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ISSN : 0254-8704
http : //www.jeb.co.in

J. Environ. Biol.
30(2), 247-251 (2009)
info@jeb.co.in

Distribution and abundance of fish populations in Harike wetland-A Ramsar site in India

Anish Dua* and Chander Parkash

Laboratory of Aquatic Biology, Department of Zoology, Guru Nanak Dev University, Amritsar - 143 005, India

(Received: March 30, 2007; Revised received: September 27, 2007; Accepted: October 15, 2007)

Abstract: *Harike wetland was declared a Ramsar site in 1990. It is located at the confluence of two major rivers of Indus rivers system, the Beas and the Sutlej, but was never explored extensively for its existing fish biodiversity. Earlier only 27 fish species of commercial value were reported from the wetland. Acknowledging its importance for rich diversity, fish assemblages in seven different reaches of Harike wetland were studied to determine their abundance and distribution. 61 fish species of 35 genera were recorded from Harike wetland during the present study. Cirrihinus mrigala and Cyprinus carpio belonging to family Cyprinidae were the dominant fish species. Lake and Riyasat having many microhabitats supported highest diversity of fishes (60 and 56 respectively) followed by Beas (20) Sutlej (14), Confluence (12), Reservoir (9) and Downstream (8). Among the IUCN designated threatened species, 1 Critically Endangered, 4 Endangered and 13 Vulnerable fish species of India are found in Harike wetland. Species diversity index, dominance, evenness and catch per unit effort were calculated to ascertain the fish distribution in Harike wetland.*

Key words: *Fish abundance, Species diversity index, Dominance, Evenness, Catch per unit effort, Harike wetland*
PDF of full length paper is available with author ***(*anishdua@gmail.com)***

Introduction

Wetland ecosystems are fragile but vital ecosystems, recognized for their role in conservation of fish biodiversity and are designated as Ramsar sites (Internationally recognized wetlands) on the basis of the number of threatened fish species they support (Kottelat and Whitten, 1996). 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 role of wetlands in conserving fish diversity has been widely acknowledged as these ecosystems are used by fishes as a refuge for breeding, feeding and nesting purposes at one or the other stage of their life cycle (Wetzel, 2001). Unfortunately, the role of wetlands in fish conservation has been poorly documented in the Punjab State. Earlier 116 species of fish were recorded from the reorganised Punjab (Johal and Tandon, 1979, 1980) but after a long gap 26 and 16 species were reported from Harike wetland by Ladhar *et al.* (1994), Dhillon and Kaur (1996). Since Harike is at the confluence of two major rivers of Punjab it was evident that there is a huge gap in these reportings. To fill this gap the present study was carried out in order to examine the diversity, distribution and abundance of fish species in different reaches of Harike wetland located in Central Asian Indian Flyway Zone of bird migration.

Materials and Methods

Harike wetland is located at the confluence of rivers Beas and Sutlej in the Punjab State (Fig. 1). Fishing operations were carried out in the wetland from May 2002 to December 2003 by employing various nets of different mesh sizes in seven reaches of the Harike wetland. These sits are: Lake, Riyasat and Reservoir (representing lacustrine habitats), Beas, Sutlej and Confluence (representing riverine habitats) and Downstream. Four types of nets *i.e.* Gill net, Cast net, Hand net and Hook and Line were used. The fishes caught were examined for their morphological features; color bands or spots present on the body and these were recorded in the field. Two specimens of each species were taken for identification while the rest were released back into the water. The specimens were transported to the lab after wrapping them in cotton soaked in 10% formalin solution and packed in a polythene bag. The large sized fishes were injected with the formalin solution of same concentration to prevent the decay of visceral organs. Before identification these were washed in running tap water for half an hour and then their species was ascertained on the basis of various morphometric characters and meristic counts following the criteria given by Jayram (1999), Jhingaran and Talwar (1991). The data collected on fish species was then subjected to analysis for Species diversity index, Evenness index and Dominance by using computer softwares PRIMER-E for WINDOWS Version 5.2.2 (Anonymous, 2001) and PAST Version 1.24 (Hammer *et al.*, 2001). One way ANOVA was calculated to observe significant difference between Species richness and Species abundance at all the sampling sites by using SPSS for WINDOWS release 10.0.5 (Anonymous, 1999).

