Pakistan J. Zool., vol. 47(6), pp. 1699-1707, 2015.

Seasonal Variations in Hematological and Serum Biochemical Profile of *Channa marulius* are Complementary to the Changes in Water Quality Parameters of River Chenab in Pakistan

Muhammad Latif,[1,] * Muhammad Ali[2] and Furhan Iqbal[1]
[1]*Institute of Pure and Applied Biology, Zoology Division. Bahauddin Zakariya University Multan 60800, Pakistan*
[2]*Government College University Faisalabad, 38000, Pakistan*

Abstract.- The river Chenab is a rich source of biodiversity and 33 fish species has been identified and reported from Chenab waters including *C. marulius*. The giant snakehead, *C. marulius* (Hamilton), is a fast growing fish having high market value and consumer preference in Pakistan. The aim of this study was to determine the seasonal variations in hematological and selected parameters of serum biochemical profile of *C. marulius* and to correlate them with the changes in water quality parameters of River Chenab during the two consecutive sampling sessions. Water and fish samples were collected from the same pit area of Muhammad Wala Head works during December to April for the seasons 2010-11 and 2011-12 respectively. A total of 51 *C. marulius* specimens (33 during first and 18 during second sampling season) were captured with the help of fishing nets. Water quality parameters and complete blood count for *C. marulius* was determined by standard protocols. Our results indicated significant variations in hematological parameters of *C. marulius* during both sampling seasons that were complementary to the changes in water quality parameters of river Chenab indicating that environmental changes affects the blood chemistry of *C. marulius*.

Key words. *Channa marulius*, seasonal variations, water quality, hematology, serum biochemistry.

INTRODUCTION

Fish plays an important role in monitoring of water quality because they respond with great sensitivity to direct as well as indirect changes in the aquatic environment (Borkovic *et al*., 2008). The direct changes in an ecosystem affect the lower level of biological organization while indirect changes affect the food chain and the behavior of the organism (Osman *et al*., 2007a,b).

The river Chenab originates from Jammu and Kashmir and after receiving several tributaries, it enters in Pakistan near district Sialkot. In the Punjab, this river flows through Gujrat, Sargodha and Gujranwala districts. It receives river Jhelum at Trimmu in district Jhang and river Ravi at Sidhnai in district Khanewal. It then flows through districts of Multan and Muzaffargarh and joins river Sutluj in district Muzaffargarh (Salam and Rizvi, 1999). The river Chenab is a rich source of biodiversity and 33 fish species has been identified and reported from Chenab waters including *Channa marulius* (Ali *et al*., 2005a).

The giant snakehead, *C. marulius* (Hamilton), is a fast growing fish having high market value and consumer preference (Khan *et al*., 2012). It is a native fish and according to IUCN status it is near to be vulnerable (Rafique and Khan, 2012). In China, it is considered as a food fish that is important for wound healing (Rahim, 2009). Tolerance to a variety of habitats and carnivorous food habit make them an important element of fish farming that demands an understanding of their biology and ecological requirements (Dua and Kumar, 2006).

Environmental risk assessment of waters has traditionally been based on measurement of chemical and physical parameters of water and has included biological quality elements. Fish are intimately associated with the aqueous environment; physical and chemical changes in the environment are rapid and reflected as measurable physiological changes in fish (Fazio *et al*., 2013). Information about the hematological profile is an important tool that can be used for effective and sensitive monitoring of physiological and pathological state of a fish (Kohanestani *et al*., 2013) as these

* Corresponding author: latifck@yahoo.com
0030-9923/2015/0006-1699 $ 8.00/0

parameters are closely related to the response of fish to environmental and biological factors (Steinhagen *et al*., 1990; Fernandes and Mazon, 2003). Many factors can seasonally affect blood parameters changes in fish such as the reproduction cycle (Svoboda *et al*., 2001; Bayir, 2005), diet (Guijarro *et al*., 2003), temperature (Sandnes *et al*., 1988), pH (Kavadias *et al*., 1996) and photoperiod (Kavadias *et al*., 2003). The aim of this study was to determine the seasonal variations in hematological and selected parameters of serum biochemical profile of *C. marulius* and to correlate them with the changes in water quality parameters of River Chenab during 2010-12.

