25.33" E
Tall Jheel (East bank Upstream)	TJ	2.46	30°31'59.6" N, 70°51'25.33" E
Hockey Jheel (East bank Upstream)	HK	2.85	30°31'41.6" N, 70°52'27.76" E
Kali Jheel (West bank Upstream)	KJ	4.86	30°31'45.4" N, 70°48'6.21" E
Cheetti Jheel (West bank Upstream)	CJ	2.70	30°30'55.9" N, 70°49'21.98" E
Muzaffar garh Canal (East bank Upstream)	MGC	1.70	30°30'58.5" N, 70°52'10.33" E
Head Taunsa bridge (Downstream East bank)	HB	1.81	30°30'14.8" N, 70°51'49.27" E

Statistical analysis

The data of different species for abundance and occurrence was calculated for Species richness (S), Shannon diversity Index (H'), Simpson diversity Index (D) and Evenness (H/S). The maximum probable species richness of the area under survey like, Chao 1 and Chao 2, Jackknife 1 and Jackknife 2 and bootstrap were extrapolated and calculated. The Jackknife method is used as resampling technique to calculate variance and bias estimation while Bootstrap measure the accuracy (Variance, Bias, Confidence interval and prediction error) of the samples (Efron and Tibshirani, 1993). The accuracy of the data and results were verified by Applying all the Diversity Indices separately according to sampling months and sampling sites. PAST Statistics Software (Hammer *et al.*, 2001) was used for the performance of all statistical analysis.

RESULTS AND DISCUSSION

Monthly occurrence of fish fauna at Taunsa Barrage

Seventy different species of the fishes were collected from the study area. A total of 2249 specimens of fish were collected from eight sites. The detail of fish species collected on monthly basis for the period of one year (September 2013 to August 2014) is given in Table II. The maximum number of fishes was collected during the month of January 2014 (425 specimens), followed by the months of February > November > December > March > May > October > April > August > July > June > September.

Ichthyodiversity at Taunsa Barrage

The highest Ichthyodiversity in study area was also calculated during December 2013 (39 species) followed by January > February > November > May > March > August > October > July > June > April > September (8 species). Numerically most abundant and diverse family was Cyprinidae comprising 27 species followed by Bagridae (eight species). The third most diverse family was Sisoridae represented by five species in the study area. Chandidae and Cichlidae two exotic fish families were represented by three species each. The least abundant family was Botiidae and the least diverse families were Cobiidae, Heteropneustidae, Belonidae and Mugilidae represented by only one species for each (Table II). *Cirrhinus reba*, *Labeo rohita*, *Gudusia chapra*, *Puntius sophore*, *Cirrhinus mrigala*, *Labeo gonius*, *Channa punctata* and *Oreochromis mossambicus* were recorded the most abundant numerically species (4-8%).

Table III shows different diversity indices used to calculate the species abundance data. Highest species richness was recorded during the month of December > January > February. The highest species richness in these months may be attributed due to lowest water level results in easy approach for fish sampling. Similarly the highest values for Shannon's Diversity Index (H') was represented during December > January > November > February > May > July > August > March 2014, (2.64), October 2013 and June 2014, (2.62), April 2014, (2.25) and September.

Highest Simpson diversity index (I/D) was recorded during the month of December and January (0.95) followed by November and February and the lowest value was recorded in the month of September. Similarly, the highest values of Species Evenness (H/S) was recorded in the month of September > July and its least value was recorded during the month of February. Similarly the detailed values of different diversity indices on the basis of sampling sites is given in the Table IV. The accuracy of the data was strengthened by calculating the close values of Alpha diversity (Table III) and Quadrate diversity parameters (Table V).

Commercially important fish species captured at Taunsa Barrage of Indus river include *Chitala chitala*, *Cirrhinus mrigala*, *Cirrhinus reba*, *Catla catla*, *Labeo rohita*, *Labeo gonius*, *Labeo calbasu*, *Labeo dyocheilus*, *Labeo bogga*, *Labeo boggut*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Cyprinus carpio*, *O. mossambicus*, *O. niloticus*, *O. aureus*, *Channa punctata*, *Channa marulius*, *Channa striata*, *Mastacembelus armatus*, *Macrognathus pancalus*, *Wallago attu*, *Ompok bimaculatus*, *Eutropiichthys vacha*, *Sperata seenghala*, *Rita rita* and *Bagarius bagarius*. The highest abundance and diversity of fish species collected in winter season may be due to less water current in study area.

Our study confirm the existence of two new species *Goanolsa manminus* and *Rita macracanthus* at Taunsa Barrage as reported earlier by Arshad (2011) and Hee (2004), respectively.

Table II.- Ichthyodiversity of Indus River at Taunsa Barrage September 2013 to August 2014.