Results and Discussion

61 species of fishes were recorded from Harike wetland and these belong to 17 families and 35 genera (Table1). Maximum number of species (27) recorded were of family Cyprinidae followed by families Bagridae (7 species), Siluridae, Schilbeidae, Channidae,

Table - 1: Record of fish species from Harike wetland Ramsar site

Superclass	:	Gnathostomata
Class	:	Actinopterygii
Subclass	:	Neopterygii
Division	:	Teleostei
Order I	:	Osteoglossiformes
Family1	:	Notopteridae
Species	:	**1** *Notopterus notopterus* (Pallas)
		2 *Notopterus chitala* (Hamilton-Buchanan)
Order II	:	Clupeiformes
Family 2	:	Clupeidae
Species	:	**3** *Gudusia chapra* (Hamilton-Buchanan)
Order III	:	Cypriniformes
Family 3	:	Cyprinidae
Species	:	**4** *Catla catla* (Hamilton-Buchanan)
		5 *Cirrihinus mrigala* (Hamilton-Buchanan)
		6 *Cirrhinus reba* (Hamilton-Buchanan)
		7 *Cyprinus carpio communis* (Linnaeus)
		8 *Cyprinus carpio specularis* (Linnaeus)
		9 *Labeo angra* (Hamilton-Buchanan)
		10 *Labeo bata* (Hamilton-Buchanan)
		11 *Labeo caeruleus* (Hamilton-Buchanan)
		12 *Labeo calbasu* (Hamilton-Buchanan)
		13 *Labeo dero* (Hamilton-Buchanan)
		14 *Labeo gonius* (Hamilton-Buchanan)
		15 *Labeo lippus* (Fowler)
		16 *Labeo rohita* (Hamilton-Buchanan)
		17 *Osteobrama cotio cotio* (Hamilton-Buchanan)
		18 *Puntius jerdoni* (Day)
		19 *Puntius sarana sarana* (Hamilton-Buchanan)
		20 *Puntius sophore* (Hamilton-Buchanan)
		21 *Puntius terio* (Hamilton-Buchanan)
		22 *Puntius ticto* (Hamilton-Buchanan)
		23 *Salmostoma bacaila* (Hamilton-Buchanan)
		24 *Salmostoma horai* (Silas)
		25 *Salmostoma phulo* (Hamilton-Buchanan)
		26 *Amblypharyngodon mola* (Hamilton-Buchanan)
		27 *Esomus danricus* (Hamilton-Buchanan)
		28 *Parluciosoma daniconius* (Hamilton-Buchanan)
		29 *Schizothorax richardsonii* (Gray)
		30 *Gara gotyla gotyla* (Gray)
Order IV	:	Siluriformes
Family 4	:	Bagridae
Species	:	**31** *Aorichthys aor* (Hamilton-Buchanan)
		32 *Aorichthys seenghala* (Sykes)
		33 *Mystus bleekari* (Day)
		34 *Mystus cavasius* (Hamilton-Buchanan)
		35 *Mystus horai* (Jayaram)
		36 *Mystus vittatus* (Bloch)
		37 *Rita rita* (Hamilton-Buchanan)
Family 5	:	Siluridae
Species	:	**38** *Ompok bimaculatus* (Bloch)
		39 *Ompok pabda* (Hamilton-Buchanan)
		40 *Wallago attu* (Schneider)
Family 6	:	Schilbeidae
Species	:	**41** *Clupisoma garua* (Hamilton-Buchanan)
		42 *Eutropiichthys murius* (Hamilton-Buchanan)
		43 *Eutropiichthys vacha* (Hamilton-Buchanan)
Family 7	:	Sisoridae
Species	:	**44** *Bagarius bagarius* (Sykes)
		45 *Glyptothorax punjabensis* (Mirza and Kashmiri)
Family 8	:	Clariidae
Species	:	**46** *Clarias batrachus* (Linnaeus)
Family 9	:	Heteropneustidae
Species	:	**47** *Heteropneustes fossilis* (Bloch)
Order V	:	Cyprinodontiformes
Family 10	:	Belonidae
Species	:	**48** *Xenentodon cancila* (Hamilton-Buchanan)
Order VI	:	Synbranchiformes
Family 11	:	Synbranchidae
Species	:	**49** *Monopterus (Amphinous) cuchia* (Hamilton-Buchanan)
Order VII	:	Perciformes
Family 12	:	Ambassidae
Species	:	**50** *Chanda nama* (Hamilton-Buchanan)
		51 *Pseudembassis ranga* (Hamilton-Buchanan)
Family 13	:	Nandidae
Species	:	**52** *Nandus nandus* (Hamilton-Buchanan)
Family 14	:	Gobiidae
Species	:	**53** *Glossogobius giuris* (Hamilton-Buchanan)
Family 15	:	Belontiidae
Species	:	**54** *Colisa fasciatus* (Schneider)
		55 *Colisa lalia* (Hamilton-Buchanan)
Family 16	:	Channidae
Species	:	**56** *Channa marulius* (Hamilton-Buchanan)
		57 *Channa punctatus* (Bloch)
		58 *Channa striatus* (Bloch)
Family 17	:	Mastacemblidae
Species	:	**59** *Macrognathus aral* (Bloch and Schneider)
		60 *Macrognathus pancalus* (Hamilton-Buchanan)
		61 *Mastacembelus armatus* (Lacepede)

