

THE STATUS OF FISH DIVERSITY OF RIVER CHENAB, PAKISTAN

M. Altaf¹, A. Javid¹, A. M. Khan^{2*}, A. Hussain⁴, M. Umair³, Z. Ali²

¹Department of Wildlife and Ecology, UVAS, Lahore, Pakistan,

²Department of Zoology, University of the Punjab, Lahore, Pakistan,

³Department of Plant Sciences, Quaid-i-Azam University, Islamabad Pakistan,

⁴Department of Fisheries and Aquaculture, UVAS, Lahore, Pakistan

*Corresponding Author's Email: majid.zool@pu.edu.pk

ABSTRACT

River Chenab is an important wetland of Punjab, Pakistan. Water is becoming polluted due to anthropogenic impact i.e. industrial waste, urbanization, agriculture intensification and global warming. The main objectives of the study were to know the diversity and distribution of fish species of river Chenab. The study was focused at three heads of the river namely Head Marala (district Sialkot), Head Khanki (district Gujrat) and Head Qadirabad (district Gujranwala). Status of fish diversity was recorded with the help of local fisherman from the study area; the data was collected in all seasons. Both, direct and indirect methods were applied to find out fish diversity of the area. The diversity indices were analyzed through statistical software PAST version 2.17 C. During the sampling 34 species was recorded from the river Chenab. The diversity indices indicate a higher diversity at the Head Qadirabad than at Head Khanki and Head Marala. The possible reason may be the presence of a large number of natural and manmade ponds. During flood, fish from these ponds move to the river; further eggs and fingerlings move to rivers through birds and fisherman.

Key words: Fish Diversity, River Chenab, Pakistan.

INTRODUCTION

Pakistan has largest canal system and also has more than 225 wetlands; only 19 are listed as Ramsar sites. Pakistan covers 780,000 hectares area which consists of 9.7% (73% of freshwater and 26.06% of coastal wetland areas) of the total wetland area of the country (IUCN, 1989; Altaf *et al.* 2014). Freshwater is an essential and limited resource; which is necessary for animals as well as human activities like agriculture, industry, drink and domestic needs (Bartram and Ballance, 1996). The water history and water resource use is as old as human evolution (Gleick *et al.* 2002). Water played vital role in the evolution of human societies and civilizations. Most of the ancient human societies and civilizations established near the freshwater resources like rivers, ponds and streams (Gupta and Gupta, 2006).

Water quality is very important for the survival of the living, which is at the mercy of the natural and anthropogenic impacts. Water quality is decreasing day by day due to anthropogenic impact i.e. agriculture intensification, industrialization and extreme urbanization (Singh *et al.* 2007). Heavy metals are the pollutants, which pollute the environment for a long time and with an irreversible impact on the productivity of aquatic ecosystem and ecology (Majagi *et al.* 2008). Heavy metals in freshwater medium are destructive for aquatic biodiversity even at very low quantity (Schüürmann and Markert, 1998).

Diversity is divided into two components as; richness (number of species in a specific area) and evenness (population) (Magurran, 2004). The world has more than 27,977 species of fish (represented by 515 families and 62 orders) (Nelson, 2006; Helfman *et al.* 2009). Pakistan has wide diversity of fresh and marine water fishes with more than 171 species of freshwater fishes (Peter, 1999; Mirza, 2004). Richness of the fish of tropical to subtropical rivers is correlated within the river basin (Welcomme, 1979). Asian region has number of large basins for growth and nesting of fish. The dynamic features of these river ecosystems are the result of changes in level of water because of change in rainfall in nesting and growth area (Thorp *et al.* 2008). This dynamics brings about variety in fish community morphology which is often brought about by impact of environmental factors inside the river ecosystem (Taylor *et al.* 2006), species interactions (Winemiller, 1989), food availability and fish movements (Taylor, 1997). Mostly lotic water fishes synchronize nesting activity with the flood season and migrate upstream during rainy season and move back in the dry season (Dudgeon, 1992). Some of them are very important economically, these are used as food, as well as ornamental and medical purposes. The main objectives of the study was to determine the diversity of fish and distribution of fish species of the river Chenab, Punjab, Pakistan.