Family/Species	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Notopteridae													
<i>Chitala chitala</i>	07	02	--	--	--	--	--	--	--	--	--	04	13
<i>Notopterus notopterus</i>	--	04	02	06	27	--	03	04	01	--	02	02	51
Clupeidae													
<i>Gudusia chapra</i> (Hamilton, 1822)	--	04	14	04	22	65	14	11	01	02	03	01	141
<i>Gonialosa manminis</i> (Hamilton, 1822)	--	--	--	--	12	08	08	--	--	--	--	--	28
Cyprinidae													
<i>Cirrhinus mrigala</i>	07	02	04	30	40	15	03	02	--	02	03	15	123
<i>Cirrhinus reba</i>	02	01	06	09	27	18	55	42	02	01	11	05	179
<i>Catla catla</i>	03	02	01	02	04	05	--	--	01	01	07	11	37
<i>Labeo rohita</i>	01	27	01	08	45	29	06	03	01	03	04	16	144
<i>Labeo gonius</i>	--	04	03	02	06	34	31	17	--	--	05	08	110
<i>Labeo calbasu</i>	--	04	01	--	04	01	--	--	01	--	06	05	022
<i>Labeo dyocheilus</i>	--	03	--	06	03	03	--	--	--	--	--	--	015
<i>Labeo bogga</i>	--	--	--	03	--	--	01	--	--	02	--	--	006
<i>Labeo boggut</i>	--	--	--	01	04	--	05	--	--	--	--	--	10
<i>Ctenopharyngodon idella</i>	01	--	--	--	02	--	--	--	03	--	--	--	06
<i>Hypophthalmichthys molitrix</i>	--	--	02	01	--	--	--	--	--	--	--	03	06
<i>Cyprinus carpio</i>	--	--	02	--	02	--	--	--	--	--	--	01	05
<i>Systomus sarana</i>	--	11	14	03	13	04	03	03	--	--	02	02	55
<i>Puntius sophore</i>	--	--	56	19	04	23	09	06	03	13	--	--	133
<i>Puntius conchoniis</i>	--	--	07	--	--	04	--	--	--	--	--	--	11
<i>Puntius ticto</i>	--	--	03	03	02	05	03	--	--	--	--	--	16
<i>Puntius terio</i>	--	--	06	--	--	06	02	02	--	--	--	--	16
<i>Puntius chola</i>	--	--	17	06	--	--	12	--	02	01	--	--	38
<i>Puntius punjabensis</i>	--	--	5	--	--	03	--	--	--	--	--	--	08
<i>Aspidoparia morar</i>	--	--	15	--	--	02	--	--	02	01	--	--	20
<i>Securicula gora</i>	--	--	02	--	06	02	--	--	01	--	--	--	11
<i>Salmophasia bacaila</i>	--	--	--	--	14	07	--	--	02	--	--	--	23
<i>Salmophasia punjabensis</i>	--	--	--	--	02	01	--	--	15	--	--	--	18
<i>Osteobrama cotio</i>	--	--	--	09	03	08	02	--	10	--	--	--	32
<i>Crossocheilus diplochilus</i>	--	--	--	--	--	03	--	--	--	--	--	--	03
<i>Chela cachius</i>	--	--	--	02	--	03	--	--	10	02	--	--	17
<i>Amblypharyngodon mola</i>	--	--	--	--	--	--	--	--	--	--	01	--	01
Cichlidae													
<i>Oreochromis mossambicus</i>	06	08	26	11	37	02	01	--	--	04	--	01	96
<i>Oreochromis niloticus</i>	--	05	03	13	13	--	--	--	--	--	--	--	34
<i>Oreochromis aureus</i>	--	06	06	09	20	01	--	--	--	--	--	02	44
Channidae													
<i>Channa punctuata</i>	--	21	13	12	25	8	18	05	04	--	--	--	106
<i>Channa striata</i>	--	03	--	06	--	--	02	--	--	--	--	--	11
<i>Channa marulius</i>	--	--	--	02	--	02	--	--	03	05	--	--	12
Mastacembelidae													
<i>Mastacembelus armatus</i>	--	01	--	02	01	03	--	--	--	01	--	02	10
<i>Macrognathus pancalus</i>	--	--	--	--	02	--	--	--	--	--	--	--	02
Siluridae													
<i>Wallago attu</i>	--	03	--	01	07	02	02	--	--	--	--	03	18
<i>Ompok bimaculatus</i>	--	--	01	--	02	--	03	01	--	--	--	--	07
<i>Ompok pabda</i>	--	01	01	--	15	01	08	08	--	--	01	01	36