Mastacembelidae (3 species each), Gobiidae, Notopteridae, Sisoridae, Ambassidae and Belontiidae (2 species each), Clupeidae, Clariidae, Heteropneustidae, Synbranchidae, Belonidae and Nandidae (1 species each). Only two species *Wallago attu* and *Cirrihinus mrigala* were found at all seven sites. Two species, most abundantly found in the Harike wetland were *Cirrihinus mrigala* and *Cyprinus carpio communis* and these constitute 23% of the total fish catch. 20, 14, 60, 56, 12, 9, 8 fish species were recorded from Beas, Sutlej, Lake, Riyasat, Confluence, Reservoir and Downstream respectively (Table 2). IUCN designated (Molur and Walker, 1998), one Critically Endangered, four Endangered and thirteen Vulnerable species of fish are being reported from Harike wetland (Table 2) in the present study. Earlier only 26 species of commercial importance were reported by Ladhar *et al.* (1994). Species richness and species abundance were ascertained for all the sites (Fig. 2). The two sites *i.e.* Reservoir and Downstream were not considered for analysis because of low species richness and species abundance. Reservoir is a site which is heavily choked with silt while in Downstream, water availability was very low during most of the study period. The dams and barrage hinder the movements of fishes thus their diversity decreases in downstream of the barrage (Katano *et al.,* 2006). Species richness and species abundance were higher at two reaches *i.e.* Lake and Riyasat followed by Beas and Sutlej and lowest at the confluence. The species richness and