MATERIALS AND METHODS

The study was carried out in the following three years (from Dec. to Nov.) viz. 2006-07, 2009-10 and 2013-14 during sun-up (5:00 am to 10:00 am) hours. Data on ecology and population status of fish diversity was recorded with the help of local fisherman from the study area; the data was collected in all seasons in whole years.

Study area: River Chenab starts from the Kangra and Kulu districts of Himachal Pradesh, provinces of India and enters in Pakistan near Diawara village, district Sialkot. Total length (in Pakistan and India) of river

Chenab is 960 km. Annual water flow is 26.44 billion cubic meters. River Chenab forest is included in Tropical thorn forest (Siddiqui, 1997) large area of which has changed into agriculture land. Some agricultural land lies in river basin and island type dry areas are prominent. Head Marala, Head Qadirabad, Head Khanki and head Trimmu are the important water reservoirs of the river (Siddiqui and Tahir-Kheli, 2004). Head Marala is located at 32° 38'59 N, 74° 28'05 E, elevation of 243 m. Head Khanki is present at 32°25'07 N, 073°57'39 E, and 220 m elevation. Head Qadirabad is present at 32°20'16 N, 073°42'36 E, and 205 m elevation (Figure-1).

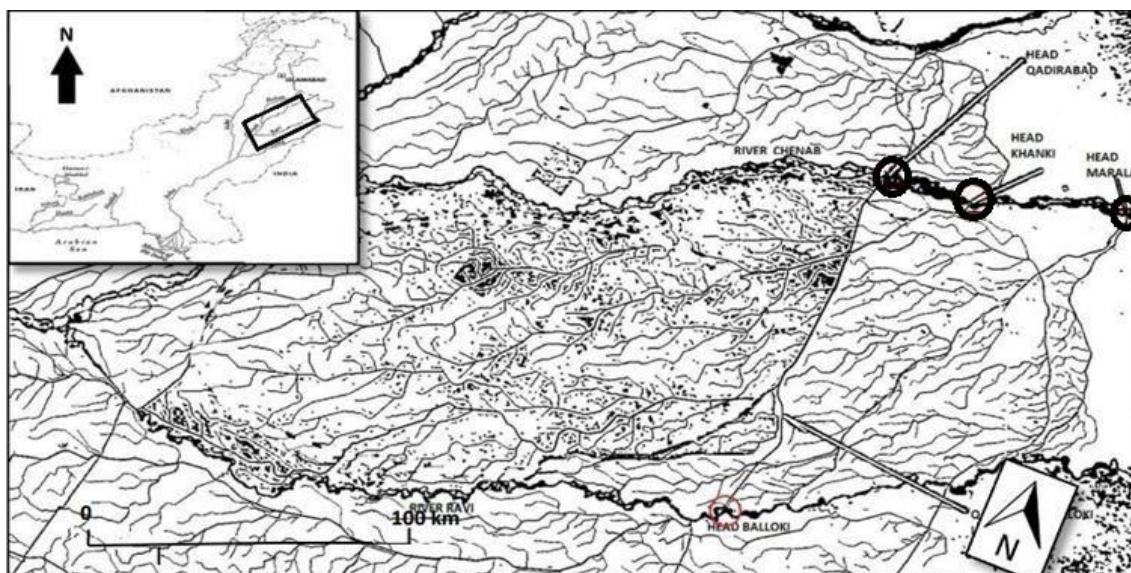


Figure: 1. The Map of river Chenab along with three study sites i.e. Head Marala, Khanki, and Qadirabad

Climate: Climate of the area is sub-tropical with annual average temperature ranging from 5°C during winter to 45°C during summer. The pH of water is alkaline and averages 7.9 to 8.1 (Irrigation and Power Department Punjab, 2007).