MATERIALS AND METHODS

The present study was carried out during 2010-12 in River Chenab waters at Muhammad wala Head works (N 30° 18' 1; E 71° 20' 41) in Muzaffar Garh District. Water and fish samples were collected from the same pit area of Muhammad Wala Head works for two consecutive years (2010-11 and 2011-12) during December to April. A total of 51 *C. marulius* specimens (33 during first and 18 during second sampling season) were captured with the help of fishing nets. Fish length and wet body weight were measured, on the sampling site, by digital caliper [± 1mm] and weighing scale (± 0.01g) respectively following Ali *et al*. (2005).

The blood samples were drawn by cardiac puncture using 21 gauge hypodermic needle in EDTA containing vials. Haematology analyzer (Sysmex automatic KX 21) was used to determine the complete blood count [white blood cell count (WBC), red blood cell count (RBC), platelets count, hemoglobin (Hb) content, hematocrit (PCV), leukocytes differential count, mean corpuscular or cell volume (MCV), mean cell hemoglobin content (MCH) and the mean cellular hemoglobin concentration (MCHC)] for each fish following Qadir *et al*. (2014). A part of whole blood was centrifuged at 13,000 rpm for 10 min. and selected biochemical parameters from resultant serum alanine transaminase (ALT), aspartate aminotransferase (AST), total protein and total cholesterol were determined in serum by using Beckman coulter CX9 Pro Chemistry analyzer following Qadir *et al*. (2014).

pH of water samples were determined by using pH meter (eco Testr pH 1, Eutech instruments Oakton). Temperature and total dissolved solids were determined by using an instrument from Jenco (Model 3010, USA). Dissolved oxygen was determined by using oxygen meter (YSI 55, USA), whereas all other studied water quality parameters (electrical conductivity, calcium, magnesium, sodium, total alkalinity and chloride) were determined following the standard protocols as recommended by APHA (2005).

Statistical analysis

All the data is presented as mean ± standard deviation (SD) of mean. Statistical package Minitab (Version 16, USA) was used for the analysis of results. One way analysis of variance (ANOVA) was applied to compare various parameters of hematology, serum biochemical profile of *C. marulius* and water quality parameters of River Chenab between the sampling months.

RESULTS

Weight-length and condition factor

Average weight and length of *C. marulius* was 371.5±218.7 g and 35.5±7.3 cm respectively, during sampling season 2010-11. While In the sampling season 2011-12, however, the average weight of *C. marulius* was 389.1±196.5 g and body length was 36.5±5.7 cm. The condition factor of *C. marulius* was 0.72±0.05 and 0.70±0.02 during sampling seasons 2010-11 and 2011-12 respectively indicating an almost similar growth pattern of this fish species during both sampling seasons.

Hematological parameters of C. marulius

Data analysis of the studied hematological parameters of *C. marulius* from river Chenab waters indicated that most of the studied parameters varied non significantly within the sampling season 2010-11. WBC count ($P=0.03$), MCHC ($P=0.04$) and PCV ($P = 0.009$) were the only parameters that varied significantly with the sampling season (Table I). During second sampling season (2011-12) hemoglobin ($P=0.001$), RBC ($P<0.001$), PCV ($P=0.001$), MCV ($P=0.05$) and WBC ($P=0.009$) also varied significantly with season (Table II).

Table I.- **Seasonal variations in the hematological parameters of *Channa marulius* captured from River Chenab during 2010-2011 sampling season. Minimum-maximum range for each parameter is mentioned in parenthesis. Data is expressed as Mean ± Standard deviation. P – value indicates the results on one way ANOVA test calculated for each parameter.**

