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Fish Catch Composition and Biodiversity Indices at Harike Wetland- A Ramsar Site in India

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ABSTRACT

The present study was carried out to evaluate the fish biodiversity and catch composition in Harike Wetland, Punjab. Total 37 fish species were recorded from Harike wetland and these belong to 14 families and 25 genera. Maximum number of species (16) recorded under family *Cyprinidae* followed by *Bagridae* (4 species) and *Siluridae* (3 species). Maximum number of species was recorded in May and minimum in July. Dendrogram from Bray – Curtis similarity matrix revealed close association among family *Bagridae, Siluridae Channidae Notopteridae* and family *Cyprinidae* dominated the catch composition and established as the controlling factor of the overall fish catch composition in the Harike wetland. Principal Component Analysis (PCA) ordination of the fish family revealed family *Cyprinidae* contributed the maximum variability. Shannon's index revealed light polluted nature of Harike wetland during pre-monsoon whereas, during the monsoon moderate polluted nature of Harike wetland has been observed. Pielou's evenness index revealed moderate evenness of the abundance of the fish population in Harike wetland. Margalef Richness Index revealed richness in fish biodiversity of this wetland. It can be concluded that despite of different natural and anthropogenic disturbances the wetland is still supporting a good number of fish species which is to be conserved.

Keywords: Harike Wetland, fish biodiversity, *Cyprinidae*, Principal component analysis (PCA), Shannon's index

Harike is a very rich wetland in terms of fish species diversity. Being at the confluence of two major rivers of Indus river system i.e. the Beas and Sutlej, it represents fish fauna of both the rivers and provides suitable environmental conditions for breeding, feeding and nesting. This wetland covers the land area of Tarn Taran, Ferozepur and Kapurthala districts in Punjab. The wetland is about 12 km long and 11 km in width covering an area of about 8,435 ha (Mabwoga *et al.,* 2010). The portion of the Harike Wetland fed by the Sutlej River is excessively eutrophic and the portion fed by Beas water is mildly eutrophic, but eutrophication has not yet been seen in the middle portion of the reservoir and the downstream areas (Parwana and Bansal, 1991).

Presence of fishes in an aquatic habitat is a good indicator of the health and status of that ecosystem. Contemporary freshwater fish diversity has seen a constant decline in recent years due to destruction of habitat on account of various natural and anthropogenic factors (Dudgeon *et al.,* 2006). The polluted water and declining water table in Harike wetland is affecting water quality, biodiversity and fish growth (Jain *et al.,* 2008; Brraich and Jangu, 2013, 2015).The diversity of 116 fish species were recorded from re-organized Punjab by (Johal and Tandon, 1981) but after a long gap only 26 and 16 species were reported from Harike wetland by Ladhar *et al.,* (1994), (Dhillon and Kaur, 1996), respectively. Fishery resources of Harike has decreased sharply on an average of 57% during the period of 1999 to 2005 and river Sutlej too showed similar decreasing trend of 52.79% during the same tenure (Moza

and Mishra, 2008). Data regarding fish diversity and catch composition of Harike water body is poorly documented. To fill the gap, the present study was initiated to evaluate the fish catch composition and biodiversity indices as measures of ecological degradation of this Ramsar site.

MATERIALS AND METHODS

Present study was conducted for a period of four months (May – August, 2016) comprising summer and monsoon seasons at Harike wetland; the largest wetland of Northern India, situated 31˚13'N and 75˚12'E. Assessment of fish catch composition and biodiversity were conducted in landing center adjacent to Harike wetland. Fish were identified upto species level based on the taxonomic key of Talwar and Jhingran (1991), Jayaram (1999), Menon (1999) and Jhingran (1999).

Diversity indices

Shannon diversity index

$$H' = -\sum_{i=1}^{S} (pi \ln pi)$$

Where, *S* is the number of species in the sample

pi is the proportion of i^{th} species in the total sample

Margalef's richness index (1959)

$$d = \frac{S-1}{\ln(N)}$$

Where, *S* is the number of taxa, and *n* is the number of individuals.

Pielou's evenness index

$$J' = H' / H' MAX = H' / Log S$$

Where, H′ Max is the maximum possible value of Shannon diversity index which would be achieved if all species were equally abundant. Statistical analysis including Dendrogram from Bray – Curtis similarity matrix and ordination of the fish family by Principal Component Analysis (PCA) was performed by using software, primer Ver.6 (developed by Plymouth Research Lab. U.K.).