Both, direct (total count) and indirect (meetings with locals, carcasses and remaining of fishes) methods were applied to find out fish diversity of the area. Mirza, (2004) was consulted for identification and previous distribution of fishes of the study area. Boat surveys were also conducted once in each season for diversity of fish. Fish specimens were collected from river Chenab. The fishing effort was done by using gill nets with the same length (100 m to 20 m) and height (1.6 m), but with mesh size 1.5 inches and more. Wahera nets were also (Altaf *et al.* 2011a,b) used during the study for fish collection. Some collected specimens were preserved in Department of Zoology, University of the Punjab and Department of Zoology, Government Islamia College Gujranwala.

Statistical Analysis: Computation of data for the Simpson (S), Shannon diversity (H'), Evenness (E), Margalef (R) and Dominance (D) of fish was recorded by using a computer-based program PAST version 2.17C (Hammert, 2001).

RESULTS AND DISCUSSION

The river Chenab is the most important wetland of Pakistan, which has wide diversity of the flora and fauna. During the research 34 species (Table-1, Figure-2) and 1766 number of the fishes were recorded from the river Chenab. Mirza *et al.* (2006) recorded 51 species and 1191 fish specimens from the river Jhelum. Khan *et al.* (2008) recorded 20 species from the Chashma barrage and 22 species were collected from the Taunsa barrage. Mirza *et al.* (2011) documented 51 species during the survey of the river Jhelum. Altaf *et al.* (2011b) identified 33 species from the head Qadirabad. Khan *et al.* (2011) recorded the 50 species from the Ravi while 30 species

recorded from the river Jhelum. Qadir (2010) recorded 24 species and 1506 specimen from the Nullah Aik and Nullah Palku.

The diversity indices (Table-2) of this area indicated the dominance of fish at head Qadirabad as 0.09, at Head Khanki as 0.13 and at Head Marala as 0.12, Simpson index at Head Qadirabad was 0.91, Head Khanki 0.87 and Head Marala 0.88, Shannon index at Head Qadirabad was 2.83, at Head Khanki 2.57 and at Head Marala 2.62, Evenness at Head Qadirabad was 0.5, Head Khanki 0.41 and Head Marala 0.43. Margalef index at Head Qadirabad was 5.14, Head Khanki 5.02 and Head Marala 4.77, Brillouin index at Head Qadirabad 2.72, Head Khanki 2.46 and Head Marala 2.53 and Menhinick index at Head Qadirabad was calculate as 5.14, Head Khanki 5.02 and Head Marala 4.77. Khan *et al.* (2011) collected the specimen from the river Ravi computed

them as; Shannon index was 1.33, Simpson index was 0.912 and Evenness was 0.41, while at river Jhelum Shannon index was 1.329, Simpson index was 0.949 and Evenness was 0.906. Altat *et al.* (2011b) recorded the Shannon index as; 3.11 from head Qadirabad. Statistical computed results and diversity indices indicate that high diversity is present at the head Qadirabad. The reason may be that there is present large number of natural and manmade ponds which also culture fish; during the flood (in 2010, 2014) these fishes move to the river; further eggs and fingerlings are also disperse through birds (i.e. egrets, cormorants, kingfishers, herons, terns and etc.) and fisherman (During fishing activities). While other areas like Head Khanki and Marala have very low number of artificial and natural ponds so these areas have lower diversity than head Qadirabad.