Blood parameters	December 2010	January 2011	February 2011	March 2011	April 2011	P-Value
Hemoglobin (g/dl^{-1})	12.2 ± 0.96 (10.4-13)	11.5 ± 2 (7-13.5)	12.3 ± 3.07 (6.9-14.8)	8.6 ± 2.27 (6.6-12.9)	11.1 ± 3.16 (5-13.8)	0.07
RBC ($x10^{12} . L^{-1}$)	2.6 ± 0.16 (2.46-2.8)	2.5 ± 0.48 (1.39-2.93)	2.6 ± 0.70 (1.35-3.19)	1.8 ± 0.51 (1.41-2.76)	2.3 ± 0.66 (1.12-3.07)	0.08
PCV (%)	42.4 ± 5.29 (31.7-45.4)	37.5 ± 12.43 (14.2-49.5)	32.5 ± 9.40 (16.6-41.9)	22.2 ± 5.47 (16.2-31.7)	29.8 ± 10.21 (13.2-42.1)	0.009 **
Platelets ($x10^{9} . L^{-1}$)	22.2 ± 8.66 (9-31)	33.5 ± 18.57 (13-66)	71.7 ± 67.52 (24-204)	51.2 ± 48.70 (25-150)	74.7 ± 67.30 (20-208)	0.21
MCV (fl)	157.6 ± 22.48 (114.6-179)	132.5 ± 42.57 (45.1-169.1)	124.8 ± 5.57 (119.8-135.8)	120.6 ± 6.67 (112.2-127.1)	126.9 ± 23.94 (111.7-173.7)	0.15
MCH (pg)	46.3 ± 2.63 (44.1-51.2)	44.3 ± 7.07 (26.7-51)	47.7 ± 1.77 (46.5-51.2)	47.0 ± 1.69 (43.8-48.6)	47.0 ± 3.68 (43.9-53.1)	0.60
MCHC (gdl^{-1})	29.8 ± 5.34 (27.1-40.6)	33.9 ± 9.16 (27.1-49.6)	38.3 ± 2.32 (34.7-41.6)	39.0 ± 2.47 (37.1-43.3)	37.6 ± 4.76 (30.5-44.6)	0.04 *
WBC ($x10^{9} . L^{-1}$)	72.2 ± 16.18 (43.2-88.2)	58.6 ± 29.29 (7.4-89.5)	48.2 ± 16.67 (25.4-77.1)	32.8 ± 22.48 (10.3-63.8)	52.8 ± 15.58 (33.5-79.5)	0.02 *

P > 0.05 = Non significant; P < 0.05 = Least significant (*); P < 0.01 = Significant (**)

River Chenab's water quality parameters

During this sampling season 2010-11, all studied parameters of water quality of Chenab river varied significantly except pH (P = 0.22) and dissolved oxygen (P = 0.11) indicating that water quality was varying with seasonal changes and these results are complementing the hematological findings in *C. marulius* indicating that changes in water quality are directly affecting the fish health (Table III).

During the second sampling season (2011-12), all studied parameters of River Chenab's water quality again varied significantly except pH (0.69) and dissolve oxygen (P=0.11) confirming our observations in first sampling season that variations in water quality is affecting the blood profile of *C. marulius* (Table IV).

DISCUSSION

Fresh water environments, unlike the marine ones, are subjected to variations in the environmental factors such as temperature, dissolved oxygen, light penetration, turbidity, density, etc. These factors are responsible for distribution of organisms in different fresh water habitats according to their adaptations, which allow them to survive in that specific habitat (Iqbal *et al.*, 2004). The dispersal of a fish, therefore, depends entirely on its facility to accommodate itself to a variety of physical conditions and degree of vitality by which it is enable to survive under more or less sudden changes (Ali *et al.*, 2005b). Comparison of our water quality results with the standard values (Table V) revealed that despite of seasonal fluctuations, most of the studied water quality parameters remained within safe levels during both sampling seasons.

Information about the hematological profile is an important tool that can be used for effective and sensitive monitoring of physiological and pathological state of a fish (Kohanestani *et al.*, 2013). Analysis of water quality of Chenab River revealed that studied parameters of blood and serum had significant variations during sampling months and a similar trend was observed in the studied parameters of river waters. The aquaculture and agricultural activities in this region start in spring and summer, and the industries start releasing their effluents into the river waters resulting in major changes in water quality which is reflected ultimately in physiological response of the biota (De

Table II.- **Seasonal variations in the hematological parameters of *Channa marulius* captured from River Chenab during 2011-2012 sampling season. Minimum-maximum range for each parameter is mentioned in parenthesis. Data is expressed as Mean ± Standard deviation. P – Value indicates the results on one way ANOVA test calculated for each parameter.**

