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Fresh Records on Water Quality and Ichthyodiversity of River Swat at Charsadda, Khyber Pakhtunkhwa

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Abstract.- A study on the fish fauna and water quality parameters of River Swat at Charsadda, Khyber Pakhtunkhwa, Pakistan was conducted, with an aim to determine fresh records of water quality variables and fish fauna after heavy floods of July, 2010 in the province. For fish distribution a 35 km belt of the river was explored for four months and every effort was made to collect the fish specimen by any legal mean. During this study the mean values recorded for physico- chemical parameters were water temperature 19.8°C, pH 7.6, dissolved oxygen 9.65 mg/l, electrical conductivity 199.47 µS/cm, TDS 127.66 mg/l, TSS 93.78 mg/l, total hardness 118.75 mg/l, calcium hardness 75 mg/l, magnesium hardness 43.75 mg/l, sodium 5.325 mg/l, potassium 3.175 mg/l, total alkalinity 97 mg/l, chloride 15.3 mg/l and nitrite 0.0092 mg/l. All these values were within the limits prescribed by the standard methods for the examination of water, sewage and industrial wastes. In the present study a total of 38 fish species belonging to; 6 orders, 9 families and 24 genera were recorded. Cyprinidae was the richest family and was represented by 20 species, Nemacheilidae by 4, Sisoridae by 6, Channidae and Schilbidae by 2, Mastacembelidae, Schilbidae, Belonidae and Chandidae by single species. Results report six (6) species missing in the present study in comparison with the past records.

Key words: Fish fauna, Cyprinidae, Channidae.

INTRODUCTION

The River Swat is one of the main rivers flowing in Khyber-Pakhtunkhwa (Fig. 1). It passes through the entire District Swat and enters District Dir at Chakdara. It joins River Panjkora at lower Dir and then passes through Malakand, Charsadda and finally enters the River Kabul at Nissata.

Topographically the River Swat flows down the altitude at a faster speed through a series of hills. The River is wider at one place and narrows at another. The River is fed by glaciers and snow and has a great volume in summer. Down in the plains it passes through thickly populated towns and agricultural fields irrigating large areas of District Swat and District Charsadda.

Different species or age classes of same specie vary considerably in vulnerability to flooding (Harrell, 1978). Juvenile life stages are particularly susceptible to heavy losses during extreme floods in high-gradient systems (Elwood and Waters, 1969). Suspended sediment loads due to flooding can result in increased water column respiration, decreasing dissolved oxygen concentrations (Roozen *et al.*, 2003). Large numbers of young fish are even lost during average seasonal flooding in systems where the timing of high flows coincides with fragile life stages (Nehring and Miller, 1987). Very young fishes may be particularly vulnerable to floods because of their poor swimming ability and small size (Harvey, 1987). Floods cause a sudden dramatic change in all environmental parameters and all these changes influence the organisms inhabiting the reservoir ecosystem from microorganisms to fish (Godlewska *et al.*, 2003). Floods can alter both assemblage structure and abundance of fishes in stream reaches (Ross *et al.*, 1985).

Floods which occur over much shorter periods of time than drought can alter stream channel morphology, kill or displace biota downstream (Harrell, 1978). Flood causes major disturbances to stream ecosystems that kill or displace organisms and modify habitats (Franssen *et al.*, 2006). The large input of organic matter to aquatic flood plain habitats may reduce dissolved oxygen and result in the emigration or death of a great number of fishes (Winemiller, 1989). Summer floods are detrimental to cyprinids and catostomids