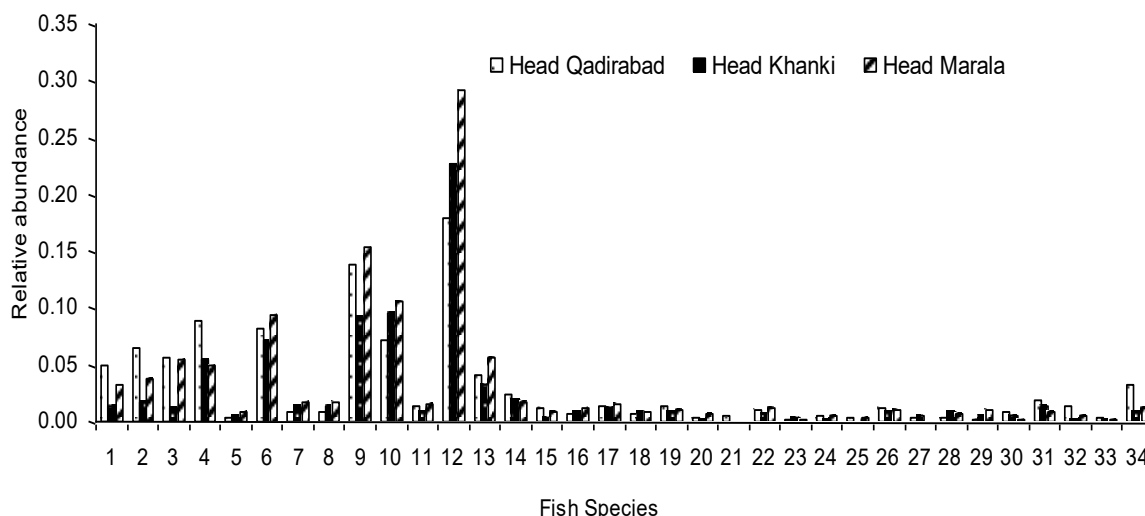
Table 1. Fish diversity record from 2013-14 from river Chenab

Sr. No	Scientific name	Common Name	IUCN Status	H.Q. (R.A.)	H.K. (R.A)	H.M. (R.A)
1	<i>Ctenopharyngodon idella</i>	Grass Carp	NE	0.049	0.013	0.032
2	<i>Cyprinus carpio</i>	Common Carp	VU	0.065	0.018	0.037
3	<i>Hypophthalmichthys molitrix</i>	Silver Carp	NT	0.057	0.011	0.055
4	<i>Cirrhinus mrigala</i>	Mori	LC	0.089	0.055	0.049
5	<i>Cirrhinus reba</i>	Reba Machhali	LC	0.003	0.005	0.008
6	<i>Labeo rohita</i>	Raho	LC	0.081	0.071	0.094
7	<i>Labeo calbasu</i>	Kalbans	LC	0.008	0.013	0.016
8	<i>Labeo dero</i>	Dero Machhali	LC	0.008	0.013	0.018
9	<i>Catla catla</i>	Thaila	LC	0.138	0.093	0.154
10	<i>Channa punctate</i>	Dola	LC	0.071	0.096	0.106
11	<i>Channa marulious</i>	Soul	LC	0.013	0.008	0.015
12	<i>Oreochromis aureus</i>	Tilapia	NE	0.179	0.227	0.292
13	<i>Rita rita</i>	Khaga	LC	0.041	0.032	0.057
14	<i>Bagarius bagarius</i>	Foji Khaga	NT	0.024	0.019	0.018
15	<i>Mystus cavasius</i>	Tangra Machhali	LC	0.011	0.003	0.008
16	<i>Mastacembelus armatus</i>	Baam Machhali	LC	0.006	0.008	0.011
17	<i>Sperata sarwari</i>	Sangari	NE	0.013	0.011	0.015
18	<i>Wallago attu</i>	Mali	NT	0.006	0.008	0.008
19	<i>Eutropiichthys vacha</i>	Jhali	LC	0.013	0.008	0.010
20	<i>Tor macrolepis</i>	Masheer	NE	0.003	0.002	0.006
21	<i>Clupisoma garua</i>	Bachhwa	LC	0.005	0.000	0.000
22	<i>Notopterus notopterus</i>	But Pari	LC	0.010	0.006	0.011
23	<i>Barilius modestus</i>	Lahori Chalwa	NE	0.002	0.003	0.002
24	<i>Puntius sophore</i>	Sophore Popra	LC	0.005	0.002	0.005
25	<i>Puntius ticto</i>	Ticto Popra	LC	0.003	0.000	0.003
26	<i>Parambassis ranga</i>	Ranga Sheesha	LC	0.011	0.008	0.010
27	<i>Sisor raddophorus</i>	Kirla Machhali	LC	0.003	0.005	0.000
28	<i>Xenoto doncancila</i>	Kaan Machhali	LC	0.003	0.008	0.006
29	<i>Garra gotyla</i>	Pather Chat	LC	0.002	0.005	0.010
30	<i>Osteo bramacotio</i>	Pali Roo Machhali	LC	0.008	0.005	0.002
31	<i>Salmo stomabacaila</i>	Choti Chal Machhali	LC	0.019	0.013	0.008
32	<i>Hetero pneustesfossilis</i>	Sangehi Machhali	LC	0.013	0.002	0.005
33	<i>Gagata cenia</i>	Gagata Cenia	LC	0.003	0.002	0.002
34	<i>Macrogathus pancalus</i>	Garoj	LC	0.032	0.008	0.011