RESULTS AND DISCUSSION

Total 37 species of fishes were recorded from Harike wetland and these belong to 14 families and 25 genera (Table 1).

Table 1: Record of fish species from Harike wetland

	May	June	July	August
Superclass: Gnathostomata				
Class: Actinopterygii				
Subclass: Neopterygii				
Division: Teleostei				
Order : Cypriniformes				
Family: Cyprinidae				
Catla catla (Hamilton-Buchanan)	+	+	+	+
Cirrihinus mrigala (Hamilton-Buchanan)	+	+	+	+
Cirrhinus reba (Hamilton-Buchanan)	+	+	-	+
Cyprinus carpio communis (Linnaeus)	+	+	+	+
Labeo bata (Hamilton-Buchanan)	+	+	-	+
Labeo calbasu (Hamilton-Buchanan)	+	+	+	+
Labeo dero (Hamilton-Buchanan)	+	-	-	+
Labeo dyocheilus (McClelland)	+	-	+	+
Labeo gonius (Hamilton-Buchanan)	+	+	-	-
Labeo rohita (Hamilton-Buchanan)	+	+	+	+
Osteobrama cotio cotio (Hamilton-Buchanan)	+	+	+	+
Puntius sophore (Hamilton-Buchanan)	+	-	+	-
Puntius ticto (Hamilton-Buchanan)	+	+	-	-
Salmostoma phulo (Hamilton-Buchanan)	+	+	+	+
Amblypharyngodon mola (Hamilton-Buchanan)	+	-	+	-

Esomus danricus (Hamilton-Buchanan)	+	+	-	-
Order : Siluriformes				
Family: Bagridae				
Aorichthys aor (Hamilton-Buchanan)	+	-	-	+
Aorichthys seenghala (Sykes)	+	-	+	+
Mystus bleekari (Day)	+	-	-	+
Rita rita (Hamilton-Buchanan)	+	+	+	+
Family: Siluridae				
Ompok bimaculatus (Bloch)	+	-	-	+
Ompok pabda (Hamilton-Buchanan)	+	-	+	-
Wallago attu (Bloch& Schneider, 1801)	+	+	+	+
Family: Schilbeidae				
Clupisoma garua (Hamilton-Buchanan)	+	-	+	+
Family: Sisoridae				
Bagarius bagarius(Sykes)	+	+	-	+
Family: Clariidae				
Clarius batarachus (Linnaeus)	+	+	-	-
Order : Cyprinodontiformes				
Family: Belonidae				
Xenentodon cancila (Hamilton-Buchanan)	+	+	-	-
Family: Synbrachidae				
Monopterus cuchia (Amphinous)	+	+	-	+
Order : Perciformes				
Family: Ambassidae				
Chanda nama (Hamilton-Buchanan)	+	-	+	-
Family: Nandidae				
Nandus nandus (Hamilton-Buchanan)	+	+	-	-
Family: Channidae				
Channa marulius (Hamilton-Buchanan)	+	+	+	+
Channa striatus (Bloch)	+	+	+	+
Family:Mastacemblidae				
Macrognathus pancalus (Hamilton-Buchanan)	+	-	-	+
Mastacembelus armatus (Lacepede)	+	+	-	+
Order: Clupeiformes				
Family: Clupidae				
Gadusia chapra	+	-	+	+
Order: Osteoglossiformes				
Family: Notopteridae				
Notopterus notopterus	+	+	+	+
Notopterus chitala	+	+	+	+

Maximum number of species (16) recorded under family *Cyprinidae* followed by *Bagridae* (4 species), *Siluridae* (3 species), *Channidae* (2 species), *Mastacembelidae* (2 species each), *Notopteridae* (2 species), contributed significantly. *Catla catla, Cirrihinus mrigala, Cyprinus carpio* communis, *Labeo calbasu, L. rohita, Osteobrama cotio cotio, Salmostoma phulo* of *Cyprinidae* family; *Rita rita* of *Bagridae* family; *Wallago attu* of *Siluridae* family; *Channa marulius* and *C. striatus* of *Channidae* family; *Notopterus notopterus and N. chitala* of *Notopteridae* family were found in all months (May–August). Month wise availability of the fish species and genera has been depicted in the Table 2.