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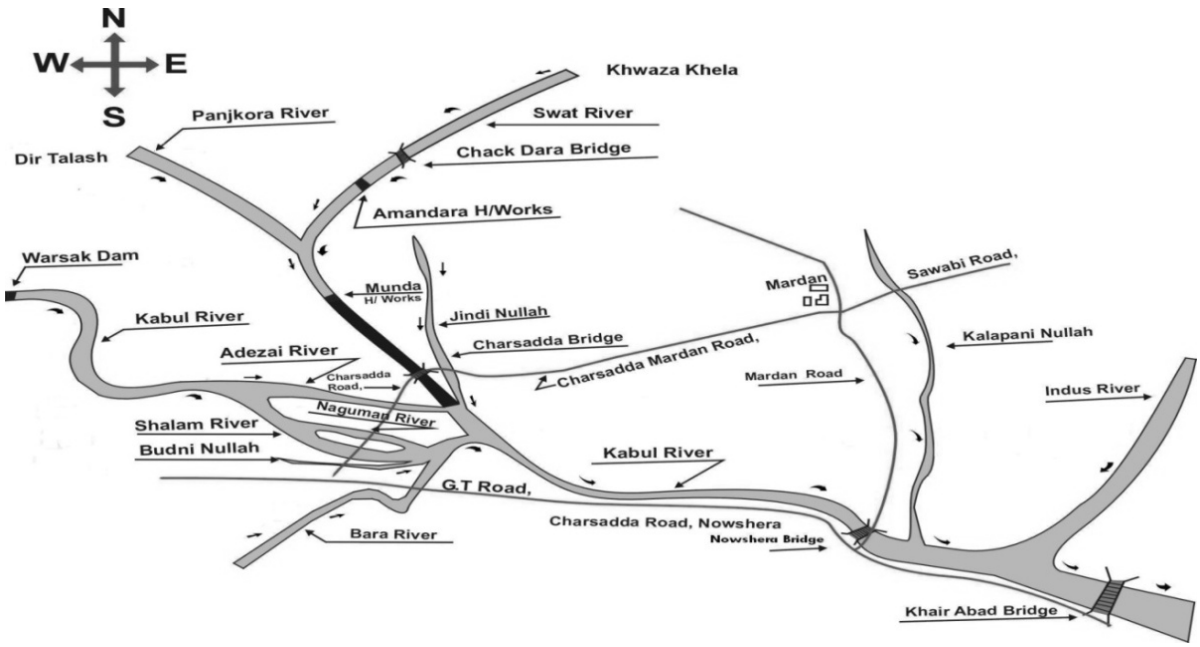

Fig. 1. Showing the rivers network of Khyber Pakhtunkhwa; study area marked in black. Source: Irrigation Department, Peshawar, 2011.

that spawn during the late spring and summer (Pearsons and Hiram, 1992). Water quality has been affected by a combination of factors including sewage and industrial wastes, agricultural run-off and salinisation (Yousafzai *et al.*, 2010). Mirza (2007) has reported 39 fish species from lower portion of River Swat. About 54 fish species have been identified from River Kabul and its tributaries (Yousafzai *et al.*, 2010, 2012; Yousafzai and Shakoori, 2009, 2011). The lower part of River Swat is more concentrated in fish fauna in comparison to upper part of River Swat, because it shares its ichthyofauna with River Kabul.

The highest flood ever recorded in the River Swat was the mighty flood of July, 2010. The water discharges of River Swat recorded were 355,000 cusecs. The whole Khyber Pakhtunkhwa was affected by the flood and most of the dry land of the study area was drowned in water. The aim of this study was to assess changes in water quality and fish diversity by the floods.

MATERIALS AND METHODS

Composite water samples for the assessment of physico-chemical parameters were collected from different localities of the River in clean plastic bottles. Samples were collected in triplicate and twice a month for four months. Bottles were rinsed with distilled water and then with the river water before sample collection.

Water temperature and dissolved oxygen was measured on the spot by using mercury thermometer and DO Meter (WPA, ox20, UK). Rest of the parameters was estimated in the laboratory. The water pH was measured by using pH meter (Mettler Delta 320. Halstead, C09 2DX, England). Electrical conductivity and total dissolved solids (TDS) were determined by conductivity meter and TDS meter (Model 4520, Jenway, UK). For electrical conductivity, water temperature was fixed at 25°C. Total suspended solids (TSS) were measured by evaporating 50 ml of water sample on a water bath, the remainders were dried in oven (Memmert 854. West Germany) at 105°C and weighted through digital balance (Sartorius Germany, ME 414S, 0.0001 g). Sodium and potassium were measured by Flame photometer (Jenway Model PFP7, UK). Total alkalinity, chloride, nitrite and total hardness were determined by titration method of Clesceri *et al.*

(1999).

Fishes were collected with the help of local fishermen by using cast nets, drag nets, hooks and rods. Fishes after collection were euthanized humanely and were preserved in 10% formalin for morphometric measurements and identification. Fishes were identified up to specie level by using the methods of Jayaram (1999), Talwar and Jhingran (1991) and Mirza and Sandhu (2007).