Continued

Family/Species	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Schilbeidae													
<i>Eutropiichthys vacha</i>	--	03	--	03	04	--	--	--	02	--	03	01	16
<i>Clupisoma garua</i>	--	02	--	--	--	01	--	03	10	--	01	01	18
<i>Pseudeutropius atherinoides</i>	--	--	--	01	--	--	--	01	16	--	--		18
Bagridae													
<i>Sperata seenghala</i>	01	02	--	01	--	04	--	--	03	05	--	02	18
<i>Mystus bleekeri</i>	--	--	24	12	02	07	16	05	--	--	--	--	66
<i>Mystus cavasius</i>	--	--	40	05	05	08	08	04	01	--	02	--	73
<i>Mystus horai jayram</i>	--	--	--	12	--	--	--	--	--	01	--	--	13
<i>Mystus vittatus</i>	--	--	15	03	--	05	--	--	--	03	--	--	26
<i>Mystus tengara</i>	--	--	24	--	--	--	03	--	--	--	--	--	27
<i>Rita rita</i>	--	--	--	02	--	--	--	--	14	--	01	03	20
<i>Rita macracanthus</i>	--	--	--	--	--	--	--	--	--	--	02		02
Chandidae													
<i>Chanda nama</i>	--	--	09	09	07	19	--	02	--	04	--	--	50
<i>Parambassis ranga</i>	--	--	13	04	13	29	--	--	03	14	--	--	76
<i>Parambasiss baculis</i>	--	--	18	--	14	30	--	--	--	02	--	--	64
Botiidae													
<i>Botia lohachita</i>	--	--	02	--	--	--	--	--	--	--	--	--	02
<i>Botia birdi</i>	--	--	--	--	--	--	--	--	01	--	--	--	01
Gobiidae													
<i>Glossogobius giuris</i>	--	--	03	02	08	--	--	--	--	--	--	--	13
Osphronemidae													
<i>Colisa fasciata</i>	--	--	--	03	--	--	--	--	--	--	--	01	04
<i>Colisa lalia</i>	--	--	--	04	--	--	--	--	--	--	--	--	04
Heteropneustidae													
<i>Heteropneustes fossilis</i>	--	--	--	08	--	--	--	--	--	--	--	--	08
Sisoridae													
<i>Bagarius bagarius</i>	--	--	--	--	03	--	--	--	02	01	02	05	13
<i>Glyptothorax cavia</i>	--	--	--	--	--	--	--	--	02	--	03	--	05
<i>Glyptothorax punjabensis</i>	--	--	--	--	--	--	--	--	--	--	03	--	03
<i>Glyptothorax stocki Mirza and Nijssen</i>	--	--	--	--	--	--	--	--	02	--	04		06
<i>Sisor rabdophorus</i>	--	--	--	--	--	--	--	--	--	01	12	--	13
<i>Nangra nangra</i>	--	--	--	--	--	--	--	--	--	--	01	--	01
Belonidae													
<i>Xenodon cacila</i>	--	--	--	--	05	--	--	--	--	--	--	--	05
Mugilidae													
<i>Sicamugil cascasia</i>	--	--	--	--	--	--	--	--	10	--	--	--	10
Grand total	28	119	358	238	425	371	220	119	128	69	79	95	2249
Percentage population	1.24%	5.29%	15.92%	10.58%	20.48%	16.49%	9.78%	5.29%	5.69%	3.06%	3.51%	4.22%	
Total species	8	22	34	39	38	37	25	17	29	21	22	23	
Percentage diversity	11.4 %	31.4%	48.6%	55.7%	54.23%	52.8 %	35.7 %	24.3 %	41.4 %	30 %	31.4%	32.8%	

Table III.- Monthly diversity indices of fish fauna of Taunsa Barrage.

Index	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
No. of individuals	28	119	358	238	425	371	220	119	128	69	79	95	2249
Richness (S)	8	22	34	39	38	37	25	17	29	21	22	23	70
Chao richness (Chao1)	9.5	22.5	35.67	40	38	38.67	25	17	32	25.67	23.67	26.5	70.75
Simpson (1/D)	0.81	0.89	0.93	0.95	0.95	0.93	0.89	0.83	0.92	0.90	0.92	0.91	0.96
Shanon,s (H')	1.81	2.62	3.0	3.31	3.2	3.01	2.64	2.25	2.92	2.62	2.81	2.71	3.66
Eveness_ e ^H/S	0.76	0.62	0.59	0.70	0.64	0.55	0.56	0.56	0.64	0.66	0.75	0.65	0.55

Table IV.- Site based diversity indices of study area of Indus River at Taunsa Barrage.

Index	NJ	S1	TJ	HK	KJ	CJ	MC	HB	Total
No. of individuals	498	167	93	273	387	296	365	173	2249
Richness (S)	46	28.	17	44	39	29	42	39	70
Chao richness (Chao1)	47	28.1	17.3	45.11	39.7	29	42.4	43.9	70.75
Simpson (1/D)	0.95	0.92	0.90	0.95	0.94	0.91	0.93	0.94	0.96
Shanon,s (H')	3.35	2.95	2.58	3.46	3.18	2.92	3.16	3.26	3.66
Evenness_e`H/S	0.62	0.66	0.77	0.72	0.61	0.64	0.56	0.67	0.55

For Abbreviations, see Table I.