Table 2: Month wise fish genera and species availability in Harike wetland

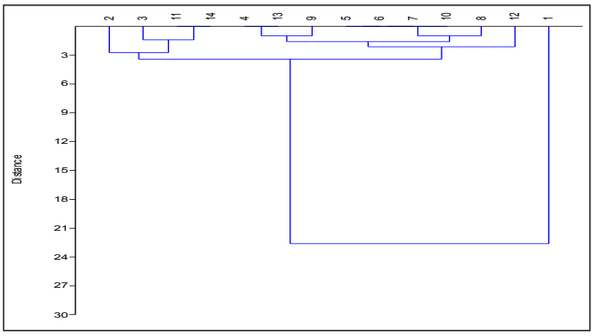
Sl. No.	Family	Number of genera				Number of species			
		May	June	July	Aug.	May	June	July	Aug.
1	Cyprinidae	09	08	08	06	16	12	10	11
2	Bagridae	03	01	02	04	04	01	02	04
3	Siluridae	02	01	02	02	03	01	02	02
4	Schilbeidae	01	0	01	01	01	00	01	01
5	Sisoridae	01	01	0	01	01	01	00	00
6	Clariidae	01	01	00	00	01	01	00	00
7	Belonidae	01	01	00	00	01	01	00	00
8	Synbrachidae	01	01	00	01	01	01	00	01
9	Ambassidae	01	00	01	00	01	00	01	00
10	Nandidae	01	01	00	00	01	01	00	00
11	Channidae	01	01	01	01	02	02	02	02
12	Mastacemblidae	01	01	00	01	02	01	00	02
13	Clupidae	01	0	01	01	01	00	01	01
14	Notopteridae	01	01	01	01	02	02	02	02
	Total	25	18	17	19	37	24	21	26

Maximum number of genera (25) and species (37) were recorded in the month of May and minimum number of genera (17) and species (21) were recorded in the month of July. This may be attributed due the onset of monsoon the water level of the wetland has increased in July; which may have restricted the range of the gear used to harvest fish from all the niches of the wetland. Two species, most abundantly found in the Harike wetland were *L. rohita* and *C. carpio communis* of *Cyprinidae* family in overall catch. In total *Cyprinidae* family was predominated in catch composition and accounted about 49.56% of total catch composition followed by *Siluridae* (15.81%), *Bagiridae* (12.69%), *Channidae* (7.90%), *Notopteridae* (6.88%) contributed significantly (Table 3).

Table 3: Family wise catch composition (%)

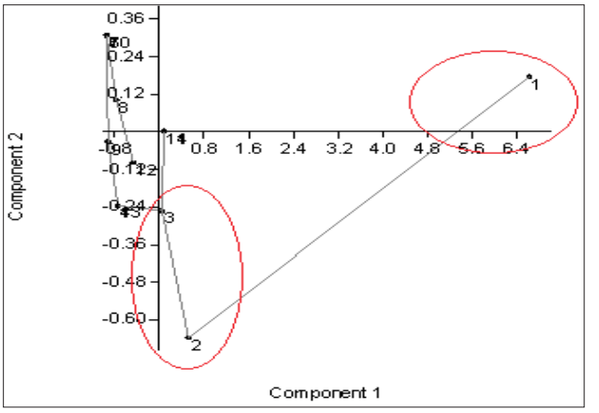
Family	Weight basis Catch composition (%)				
	May	June	July	August	Average
Cyprinidae	50.35	53.7	51.7	42.5	49.56
Bagiridae	9.0	10.25	16.0	15.5	12.69
Siluridae	14.25	17.5	14.0	17.5	15.81
Schilbeidae	1.0	-	0.9	0.8	0.90
Sisoridae	1.0	1.25	-	1.0	1.08
Clariidae	1.0	1.5	-	-	1.25
Belonidae	0.5	0.8	-	-	0.65
Synbrachidae	0.6	0.8	0.6	-	0.67
Ambassidae	0.5	-	0.3	-	0.40
Nandidae	0.1	0.2	-	-	0.15
Channidae	8.50	7.5	7.0	8.6	7.90
Clupidae	3.5		3.0	4.2	3.57
Mastacemblidae	2.4	2.0	-	0.7	1.70
Notopteridae	7.3	4.5	*6.5*	9.2	6.88

Dendrogram revealed that family *Bagridae*, *Siluridae*, *Channidae* and *Notopteridae* were closely associated and present in together in catch; whereas, *Schilbeidae* and *Ambassidae* family, *Belonidae* and *Synbrachidae* family revealed close association of their overall abundance. Family *Cyprinidae* dominated the catch composition and established as the controlling factor of the overall fish catch composition in the Harike wetland (Fig. 1). Principal Component Analysis (PCA) ordination of the fish family was performed to present a picture of the relationship between samples in terms of their similarity in abundance of fish families in catch composition, where the relative distance apart of any pair of samples was intended to reflect their relative dissimilarity. In PCA the amount of variation accounted by the new axes were maximized, proceeded by way of an eigen analysis on correlation matrix, where the new axes are uncorrelated. PCA ordination of the fish family revealed that family *Cyprinidae* contributed the maximum variability in the first PC and considered as dominant group. Second PC component revealed family *Bagridae* and *Siluridae* had close association in fish catch composition of Harike wetland (Fig. 2).