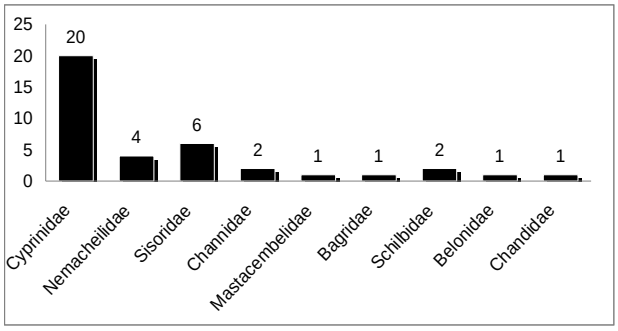

Fig. 2. Showing family wise abundance of fish species.

RESULTS

The results of the present study show in Figures 2-4 and Tables I-III. The mean values for water quality variables were: water temperature 19.8 ^{0}C, pH 7.45, dissolved oxygen 9.65 mg/L, electrical conductivity 199.47 µS/cm, TDS 127.66 mg/L, TSS 93.78 mg/L, total hardness 118.75 mg/L, calcium hardness 75 mg/L, magnesium hardness 43.75 mg/L, sodium 5.325 mg/L, potassium 3.175 mg/L, total alkalinity 97 mg/L, chloride 15.3 mg/L and nitrite were 0.0092 mg/L. During the survey of fish fauna thirty eight fish species belonging to 6 orders 9 families and 24 genera were recorded (Table III, Fig. 2). Thirty six species were indigenous and two species *Cyprinus carpio* and *Carassius auratus* were exotic. The identified fish species are shown in Table III. Table II shows the morphometric measurements recorded for different body parts measured in centimeter (cm) including total length, fork length, standard length, head length, eye diameter, post orbital length and body depth as tools for identification of different fishes.

Table I.- Physico-chemical parameters (mg/l) of water of River Swat at Charsadda.

S/No	Parameters	Mean and S.E	Standard values
1.	Temp. °C	19.8±7.505	16-40
2.	pH	7.6±0.136	6.5-9.0
3.	D.O	9.65±0.292	5 - 9
4.	E.C (µS/cm)	199.47±8.192	1000 µS/cm
5.	T.D.S	127.66±5.258	<400
6.	T.S.S	93.78±17.214	<80
7.	Total hardness	118.75±5.95	10-400
8.	Ca hardness	75±2.806	4-160
9.	Mg hardness	43.75±3.208	<15
10.	Sodium	5.325±0.32	75
11.	Potassium	3.175±0.481	<5
12.	Total alkalinity	97±4.486	10-400
13.	Chloride	15.3±1.141	10-600
14.	Nitrite	0.0092±0.00346	0.1

DISCUSSION

The highest flood ever recorded in the recent past in River Swat was the mighty flood of July, 2010. The water discharge of River Swat reached to 3, 60,000cusecs in comparison with the normal average flow of 22,557.66 cusecs the same month. The flood disturbed the aquatic fauna particularly fish population. Water quality parameters in the present study were within the normal range.

Water temperature of River Swat ranged from 15-26°C during the study period. Water temperature influences the distribution and migration of fishes (Lagler *et al.*, 1962). Temperature effects many limnological phenomenon like stratification of water, solubility of gases, pH, amplification of odor and taste and elevation of metabolic activities of plants and animals. Metabolic rate increases 2 or 3 times for every increase of 10°C. Increased metabolic rate leads to higher oxygen consumption and waste production (CO_2 and NH_3).

The pH of River Swat ranged from 7.2 to 7.9. This value fall within the limits of WHO (Utang and Akpan, 2012) recommended value, 7.5-8.5. The pH value is favorable for fishes, and show good quality of water. IUCN (1994) reported pH value of 7.3-7.9 from the same area.

Dissolved oxygen (D.O) is necessary for the respiration of living organisms both animals and plants in water. Oxygen like temperature has major

Table II.- Morphometric measurements (cm) of the fishes recorded from River Swat at Charsadda