Blood parameters	November 2011	December 2011	January 2012	February 2012	March 2012	April 2012	P- value
Hemoglobin (g/dL^{-1})	13.9 ± 0.68 (13.1-14.4)	11.9 ± 0.44 (11.6-12.4)	12.1 ± 0.72 (11.6-12.9)	14.5 ± 0.98 (13.4-15.3)	14.8 ± 1.23 (13.4-15.7)	15.4 ± 0.65 (14.7-16)	0.001 **
RBC ($x10^{12} . L^{-1}$)	2.7 ± 0.20 (2.45-2.81)	2.3 ± 0.12 (2.13-2.37)	2.3 ± 0.10 (2.18-2.37)	2.7 ± 0.05 (2.67-2.76)	2.7 ± 0.02 (2.68-2.72)	3.0 ± 0.13 (2.86-3.1)	0.001 ***
PCV (%)	36.1 ± 2.14 (33.7-37.8)	29.1 ± 2.16 (26.6-30.6)	29.4 ± 1.53 (27.7-30.6)	37.0 ± 1 (36-38)	36.4 ± 1.39 (35.5-38)	45.8 ± 7.62 (37.7-52.8)	0.001 **
Platelets ($x10^{9} . L^{-1}$)	109.0 ± 14 (99-125)	144.0 ± 58.28 (80-194)	191.7 ± 110.52 (80-301)	216.0 ± 39.28 (182-259)	174.3 ± 88.75 (82-259)	139.3 ± 180.89 (27-348)	0.79
MCV (fl)	135.1 ± 3.63 (130.9-137.5)	128.7 ± 5.41 (124.8-134.9)	129.5 ± 4.66 (126.5-134.9)	136.1 ± 3.12 (134.2-139.7)	134.4 ± 4.84 (130.2-139.7)	154.4 ± 20.34 (131.5-170.2)	0.05 *
MCH (pg)	52.1 ± 1.60 (50.4-53.6)	53.1 ± 4.56 (49.5-58.2)	53.4 ± 5.18 (49.5-59.3)	53.4 ± 3.86 (49.4-57.1)	54.8 ± 4.65 (49.4-57.7)	52.1 ± 3.43 (49.7-56)	0.96
MCHC (gdL^{-1})	38.5 ± 0.46 (38.1-39)	41.3 ± 4.65 (38.1-46.6)	41.3 ± 4.65 (38.1-46.6)	39.3 ± 3.66 (35.3-42.5)	40.8 ± 4.84 (35.3-44.3)	34.3 ± 7.26 (29.1-42.6)	0.47
WBC ($x10^{9} . L^{-1}$)	56.4 ± 13.36 (41.4-67.1)	34.7 ± 15.74 (18.4-49.8)	34.8 ± 15.83 (18.4-50)	62.0 ± 11.86 49.3-72.8)	52.2 ± 11.87 (42.1-65.3)	78.9 ± 4.96 (73.7-83.6)	0.009 **
Total cholesterol ($mgdL^{-1}$)	216.0 ± 29.46 (198-250)	242.7 ± 67 (166-290)	290.0 ± 25.51 (271-319)	242.7 ± 27.02 (215-269)	221.0 ± 7.81 (216-230)	251.7 ± 19.86 (230-269)	0.19
ALT (IUL^{-1})	20.7 ± 8.50 (11-27)	37.7 ± 19.66 (23-60)	39.0 ± 28 (19-71)	33.7 ± 36.67 (12-76)	27.3 ± 1.53 (26-29)	41.3 ± 24.85 (26-70)	0.87
AST (IUL^{-1})	229.0 ± 48.51 (181-278)	218.0 ± 22.54 (204-244)	257.7 ± 44.61 (215-304)	286.0 ± 26.51 (263-315)	216.0 ± 37.24 (187-258)	226.7 ± 61.99 (180-297)	0.34
Total protein (gdL^{-1})	3.5 ± 0.42 (3.2-4)	3.7 ± 0.21 (3.5-3.9)	4.1 ± 0.51 (3.5-4.5)	4.6 ± 0.40 (4.2-5)	3.9 ± 0.38 (3.6-4.3)	4.0 ± 0.45 (3.6-4.5)	0.07

$P > 0.05$, non significant; $P < 0.05$, least significant (*); $P < 0.01$, significant (**); $P < 0.001$, highly significant (***)

Table III.- Seasonal variations in studied water quality parameters in water samples from River Chenab during 2010-2011 sampling season. Data is expressed as Mean ± Standard deviation Minimum-maximum range for each parameter is mentioned in parenthesis. P – value indicates the results on one way ANOVA test calculated for each parameter.