1.Cyprinidae, 2. Bagridae, 3. Siluridae, 4. Schilbeidae, 5. Sisoridae, 6.Clariidae,7. Belonidae, 8. Synbrachidae, 9. Ambassidae, 10. Nandidae, 11. Channidae, 12. Mastacemblidae 13. Clupidae and 14. Notopteridae

Fig. 1: Dendrogram from Bray – Curtis similarity matrix of fish family abundance data with group average linking for the family wise occurrence of fish species at Harike wetland



1.Cyprinidae, 2. Bagridae, 3. Siluridae, 4. Schilbeidae, 5. Sisoridae, 6.Clariidae,7. Belonidae, 8. Synbrachidae, 9. Ambassidae, 10. Nandidae, 11. Channidae, 12. Mastacemblidae 13. Clupidae and 14. Notopteridae

Fig. 2: Family wise PCA ordination of catch composition at Harike wetland

Earlier only 26 species of commercial importance were reported by Ladhar *et al.* (1994). Dhillon *et al.,* (1996) identified 16 fish species, and Dua and Chander (1999) have reported 61 fish species at Harike wetland. Brraich *et al.* (2003) identified three new fish species from Harike wetland which were not earlier recorded by any worker i.e. *Nandus nandus*, *Lepidocephalichthys guntea* and *Monopterus cuchia*. Moza and Mishra (2008) reported a total of 55 fish species from Harike wetland. They also recorded fish composition of Harike wetland and stated that IMC was dominant in catch composition, present in the range of 26.63- 51.48%, followed by common carp 8.96 – 33.54% and large size catfish (4.32 – 23.65 %). The catch composition of the present study revealed the similar trend with *Cyprinidae* family contributed about 49.56% of catch followed by *Siluridae* (15.81%), *Bagiridae* (12.69%) contributed significantly.

The study of species diversity and species richness, gives ecologists insights into the stability of communities (Walker, 1988). The relationship between species diversity/ richness and community stability is quite complex. Reed (1978) found that diversity indices were closely related to evenness, whereas species numbers (richness) were unimportant in determining species diversity for plankton and micro-benthos. Shannon's index is a measure of average degree of uncertainty in predicting to what species an individual selected at random from a collection of S species and N individuals belong. This uncertainty increases as the number of the species increases and as the distribution of individuals among the species become even. H′ = 0, if there is one species in the sample and H′ will be maximum when all S species are represented by same number of individuals. Shannon index is highest when all the species in a sample are equally abundant, decrease towards zero as the relative abundance of species diverse away from the evenness (Ismail and Dorggham, 2003). Maximum values of Shannon's index recorded in May (2.06) whereas, lowest value was recorded in the month of July (1.684) from Harike wetland. The result revealed that in the month of May equality of abundance of fish species were highest and equality of abundance of fish species was lowest in the month of July (Table 4, Fig 3).

Shannon's index (H′) is also an indicator of pollution. A community becomes more dissimilar as the stress increases and accordingly species diversity decreases with decreasing water quality. Hence community dominated by relatively few species would indicate environmental stress (Plafkin *et al*., 1989). A scale of pollution in terms of species diversity (3.0 – 4.5 slight, 2.0 - 3.0 light and 1.0 – 2.0 moderate and 0.1 – 1heavy pollution) has been described by Staub *et al*., (1970). In present study Shannon's index (1949) was highest in May (2.06) whereas, lowest value was recorded in the month of July (1.684) revealed light polluted nature of Harike wetland during pre-monsoon whereas, during the monsoon (June, July and August) moderate polluted nature of Harike wetland has been observed. The phenomenon may be attributed that during the monsoon the influx of water from adjacent catchment areas have increased the pollution load in wetland water.