S/No	Fish species	Total length	Forked length	Standard length	Head length	Eye diameter	Body depth
1.	*Barilius pakistanicus*	7.6	6.5	5.8	1.2	0.4	1.2
2.	*Barilius vagra*	13	11.7	10.4	2.4	0.6	2.0
3.	*Barilius modestus*	10.8	9.5	9.0	1.5	0.5	2.0
4.	*Crossocheilus diplocheilus*	11	10	8.5	1.5	0.5	2.2
5.	*Puntius sophore*	8.3	7.6	6.7	1.8	0.4	2.3
6.	*Puntius conchonius*	7.5	6.8	5.9	1.5	0.5	2.3
7.	*Puntius chola*	6.0	5.4	4.8	1.2	0.3	2.0
8.	*Puntius ticto*	6.0	5.5	4.8	1.3	.04	2.3
9.	*Garra gotyla*	13.7	12.8	11.5	2.5	0.4	3.0
10.	*Schizothorax plagiostomus*	14.5	13	12.3	3.0	0.6	2.3
11.	*Racoma labiata*	13	12.2	11	3.2	0.5	2.5
12.	*Cirrhinus mrigala*	33	29.5	26.5	5.0	0.7	6.5
13.	*Rasbora daniconius*	12.5	11	10.5	2.2	0.5	2.5
14.	*Tor macrolepis*	13.5	12	10	2.8	0.6	2.7
15.	*Cyprinus carpio*	13	11.3	10	2.9	0.4	3.0
16.	*Carassius auratus*	13.8	12.5	10.1	2.8	0.4	4.0
17.	*Salmophasia bacaila*	7.5	6.8	6.3	1.2	0.3	1.6
18.	*Salmophasia punjabensis*	12.8	11.2	10.4	1.9	0.4	2.4
19	*Amblypharyngodon mola*	12.8	11.2	10.2	2.8	0.4	3.0
20.	*Labeo diplostomus*	20.5	18.5	17	4.0	1.0	4.8
21.	*Schistura alepidota*	7.6	7.4	6.7	1.9	0.2	1.0
22.	*Schistura prashari*	6.2	5.9	5.2	1.1	0.3	0.8
23.	*Triplophysa naziri*	12.2	11.9	10.9	2.1	0.4	1.6
24.	*Acanthocobitis botia*	6.5	6.3	5.4	0.7	0.15	1.0
25.	*Glyptothorax punjabensis*	11.7	8.4	8.0	2.2	0.1	1.4
26.	*Glyptothorax stocki*	9.5	8.5	7.5	1.5	0.1	1.0
27.	*Glyptothorax sufii*	11.5	10.5	9.4	2	0.1	2.4
28.	*Glyptothorax cavia*	9.7	8.6	7.6	1.7	0.1	1.1
29.	*Gagat cenia*	7.6	6.7	6.2	1.4	0.3	1.5
30.	*Gagata pakistanica*	7.7	6.7	6.3	1.5	0.3	1.5
31.	*Mystus bleekeri*	17.2	15.2	14.2	3.2	0.8	4.4
32.	*Clupisoma naziri*	20	17.3	16.5	3.0	0.6	4.0
33.	*Clupisoma garua*	21.0	18.0	17.0	3.0	0.6	3.8
34.	*Channa punctatus*	16.5	--	5.0	2.8	0.6	3.0
35.	*Channa gachua*	15.8	--	4.0	2.7	0.5	3.0
36.	*Mastacembelus armatus*	24	--	3.8	2.0	0.2	2.0
37.	*Xenentodon cancila*	29	--	25.5	8.0	1.6	3.0
38.	*Chanda nama*	13	12	10.2	2.8	0.4	3.6

influence on the distribution and migration of fishes. Stagnant water comparatively has less DO as compared to fresh and cold water. DO concentration ranges from 4-15 ppm. Cold water and semi cold-water fishes are more sensitive to O_2 depletion than warm water fishes. In DO level below 4 ppm, fish became under stress and cold water species can even die. The concentration of DO was 8.8 to 10.4 ppm in the present study. This DO level is productive and good for fish survival. IUCN (1994) reported 6.9-8 ppm DO concentration, from this area.

Electrical conductivity is a measure of water ability to conduct electric current, which depends upon the number of ions like phosphate, nitrate, sulfate, sulfur, Mg^{++}, Na^{+}, K^{+}, Cl^{-} etc. present in water. Electric conductivity value in the present study was 175-218 µS/cm. Conductivity of most freshwater ranges from10 to 1000µS/cm, but may exceed this if the water is polluted or receives large quantities of land runoff (Chapman, 1997). IUCN (1994) recorded value for EC was 98-369 µS/cm from this spot.

Table III.- A complete list of Scientific and vernacular names of ichthyofauna of River Swat at Charsadda.