Table - 2: Existence of fish species at seven sites of Harike wetland

Fish species	Beas	Sutlej	Lake	Riyasat	Confluence	Reservoir	D.S	IUCN Status
Amblypharyngodon mola	NF	NF	+	+	NF	NF	NF	LRlc
Aorichthys aor	+	NF	+	+	+	+	NF	ND
Aorichthys seenghala	+	+	+	+	+	+	NF	ND
Bagarius bagarius	NF	+	NF	+	+	NF	NF	VU
Catla catla	+	NF	+	+	+	NF	NF	VU
Chanda nama	NF	NF	+	+	NF	NF	NF	ND
Channa striatus	NF	NF	+	+	NF	NF	NF	LRnt
Channa marulius	NF	NF	+	+	NF	NF	NF	LRnt
Channa punctatus	NF	NF	+	+	NF	NF	NF	LRnt
Cirrihinus reba	+	NF	+	+	NF	+	NF	VU
Cirrihinus mrigala	+	+	+	+	+	+	+	LRnt
Clarias batrachus	NF	NF	+	+	NF	NF	NF	VU
Clupisoma garua	+	+	+	+	+	NF	NF	VU
Colisa fasciatus	NF	NF	+	+	NF	NF	NF	LRnt
Colisa lalia	NF	NF	+	+	NF	NF	NF	ND
Cyprinus carpio communis	+	+	+	+	+	NF	+	ND
Cyprinus carpio specularis	+	+	+	+	NF	+	NF	ND
Esomus danricus	NF	NF	+	+	NF	NF	NF	LRlc
Eutropiichthys murius	+	NF	+	+	NF	NF	NF	LRnt
Eutropiichthys vacha	NF	+	+	+	+	NF	NF	EN
Garra gotyla gotyla	NF	NF	+	+	NF	NF	NF	VU
Glossogobius giuris	NF	NF	+	+	NF	NF	NF	LRnt
Glyptothoax punjabensis	NF	NF	+	+	NF	NF	NF	ND
Gudusia chapra	NF	NF	+	+	NF	NF	NF	ND
Heteropneustes fossilis	NF	NF	+	+	NF	NF	NF	VU
Labeo angra	+	NF	+	+	NF	NF	NF	LRnt
Labeo bata	+	NF	+	+	NF	+	NF	LRnt
Labeo caeruleus	NF	NF	+	+	NF	NF	NF	ND
Labeo calbasu	+	+	+	+	NF	NF	+	LRnt
Labeo dero (lippus)	+	NF	+	+	NF	NF	NF	VU
Labeo diplostomus (dero)	+	NF	+	+	NF	NF	NF	LRnt
Labeo gonius	+	+	+	+	NF	+	+	LRnt
Labeo rohita	+	+	+	+	+	+	NF	LRnt
Macrognathus aral	NF	NF	+	+	NF	NF	NF	LRnt
Macrognathus pancalus	NF	NF	+	+	NF	NF	NF	LRnt
Mastacembelus armatus	NF	NF	+	NF	NF	NF	+	LRnt
Monopterus cuchia	NF	NF	+	+	NF	NF	NF	LRnt
Mystus bleekari	NF	NF	+	+	NF	NF	NF	VU
M. cavasius	NF	NF	+	+	NF	NF	NF	LRnt
Mystus horai	NF	NF	+	+	NF	NF	NF	ND
Mystus vittatus	NF	NF	+	NF	NF	NF	NF	VU
Notopterus chitala	+	+	+	+	+	NF	+	EN
Notopterus notopterus	NF	NF	+	+	NF	NF	NF	LRnt
Nandus nandus	NF	NF	+	+	NF	NF	NF	LRnt
Ompok bimaculatus	NF	NF	+	NF	NF	NF	NF	EN
Ompok pabda	NF	NF	+	NF	NF	NF	NF	EN
Osteobrama cotio cotio	NF	NF	+	+	NF	NF	NF	LRnt
Pseudembassis ranga	NF	NF	+	+	NF	NF	NF	ND
Puntius jerdoni	NF	NF	+	+	NF	NF	NF	ND
Puntius sarana sarana	NF	NF	+	+	NF	NF	NF	VU
Puntius sophore	NF	NF	+	+	NF	NF	NF	LRnt
Puntius terio	NF	NF	+	+	NF	NF	NF	ND
Puntius ticto	NF	NF	+	+	NF	NF	NF	CR
Rasbora daniconius	NF	NF	+	+	NF	NF	NF	VU
Rita rita	+	+	+	+	+	NF	+	LRnt
Salmostoma bacaila	NF	NF	+	+	NF	NF	NF	LRlc
Salmostoma horai	NF	NF	+	+	NF	NF	NF	ND
Salmostoma phulo punjabensis	NF	NF	+	NF	NF	NF	NF	ND
Schizothorax richardsonii	NF	NF	+	+	NF	NF	NF	VU
Wallago aatu	+	+	+	+	+	+	+	LRnt
Xenentodon cancila	+	+	+	+	NF	NF	NF	LRnt

*D.S. (Downstream), NF (Not found), ND (Not Determined), LRnt (Lower Risk-Near Threatened), VU (Vulnerable), EN (Endangered), CR (Critically Endangered), LRlc (Lower Risk-Least Concern), + (Present)

Table - 3: Total number of species (S), Total number of individuals (N), Species richness (D), Species evenness (J'), Species diversity index (H') and dominance (λ) at five sites in Harike wetland

Sites	S	N	D	J'	H'(log e)	λ (Dominance)
Riyasat	56	388	9.227	0.9173	3.693	0.03507
Lake	60	509	9.467	0.9509	3.893	0.02505
Beas	20	176	3.675	0.8116	2.431	0.1197
Sutlej	14	170	2.531	0.8093	2.122	0.1492
Confluence	12	24	3.461	0.926	2.301	0.1181

Table - 4: Average number of species(S) and individuals(N) found in different sites of Harike wetland

Sites	S	N	Average
Beas	20	176	8.8
Sutlej	14	170	10.1
Riyasat	56	388	6.9
Lake	60	509	8.4
Reservoir	9	23	2.5
Confluence	12	24	2.0
Downstream	8	21	2.6