Table 4: Diversity indices of fish species of Harike wetland

Biodiversity Indices	May	June	July	August
Fish species	37	24	21	26
Shannon (H)	2.061	1.82	1.684	1.817
Pielou's Evenness_(e^H/S)	0.5608	0.5611	0.6734	0.6837
Margalef richness	3.6	3.147	2.299	2.455

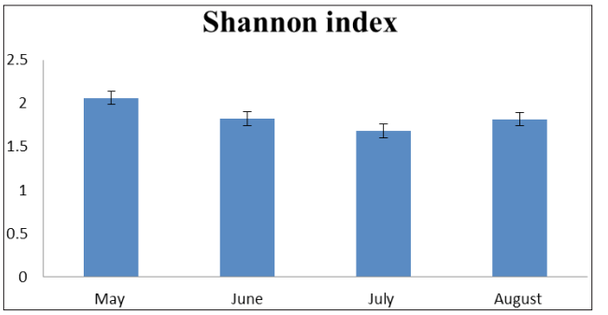


Fig. 3: Month wise variation in Shannon's index

Pielou's evenness Index reveals the evenness of distribution of various species in the sample. When all the species are equally abundant this evenness Index should be highest and decrease towards zero, as the relative abundance of the species diverse away from evenness. Maximum values of Pielou's evenness index was recorded in July (0.6837) and lowest value among all the sites was 0.5608 in May (Table 4, Fig. 4). The result revealed moderate evenness of abundance of the fish population in Harike wetland. Dua and Parkash (2009) reported slightly higher range of evenness index (0.9173- 0.9509) from Harike wetland.

Pielou (1975) observed that the concept of biodiversity (species evenness) is a central theme in community/ ecosystem ecology and can be used to explain other ecosystem properties such as biological productivity, habitat heterogeneity, habitat complexity and disturbance (Connell, 1978).

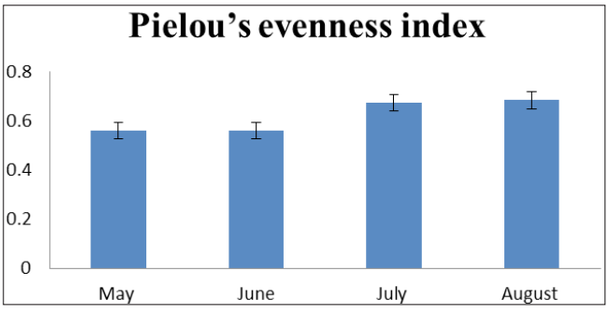


Fig. 4: Month wise variation in Pielou's evenness Index

Margalef Richness Index value recorded highest in the month of May (3.6) and lowest in the month of August (2.455) (range 2.45-3.60) which revealed that comparatively rich biodiversity was in pre-monsoon period rather than in monsoon at Harike wetland. Generally, in healthy environment Margalef's richness ranges 2.5-3.5 (Magurran, 1998; Khan *et al.,* 2004). In the present study Margalef richness index ranged from 2.45- 3.60 in different months indicating the healthy nature and richness in fish biodiversity of this wetland (Table 4, Fig. 5).

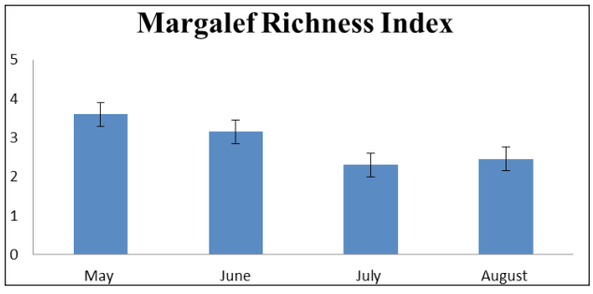


Fig. 5: Month wise variation in Margalef Richness Index

According to intermediate disturbance hypothesis (IDH) high species diversity in moderately disturbed ecosystems are attributed to co-existence of pioneer, stress-tolerant species. Same can be attributed to the findings at Harike wetland. Harike wetland itself is a mixed type of ecosystem where river Sutlej and Beas confluence. River Sutlej is carrying the waste water from Ludhiana city and is prone to anthropogenic stress thus level of disturbance was moderately high.

CONCLUSION

Based on the fish biodiversity and catch composition of landed fish, it can be concluded that despite of different natural and anthropogenic disturbances the wetland is still supporting a good number of fish species which is required to be conserved. Findings pertaining to present study may be useful as valuable time series data w.r.t. future study and policy making of this internationally important Ramsar site.

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