S/No	Order	Family	Genus and species	Vernacular names
1.	Cypriniformes	Cyprinidae	*Barilius pakistanicus*	Pepal
2.			*Barilius vagra*	Pepal
3.			*Barilius modestus*	Pepal
4.			*Crossocheilus diplocheilus*	Butten
5.			*Puntius sophore*	Tapaha
6.			*Puntius conchonius*	Tapaha
7.			*Puntius ticto*	Tapaha
8.			*Puntius chola*	Tapaha
9.			*Garra gotyla*	Kanesatt
10.			*Schizothorax plagiostomus*	Swatay
11.			*Racoma labiata*	Swatay
12.			*Cirrhinus mrigala*	Torkay
13.			*Rasbora daniconius*	Sowage
14.			*Tor macrolepis*	Mahasher
15.			*Cyprinus carpio* (exotic)	China kub
16.			*Carassius auratus* (exotic)	China kub
17.			*Salmophasia bacaila*	Spenkay
18.			*Salmophasia punjabensis*	Spenkay
19			*Amblypharyngodon mola*	Spenkay
20.			*Labeo diplostomus*	Torkay
21.		Nemacheilidae	*Schistura alepidota*	Sowa
22.			*Schistura prashari*	Sowa
23.			*Triplophys anaziri*	Sowa
24.			*Acanthocobitis botia*	Nai
25.	Siluriformes	Sisoridae	*Glyptothorax punjabensis*	Sulemanne
26.			*Glyptothorax stocki*	Sulemanne
27.			*Glyptothorax sufii*	Sulemanne
28.			*Glyptothorax cavia*	Sulemanne
29.			*Gagata cenia*	Taktake
30.			*Gagata pakistanica*	Taktake
31.		Bagridae	*Mystus bleekeri*	Brethu
32.		Schilbidae	*Clupisoma naziri*	Shermay
33.			*Clupisoma garua*	Shermay
34.	Chaniformes	Channidae	*Channa punctatus*	Asle Katasarre
35.			*Channa gachua*	Dessi katasarre
36.	Mastacembeliformes	Mastacembelidae	*Mastacembelus armatus*	Marmahay
37.	Beloniformes	Belonidae	*Xenentodon cancila*	Kann mach
38.	Perciformes	Chandidae	*Chanda nama*	Shesha kub

TDS in water are the dissolved organic and inorganic substances like carbonates, bicarbonates, sulfates, phosphates, Mg, Na, K, Cl, Ca, ions in water. For sustaining of aquatic life, the presence of these ions is very important. However, high concentration of these ions has bad effect on aquatic life. According to Mitchell and Stapp (1992) high concentration of dissolved ions can damage the gills of fish. High concentration of TDS can also reduce the photosynthetic activity and increase the water turbidity. TDS is affected by urban and fertilizer run-off, wastewater, soil erosion, decaying animals, plants, and floods etc. The TDS values in River Swat during the present study period ranged between112.3-139.5 ppm, reflecting normal value and falls within the recommended standard value (<400 ppm) for fishes (Meade, 1989).

TSS are the amount of the suspended particles in sample water. The larger amount of TSS in water reduces the water transparency, precipitation of sun light and increases the water turbidity. The TSS value of River Swat was 45.5-

120 ppm, while standard value for TSS is <80 as reported by Meade (1989). IUCN (1994) reported the TSS value of River Swat ranged between 190 and 412.

Hardness is due to the presences of dissolved minerals of calcium, magnesium, strontium, iron and manganese in water. These minerals take a large quantity of soap producing lather with water. Water hardness is described as the soap-destroying power of water. The major causes of total hardness are due to the concentration of metal ions (cations) induced mainly by Ca^{2+} and Mg^{2+}. Total hardness is calculated from the concentrations of Ca and Mg salts dissolved in water. Adequate concentration of Ca^{2+} and Mg^{2+} is necessary for the survival of fish. Ca^{2+} is necessary in bone formation and is also a blood clotting factor. Low level of Ca^{2+} reduces the resistant against diseases in fry. Mg^{2+} plays a key role in muscle's contraction and nervous impulsion. Mg^{2+} is also present in coenzymes. Fishes grow well in the hardness range of 30-100 ppm.