Note: R.A. (Relative Abundance), H.Q. (Head Qadirabad), H.K. (Head Khanki) and H.M. (Head Marala), LC

Table 2. Statistical analysis of the fish diversity of river Chenab

Serial number	Head Qadirabad	Head Khanki	Head Marala
Number of Species	34	32	32
Dominance (D)	0.09	0.13	0.12
Simpson (S)	0.91	0.87	0.88
Shannon (H')	2.83	2.57	2.62
Evenness (E)	0.50	0.41	0.43
Brillouin index (B)	2.72	2.46	2.53
Menhinick index (M)	1.37	1.46	1.24
Margalef (R)	5.14	5.02	4.77


Figure: 2. Diversity of the fish and relative abundance, numbers showed the species, serial number in table 1.

The IUCN (2014) red list results showed that the diversity of river Chenab has only one fish species (Common Carp) Vulnerable (VU), only three species (Silver Carp, Foji Khaga and Mali) as; Near Threatened (NT), 25 species are counted as Least Concern, while 5 species are Not Evaluated (EV).

During this study it was noted that grass carp, common carp and silver carp were the invasive species of Pakistan, and relative abundance (RA) of grass carp was recorded as; 0.049 from the Head Qadirabad, 0.013 (RA) from the Head Khanki and 0.032 (RA) from the Head Marala, Common carp recorded as; 0.065 (RA) from the head Qadirabad, 0.018 (RA) from the head Khanki and 0.037 (RA) from the head Marala, and silver carp recorded as 0.057 (RA) from the head Qadirabad, 0.011 (RA) from the head Khanki and 0.055 (RA) from the head Marala. These species have been recorded (Rafique and Khan, 2012) from the different parts of the Punjab as; Khanki, Qadirabad (Altaf *et al.* 2011a,b), Chashma, Taunsa, (Khan *et al.*, 2008), Jhelum and Ravi rivers (Khan *et al.* 2011).

Among the carps, mori, reba machhali and raho are the native carp species in Pakistan. During the survey mori was noted as; 0.089 (RA) from the head Qadirabad,

0.055 (RA) from the head Khanki and 0.049 (RA) from the head Marala. Reba Machhali was encountered as; 0.003 (RA) from the head Qadirabad, 0.005 (RA) from the head Khanki and 0.008 (RA) from the head Marala. Raho was observed from all three sites of the river Chenab, 0.081 (RA) from the head Qadirabad, 0.071 (RA) from the head Khanki and 0.094 (RA) from the head Marala. This fish has been encountered from the different parts of the Sindh, KPK, Balochistan and Punjab (Rafique and Khan, 2012) viz. river Jhelum (Mirza *et al.* 2011), Head Balloki, Trimmu (Khan *et al.* 2011), Taunsa, Chashma (Khan *et al.* 2008), Jhelum Bridge and Saila Baga (Mirza *et al.* 2006), Khanki and Qadirabad (Altaf *et al.* 2011a, b).