Water quality parameters	November 2010	December 2010	January 2011	February 2011	March 2011	April 2011	P value
pH	8.5 ± 1 (7.5-9.5)	7.6 ± 1 (6.5-8.6)	7.3 ± 1 (6.3-8.5)	7.6 ± 1 (6.6-8.6)	7.5 ± 1 (6.5-8.5)	9.5 ± 1 (8.2-10.2)	0.22
Electrical conductivity ($dscM^{-1}$)	0.297 ± 0.1 (0.197-0.397)	0.718 ± 0.1 (0.618-0.818)	1.6 ± 0.1 (1.5-1.7)	1.3 ± 0.1 (1.2-1.4)	1.9 ± 0.1 (1.8-2)	1.4 ± 0.01 (0.42-1.44)	0.001 ***
Calcium (mgL^{-1})	17.4 ± 15 (2.4-32.4)	76.8 ± 15 (61.8-91.8)	186 ± 2 (184-188)	180 ± 15 (165-195)	175.05 ± 15 (160.05-190.05)	160.5 ± 10 (170.5-150.5)	0.001 ***
Magnesium (mgL^{-1})	3.48 ± 3 (0.48-6.48)	15.36 ± 3 (12.4-18.4)	42 ± 1.2 (40.8-43.2)	36 ± 3 (33-39)	35.0 ± 3 (32.01-38.01)	1.84 ± 1.5 (0.21-3.21)	0.001 ***
Sodium (mgL^{-1})	41.63 ± 23 (18.6-64.6)	47.38±23 (24.3-70.3)	280.6 ± 23 (278.3-282.9)	322 ± 23 (299-345)	331.89 ± 23 (368.9-354.9)	8.2 ± 0.23 (8.05-8.51)	0.001 ***
Total alkalinity (mgL^{-1})	40.8 ± 30 (10.8-70.8)	120 ± 30 (90-150)	191.4 ± 30 (161.4-221.4)	40.4 ± 30 (110.4-170.4)	139.2 ± 30 (109.2-169.2)	17.4 ± 0.3 (17.1-17.7)	0.001 ***
Chloride (mgL^{-1})	31.5 ± 3.5 (28-35)	108.1 ± 35 (73.1-143.1)	283.5 ± 3.8 (280-287)	278.3 ± 36.8 (234.1-307.6)	269.8 ± 35 (234.8-304.8)	21 ± 3.5 (17.5-24.5)	0.001 ***
Dissolved oxygen (mgL^{-1})	4.56 ± 1 (3.56-5.56)	6.47 ± 1 (5.47-7.41)	6.77 ± 1 (5.77-7.77)	6.02 ± 1 (5.02-7.02)	5.03 ± 1 (4.03-6.03)	5.24 ± 1 (4.24-6.24)	0.11
Total dissolved solids (mgL^{-1})	190.08 ± 64 (126.08-254.08)	459.52 ± 64 (395.52-523.52)	1024 ± 64 (960-1088)	832 ± 64 (768-896)	1216 ± 64 (1152-1280)	915.2 ± 6.4 (908.8-921.6)	0.001 ***
Temperature (°C)	21 ± 1 (21-23)	20 ± 1 (19-21)	19 ± 1 (18-20)	18 ± 1 (17-19)	23 ± 1 (22-24)	21 ± 1 (20-22)	0.001 ***

P > 0.05, non significant; P < 0.001, highly significant (***)

Table IV.- Seasonal variations of studied water quality parameters in water samples from River Chenab during 2011-2012 sampling season. Data is expressed as Mean ± Standard deviation Range for each parameter is given in parenthesis. P - value indicates the results of one way ANOVA test calculated for each parameter.