Table V.- Quadrature diversity Indices of fish fauna of Taunsa Barrage (Sept- 2013 to Aug- 2014).

Method	Original data set Mean $\pm$ SD	Bootstrap replicate Mean $\pm$ SD
Chao 2	70 $\pm$ 0.66	70.8 $\pm$ 5.1
Jackknife 1	70 $\pm$ 0.00	72.9 $\pm$ 4.4
Jackknife 2	60.7 $\pm$ NA	71.1 $\pm$ 7.9
Bootstrap	71.7 $\pm$ NA	70.17 $\pm$ 3.1

The study area is also the representative of largest fish species of the Indus River including *B. bagarius*, *S. seenghala* and *C. chitala*. The construction of barrages and dam for irrigation and power generation purposes are posing serious threats to biodiversity of Taunsa Barrage. After the construction of Guddu, Sukkur and Kotri barrages on Indus River downstream, the movement of fish upstream has been restricted. As *T. ilisha* has not been reported at Tansa barrage in our study. Similarly, the population of Blind Indus dolphin has also been dramatically reduced and restricted between Taunsa and Guddu barrages after the construction of these barrages.

The introduced fish species at Taunsa Barrage include *Ctenopharangodon idella*, *Hypophthalmichthys molitrix*, *Cyprinus carpio*, *O. mossambicus*, *O. aureus* and *O. niloticus*, *Colisa fasciata* and *Colisa lalia* while rest of the 62 species belongs to native fish fauna of the Indus River. The unique feature of the abundance data was that the exotic family Cichlidae is well established and its population is increasing day by day. Cichlidae was the fourth most abundant family and *O. mossambicus* was the eighth most abundant species. Similarly, *O. niloticus* and *O. aureus* represent 1.5% and 1.9% sample collection in the study area. These alien fish species represent a significant risk for the local fish community and other aquatic animals.

The resilience of an ecosystem appears to depend upon biological diversity (Elmqvist *et al.*, 2003). The interaction between different species combined with both limnological and physical properties of an aquatic ecosystem may lead to promote the composition and novel structure of the fish fauna (Agnisto *et al.*, 2005). The fish diversity according to this study is greater than Islam and Siddiqui (1971), who reported 21 fish species belongs to 16 genera and 8 families from river Jhelum, Mirza and Ahmad (1987) described

25 species from Jhelum River from District Sargodha, Rafique *et al.* (2003) recorded 50 fish species belonging to 13 families from Jinnah Barrage at Indus River, Kar *et al.* (2006) described 69 species belonging to 49 genera, 24 families and 11 orders from India, Khan *et al.* (2008) reported 22 species from Taunsa reservoir and 36 species from Chashma reservoir of Indus River, Ali *et al.* (2010) reported 15 species of fishes belonging to 5 families and 13 genera from Suleman Mountain Range, D.G. Khan, Mirza *et al.* (2011) described 51 species belonging to 39 genera and 51 species from River Jhelum Pakistan, Hassan *et al.* (2013) described 50 species from River Sawat and Iqbal *et al.* (2013) reported 60 species of fish from Attock region of Pakistan. On the other hand, Rafique (2000) reported 189 fish species from Indus River, Rafique (2001) described 93 species from freshwater bodies of Himalayas in Pakistan, Mirza and Javed (2003) reported 82 species of fish from Chenab River, and Rafique and Khan (2012) reported 193 freshwater fish species of Pakistan biodiversity were higher than the present study.

CONCLUSION

This study reveals the picture of biodiversity and distribution pattern of fish fauna of Indus River at Taunsa Barrage. The results indicate that fish diversity of Indus River is high at Taunsa Barrage at local level but poor as compared to other major Rivers of Asia such as the Ganges, Brahmaputra, Salween, Mekong, Hwang Ho and Yangtaz. The main reasons for poor fish diversity of Indus seems due to its flow through gorges, Long torrential upper courses in Tibetan plateau and Himalayas, low mean discharge of water, high sediments load, glacier fed water and extent of drainage area (Rafique, 2000). Biodiversity and population of Indus River fishes at Taunsa Barrage are continuously decreasing day by day. Much stress is on commercial species due to over and illegal fishing. The establishment of population of three exotic species *O. mossambicus*, *O. niloticus* and *O. aureus* is alarming threat for the population of local species. Similarly the population of exotic Chinese carps, *H. molitrix*, *C. idella* and especially *C. carpio* population is comparable to local fish population.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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