Kalbans (0.008 RA from the head Qadirabad, 0.013 RA from the head Khanki and 0.0916 RA), Dero Machhali (0.008 RA from the head Qadirabad, 0.013 RA from the head Khanki and 0.018 RA from the head Marala), thaila (head Qadirabad= 0.071 RA, head Khanki=0.093 RA and head Marala=0.154 RA), Dola (head Qadirabad= 0.138 RA, head Khanki=0.096 RA and head Marala=0.106 RA), Soul (head Qadirabad= 0.013 RA, head Khanki=0.008 RA and head Marala=0.015 RA) and tilapia (0.179 RA=head Qadirabad, 0.227 RA=head

Khanki and 0.292 RA= head Marala) were recorded during research. These fish are also recorded from Sindh, KPK, Punjab (Rafique and Khan, 2012) as; river Jhelum (Rafique *et al.* 2012), head Balloki, Trimmu (Khan *et al.* 2011), Taunsa, Chashma (Khan *et al.* 2008), NullahAik and Palku (Qadir 2010), Khanki and Qadirabad (Altaf *et al.* 2011a). Khaga (0.041 RA=head Qadirabad, 0.032 RA=head Khanki and 0.057 RA=head Marala), Foji Khaga (0.024 RA =head Qadirabad, 0.019 RA=head Khanki and 0.018 RA= head Marala) encountered as; these species also recorded from the different parts of the AJK, Sindh, KPK, Balochistan, Punjab (Rafique and Khan, 2012) as; head Balloki, Trimmu (Khan *et al.* 2011), Taunsa, Chashma (Khan *et al.* 2008) and Qadirabad (Altaf *et al.* 2011a).

Tangra Machhali (head Qadirabad=0.011 RA, head Khanki=0.003 RA and head Marala=0.008 RA), Baam Machhali (head Qadirabad=0.081 RA, head Khanki= 0.071 RA and head Marala=0.081 RA), Sangari (head Qadirabad=0.013 RA, head Khanki= 0.011 RA and head Marala=0.015 RA), Mali(head Qadirabad= 0.006 RA, head Khanki=0.008 RA and head Marala=0.008 RA), But Pari (0.010 RA=head Qadirabad, 0.006 RA=head Khanki and 0.011 RA=head Marala) and Jhali (head Qadirabad= 0.013 RA, head Khanki= 0.008 RA and head Marala= 0.01 RA) were recorded. These species were also reported from different parts of the Punjab viz. river Jhelum (Mirza *et al.* 2011), head Balloki, Trimmu (Khan *et al.* 2011) NullahAik and Palku (Qadir, 2010), Qadirabad (Altaf *et al.* 2011a), Sheikhpura Dhand, Jhelum Bridge and Saila Baga (Mirza *et al.* 2006).

Calculated data shows that Bachhwa was recorded from only one site of the river Chenab viz.head Qadirabad0.053 RA. This fish has previously been recorded from the various parts of the AJK, Sindh, Punjab (Rafique and Khan, 2012) as; river Jhelum (Mirza *et al.* 2011), head Balloki, Trimmu (Khan *et al.* 2011), Taunsa, Chashma (Khan *et al.* 2008), Qadirabad (Altaf *et al.* 2011a), Jhelum Bridge, Darapur Dhand and Rasool Barrage (Mirza *et al.* 2006).

During this study Lahori Chalwa was encountered from river Chenab as; 0.002 (RA) from the head Qadirabad, 0.003 (RA) from the head Khanki and 0.002 (RA) from the head Marala. This fish has also been reported from the different parts of the Punjab as; river Jhelum (Mirza *et al.* 2011), head Balloki and Trimmu (Khan *et al.* 2011).

Sophore Popra was captured from river Chenab as; 0.005 (RA) from the head Qadirabad, 0.002 (RA) from the head Khanki and 0.005 (RA) from the head Marala. This fish has also been reported from the different parts of the Punjab as; river Jhelum (Mirza *et al.* 2006; Mirza *et al.* 2011), head Balloki, Trimmu (Khan *et al.* 2011), NullahAik and Palku (Qadir 2010), Qadirabad (Altaf *et al.* 2011a).