Total hardness value in this study ranged from 100-133 ppm.Ca^{2+} hardness ranged from 66-81 ppm, while Mg hardness was 34-52. The standard values for total hardness is 10-400 ppm. Yousafzai *et al.* (2010) have reported total hardness of 96-182.8 mg/l for River Kabul. Sodium and potassium are present in the form of ions (Na^+ and K^+) in water. These ions combine with other elements forming different compounds like Na_2CO_3, $NaNO_3$, K_2CO_3, sodium sulfides, potassium sulfide, etc. The ionic concentration of natural waters of low pH has been shown to be important in the survival of fish (Brown, 1981). These ions maintain the water pH, salinity, alkalinity, TDS, hardness and conductivity of the water.

Sodium and potassium ions are diffusing to the fish body through gills in contrast NH_4^+ ion (toxic) is excreted through gills. These ions also maintain the body pH and salinity at normal. Sodium ions reduce zinc toxicity, which is lethal to fish and present more in hard water as compare to soft water. K^+ plays a role in ion controlling sperm motility in fishes in combination with osmotic pressure. Sperm motility is prevented when the osmotic pressure is high (Cyprinidae) or low (marine fishes) compared to that of the seminal fluid (Alavi, 2006).Sodium and potassium are trace elements required in low quantity to fishes. The reported value for sodium was 4.4-6.1 ppm and potassium 2.3-4.7 ppm from River Swat. Standard values for sodium and potassium are 75 and <5 ppm respectively as reported by (Meade, 1989).

Total alkalinity of water is due to carbonates and bicarbonates anions (CO_3^{-2} and HCO_3^-). 100 ppm alkalinity is productive for fishery as reported by Ali (1993). The alkalinity of River Swat water was 83-107 ppm, which is very good and productive for fish growth. Standard value for alkalinity is 10-400 ppm (Meade, 1989). IUCN (1994) reported 40-113 ppm alkalinity value for River Swat. Chloride is the anion of chlorine.

Chlorides of metals like Na, K, Ca and Mg are highly soluble in water. Chloride concentration affects the TDS, salinity, pH and hardness of water. Chloride is requiring in trace amount to fishes. The value for chloride in River Swat for the study period was 17.8 ppm. Standard value for chloride is 10-600 ppm SAWQG (1996). IUCN (1994) reported 6-19 ppm chloride value from the same study area.

Nitrite is the source of nitrogen, soluble in water. High quantity of nitrite is lethal for fishes, as reported by Lawson (1995). High level of nitrite can cause hypoxia and due to deactivation of hemoglobin in fish blood a condition known as the "brown blood disease". The nitrite value reported was 0.001-0.017 ppm from River Swat during the study period. Standard value for nitrite is 0.01 ppm (Meade, 1989). IUCN (1994) reported 0.0 nitrite in River Swat.

Results confirm that the water quality parameters are within the limits of United States Public Health (USPH) standards for surface waters, (1976) and water quality in the present form in no way could be a limiting factor for inhabitant fish population. Possibly strong water currents have flushed fish downstream or sudden instantaneous changes in water chemistry have killed least resistant species. Lapses in collection procedure also cannot be ignored. Whatever, may be the reason a total of 38 fish species are recorded in comparison with the past records of by Mirza (2007) showing a missing of 6 species in the lower part of River Swat. Out of 38 species 36 are indigenous and 2 species *Cyprinus carpio* and *Carassius auratus* are exotic. Family Cyprinidae was the richest family in the

River Swat comprising of 20 fish species which is in accordance with many authors like Khan and Hasan (2011), Mirza (2007) and Hasan *et al*. (2013). Mirza (2007) has reported 39 fish species from lower portion of River Swat. Five fish species which have not been reported by Mirza (2007) but reported in the present study are; *Cirrhinus mrigala, Barilius vagra, Barilius modestus, Gagata pakistanica* and *Chanda nama*. Six fish species reported by Mirza (2007) from the lower portion of River Swat but not reported in the present study are; *Aspidoparia morar, Naziritor zhobensis, Devario devario, Glyptothorax naziri, Colisa fasciata* and *Colisa lalia*.

A recent survey of ichthyofaunal diversity conducted by Hasan *et al.* (2013) comprised of 35 fish species from lower part of River Swat. In the present report of fish fauna out of 38 fish species 35 are matching with the fish fauna survey of Hasan *et al.* (2013). Three fish species *i.e. Glyptothorax sufii, Cirrhinus mrigala* and *Chanda nama* have not been reported by Hasan *et al. (*2013) and Mirza (2007).

CONCLUSION

Results of the present study report a total of 38 fish species with the arrival of three new species not recorded in the past and that the pollution level is not alarming in the river and water resource is quiet fit for raising commercial fish species.

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