abundance were significantly different ($F=20.47$, $p<0.001$ and $F=3.414$, $p<0.003$) at all the sites (Fig. 2). The values of Species richness index (D), Species Diversity Index (H'), Evenness (J') and Dominance (λ) at all the seven sites are given in Table 3. Species richness as indicated by D shows that Lake and Riyasat have high species richness as compared to the other five sites. Similarly an analysis of Species Diversity Index (SDI) further supports the above statement where SDI in Lake (3.893) was highest and closely followed by Riyasat (3.693) and was followed by Beas (2.431), Confluence (2.301) and Sutlej (2.122). As the Species diversity index and Species richness index (SRI) depend upon the number of species as well as number of individuals in each species and contributes equally to the values of SDI and SRI (Ludwig and Reynolds, 1988), hence if any one of these two variables decreases or increases, it will affect the overall values of SDI and SRI. Moreover these are the areas which are represented by slow water movements with a considerable cover of macrophytes and algae which provide excellent habitats for cover from predatory fishes and also as feeding grounds to the small sized fishes (Kadye and Marshall, 2007; Tales and Berrebi, 2007). Further if we look at the average number of individuals per species, the river Sutlej has highest value (10.1) followed by river Beas (8.8), Lake (8.48), Riyasat (6.9), and Confluence (2.0) Table 4. Since the number of species in these sites is very less in comparison to the Lake and Riyasat, values of SDI are very less. Dominance is a measure of probability of finding common or dominant individuals whose population is higher. In Lake and Riyasat dominance is very low as compared to other sites because as the number of species increases, the probability of finding of individuals of common species also decreases as compared to the areas where species diversity is low. Hence it is inversely related to the SDI and SRI. Therefore the areas where SDI and SRI are of low value, dominance will be higher there.

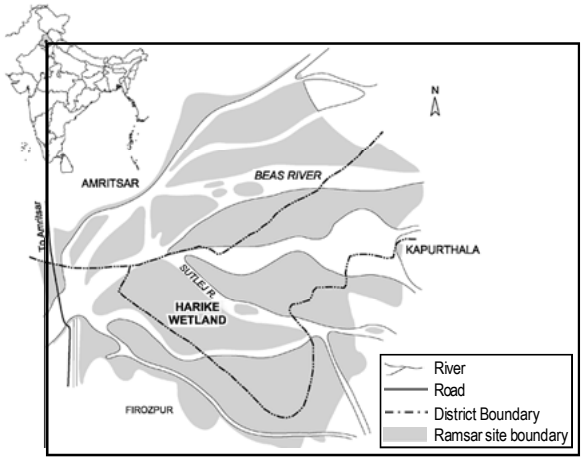

Fig. 1: Map of Harike wetland

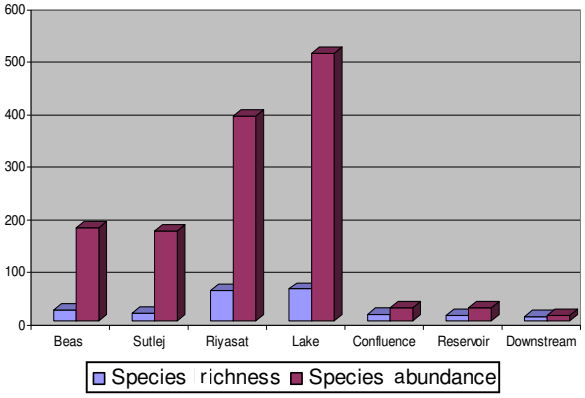

Fig. 2: Species richness and abundance at Harike wetland level

The abundance of fish population within a habitat is reflected by Evenness (J'). The measure of species richness traditionally used, without including evenness, may not be providing an accurate reflection of the fish community. The values of **J'** reveals that in Lake (0.9509) and Riyasat (0.9173) most of the fish populations are equally abundant. Though the J' is higher in case of Confluence when compared with Riyasat area but the area of Confluence was very less as compared to Riyasat and species richness and abundance were also very low. The level of significance between the sites for available fish spp and their abundance is in accordance with the other studies carried out in India and Malaysia (Johal, 2002; Martin-Smith, 1998).

From the analysis it is found that Lake and Riyasat are the two reaches where species richness, abundance and hence SDI, SRI and Evenness were higher than any other site. These two sites are most diverse in their physical microhabitat structures which provide ideal conditions for feeding, breeding and nesting. The open areas which are moderately vegetated with surface and emergent vegetation support higher species abundance and diversity than open water areas. Similarly vegetated banks were richer in above mentioned assemblage variables than degraded banks. On the other side, Beas and Sutlej being rivers provide less diverse habitats as only riverine conditions prevail in them. Therefore majority of fishes are those which are specialized for fast moving water currents. The riverine fishes enter the Lake and Riyasat area for feeding as well as breeding purposes. Confluence was not rich in diversity and abundance because this is again a heavily silted area and was avoided by fish.

The results of the study indicate that 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. Though the wetland is subjected to varied pressures (anthropogenic and natural) it still is a rich aquatic ecosystems of the Punjab state.

Acknowledgments

Authors are highly thankful to Ministry of Environment and Forests, Govt. of India for providing financial help to carry out the present study and the help extended by Wetlands International-South Asia. Thanks are due to the Department of Forest and Wildlife, Punjab State for allowing us to work in the protected area.

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