With the other fishes, *Ticto popra* specimen was also collected from two sites of the river Chenab, 0.003 (RA) from the head Qadirabad and 0.003 (RA) from the head Marala. This fish is also reported from the different parts of the Punjab as; river Jhelum (Mirza *et al.* 2011), head Balloki, Trimmu (Khan *et al.* 2011), NullahAik and Palku (Qadir 2010), Khanki, Qadirabad (Altaf *et al.* 2011a), Sheikhpura Dhand, Jhelum Bridge and Chingus Warena (Mirza *et al.* 2006).

Ranga Sheesha (0.011 RA= head Qadirabad, 0.008 RA=head Khanki and 0.01 RA=head Marala), Kirla Machhali (0.003 RA =head Qadirabad and 0.005 RA=head Khanki), Kaan Machhali (0.003 RA=head Qadirabad, 0.002 RA=head Khanki and 0.006 RA=head Marala), Pather Chat (0.002 RA=head Qadirabad, 0.005 RA=head Khanki and 0.01=head Marala) and Pali Roo Machhali (0.008 RA=head Qadirabad, 0.005 RA= head Khanki and 0.002 RA=head Marala) are recorded from all three sites of the river Chenab, 0.011 (RA) from the head Qadirabad, 0.008 (RA) from the head Khanki and 0.01 (RA) from the head Marala. This fish is also reported from the different parts of the Punjab as; head Balloki, Trimmu (Khan *et al.* 2011), NullahAik and Palku (Qadir 2010), Qadirabad (Altaf *et al.* 2011a).

Sangehi Machhali was also captured from all three sites of the river Chenab, 0.003 (RA) from the head Qadirabad, 0.002 (RA) from the head Khanki and 0.005 (RA) from the head Marala. This fish is also reported from the different parts of the Punjab as; river Jhelum (Mirza *et al.* 2011), head Balloki, Trimmu (Khan *et al.* 2011), Nullah Aik and Palku (Qadir, 2010), Qadirabad (Altaf *et al.* 2011a) and Jhelum Bridge (Mirza *et al.* 2006).

Present assessment shows that *Gagata cenia* was reported from all three sites of the river Chenab, 0.003 (RA) from the head Qadirabad, 0.002 (RA) from the head Khanki and 0.002 (RA) from the head Marala. This fish is also reported from the different parts of the Punjab as; river Jhelum (Mirza *et al.*, 2011), Nullah Aik and Palku (Qadir, 2010), Qadirabad (Altaf *et al.*, 2011a), Rasool Barrage and Marala Dhand (Mirza *et al.* 2006).

Similarly Garoj was encountered from all three sites of the river Chenab, 0.032 (RA) from the head Qadirabad, 0.008 (RA) from the head Khanki and 0.011 (RA) from the head Marala. This fish is also reported from the different parts of the Punjab as; head Balloki, Trimmu (Khan *et al.* 2011), NullahAik and Palku (Qadir, 2010), and Qadirabad (Altaf *et al.* 2011a).

REFERENCES

- Altaf, M., A. Javid, and M. Umair (2014). Biodiversity of Ramsar sites in Pakistan. LAP.
Altaf, M., A. M. Khan, M. Umair, M. Irfan, M. A. Munir, and Z. Ahmed. (2011a). Ecology and diversity

- of freshwater fishes of head Qadirabad, Gujranwala. Punjab Univ J Zool. 26(1): 1-7.
- Altaf, M., A. M. Khan, M. Umair, and S. A. Chattha (2011b). Diversity of Carps in River Chenab, Pakistan. Punjab University Journal of Zoology. 26(2): 107-114.
- Bartram, J., and R. Ballance (1996). Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programmes. CRC Press.
- Dudgeon, D. (1992). Endangered ecosystems: a review of the conservation status of tropical Asian rivers. Hydrobiologia. 248(3): 167-191.
- Gleick, P. H., W. Burns, E. Chalecki, M. Cohen, K. Cushing, A. Mann, R. Reyer, G. Wolff, and A. Wong (2002). The World's Water 2002-2003. The biennial report on freshwater resources. Island Press, Washington.
- Gupta, S., and P. Gupta (2006). General and applied ichthyology:(fish and fisheries). S. Chand.
- Hammert, Q., D. A. T. Harper and P. D., Ryan (2001). Past paleontological. PE 4(1): 9.
- Helfman, G., B. B. Collette, D. E. Facey, and B. W. Bowen (2009). The diversity of fishes: biology, evolution, and ecology. John Wiley & Sons.
- IUCN. (1989). Pakistan Fact Sheet Water. Journalist Resource Centre for the Environment. IUCN Pakistan.
- IUCN 2014. IUCN Red List of Threatened Species. Version 2014. <www.iucnredlist.org>.
- Khan, A., Z. Ali, S. Shelly, Z. Ahmad, and M. Mirza (2011). Aliens; a catastrophe for native freshwater fish diversity in Pakistan. J Anim Plant Sci. 21:435-440.
- Khan, A., H. Shakir, M. Khan, M. Abid, and M. Mirza (2008). Ichthyofaunal survey of some fresh water reservoirs in Punjab. J. Anim. Plant. Sci. 18(4): 151.
- Magurran, A. E. (2004). Measuring biological diversity.
- Majagi, S., K. Vijaykumar, M. Rajshekhar, and B. Vasanthkumar (2008). Chemistry of groundwater in Gulbarga district, Karnataka, India. Environ Monit Assess. 136(1-3): 347-354.
- Mirza, M. R. (2004). Freshwater Fishes of Pakistan. Urdu Science Board. 1: 256.
- Mirza, Z., M. Javed, and M. Mirza (2006). Fishes of the river Jhelum from Mangla to Jalalpur near head Rasool. Biologia (Pak). 52 (2): 215-227.
- Mirza, M. Mirza, and A. Sulehria (2011). Ichthyofaunal diversity of the River Jhelum, Pakistan. Biologia (Pak). 57(1&2): 23-32.
- Nelson, J. S. (2006). Fishes of the World. John Wiley & Sons.
- Peter, T. (1999). Coldwater fish and fisheries in Pakistan. FAO, Rome. Fisheries Technical Paper. 385:122-137.
- Qadir, A. (2010). Effect of anthropogenic activities on water quality and fish fauna of Nullah Aik and Nullah Palkhu tributaries of River Chenab, Pakistan. Ph.D. Thesis (unpublished). Quad-I-Azam University, Islamabad. 262.
- Rafique, M., and N. Khan (2012). Distribution and status of significant freshwater fishes of Pakistan. Rec. Zool. Surv. Pakistan 21: 90-95.
- Schüürmann, G., and B. Markert (1998). Ecotoxicology. Ecological fundamentals, chemical exposure and biological effects, Co-publication John Wiley and Sons and Spektrum Akademischer Verlag, New York: 900.
- Singh, R. K., S. L. Chavan, and P. H. Sapkale (2007). Heavy metal concentrations in water, sediments and body tissues of red worm (*Tubifex* spp.) collected from natural habitats in Mumbai, India. Environ Monit Assess. 129(1-3): 471-481.
- Siddiqi, T. A. and S. Tahir-Kheli (2004). Water and Security in South Asia. WASSA. pp. 234.
- Siddiqui K. M. (1997). Asia-Pacific forestry sector outlook study. Forestry Policy and Planning Division, Rome, regional Office for Asia and the Pacific, Bangkok.
- Taylor, B. W., A. S. Flecker, and R. O. Hall (2006). Loss of a harvested fish species disrupts carbon flow in a diverse tropical river. Science. 313(5788): 833-836.
- Taylor, C. M. (1997). Fish species richness and incidence patterns in isolated and connected stream pools: effects of pool volume and spatial position. Oecologia. 110(4): 560-566.
- Thorpe, J. H., M. C. Thoms, and M. D. Delong (2008). The riverine ecosystem synthesis. Towards conceptual.Press: London, UK, 232.
- Welcomme, R. L. (1979). Fisheries ecology of floodplain rivers. Longman London.
- Winemiller, K. O. (1989). Ontogenetic diet shifts and resource partitioning among piscivorous fishes in the Venezuelan ilanos. Environ Biol Fish. 26(3): 177-199.