Water quality parameters	November 2011	December 2011	January 2012	February 2012	March 2012	April 2012	P- Value
pH	8±1 (7-9)	7.5 ± 1 (6.5-8.5)	8.5 ± 1 (7.5-9.5)	7.6 ± 1 (6.6-8.6)	7.9 ± 1 (6.9-8.9)	8.6 ± 1 (7.6-9.6)	0.69
Electrical conductivity ($dscM^{-1}$)	0.197 ± 0.001 (0.196-0.198)	0.518 ± 0.001 (0.517-0.519)	1.2 ± 0.1 (1.1-1.3)	1.3 ± 0.1 (1.2-1.4)	1.4 ± 0.1 (1.3-1.5)	1.6 ± 1.1 (1.5-1.7)	P<0.001 ***
Calcium (mgL^{-1})	14.3 ± 0.15 (4.1-14.4)	160.8 ± 0.1 (60.7-60.9)	120 ± 1 (119-121)	1.31 ± 1 (13.0-13.2)	134.3 ± 4.9 (131-140)	150 ± 10 (140-160)	P<0.001 ***
Magnesium (mgL^{-1})	3.14 ± 3.1 (0.48-6.48)	12.36 ± 0.01 (12.5-12.37)	30.31 ± 0.90 (29.2-31)	32.1 ± 0.1 (32-32.2)	33.17 ± 2.5 (31.5-36.01)	40.63 ± 4.5 (36.2-45.2)	P<0.001 ***
Sodium (mgL^{-1})	33.7 ± 1.499 (32.1-35.6)	47.4 ± 0.5 (47-48)	180 ± 1 (179-181)	220.3 ± 0.5 (220-221)	280 ± 1 (279-281)	36.2 ± 0.1 (36.1-36.3)	P<0.001 ***
Total Alkalinity (mgL^{-1})	40.7 ± 0.1 (40.6-40.8)	120 ± 1 (119-121)	181 ± 0.5 (180.4-181.5)	141.4 ± 1 (140.4-142.4)	139.2 ± 30 (109.2-169.2)	17.4 ± 0.3 (17.1-17.7)	P<0.001 ***
Chloride (mgL^{-1})	35 ± 1 (34-36)	109.1 ± 1 (108.1-110.1)	280 ± 0.6 (280-811)	271.4 ± 0.74 (270.65-272.1)	269.8 ± 35 (234.85-304.85)	21 ± 35 (17.5-24.5)	P<0.001 ***
Dissolved oxygen (mgL^{-1})	5.36 ± 1 (4.36-6.36)	7.23 ± 1 (6.23-8.23)	6.77 ± 1 (5.77-7.77)	7.02 ± 1 (6.02-8.02)	6.03 ± 1 (5.03-7.03)	5.24 ± 1 (4.24-6.24)	0.12
Total dissolved solids (mgL^{-1})	126.08 ± 0.64 (125.4-126.7)	331.52 ± 0.64 (330.8-332.1)	768 ± 64 (704-832)	832 ± 64 (768-896)	896 ± 64 (832-960)	1024 ± 64 (960-1088)	P<0.001 ***
Temperature (°C)	22 ± 1 (21-23)	18 ± 1 (17-19)	19 ± 1 (18-20)	18 ± 1 (17-19)	20 ± 1 (19-21)	21 ± 1 (20-22)	0.002 **

$P > 0.05$, non significant; $P < 0.05$, least significant (*); $P < 0.01$, significant (**); $P < 0.001$, highly significant (***)

Table V.- Safe water quality standards Iqbal *et al.* (2004).

Parameters	Safe levels
Turbidity	Water with less than 2.5mg/liter turbidity may have 12.8 times more plankton and 5.5 times more fish production than in waters with a turbidity exceeding 100mg/liter.
Electric conductivity	Maximum acceptable electric conduction for irrigation purpose is 1.25 m.mhos. /cm. It is proportional to total dissolved solids. Natural waters have electric conductivity between 20-1500m.mhos/cm. EC above 400m. mhos/cm does not limit productivity but productivity does not increase with increasing EC.
pH	The pH range for diverse fish production is 6.5-9, for irrigation purpose is 6.0-8.2. 4.0 acid death point, 4.0-5.0 no reproduction, 4.0-6.5 slow growth, 11.0 alkaline death point.
Dissolve oxygen	Minimum acceptable level is 5.0 mg/liter for reproduction of desirable fish. 0.0 mg/liter small fish survive- short exposure, 0.3-1.0 mg/liter lethal if exposure is prolonged, and 3.5mg/liter fatal to several fish species within 20 hours.
Alkalinity	0-0.2 mg/liter low fish production 20-40 mg/liter medium fish production 40-90 mg/liter high fish production Less than 10 mg/liter rarely produce large carps.
Acidity	Low pH (Below 4.5) High Acidity High pH (Above 8.0) Low Acidity Fish production increases when acid waters are limed to increase total alkalinity above 20mg/liter.
Total hardness	More than 15mg/liter is suitable for fish growth. Less than 15 mg/liter cause slow growth of fish and require liming for high fish production. Less than 5 mg/liter hardness causes death of fish.
Total solids	Waters with less than 2.5 mg/liter of total solids cause 5.5 time more production of fish than the waters with total solids exceeding 100 mg/liter.
Total dissolved solids	Represents total mineral contents, which may or may not be toxic. Low total dissolved solids indicate enough fish diversity while maximum of 400mg/liter is required for maximum fish diversity.
Light penetration	Light penetration has inverse relationship with turbidity. Waters with less than 2.5 mg/liter turbidity show more light penetration, 12.8 times more planktons and 5.5 times more fish production. While the waters with turbidity exceeding 100mg/liter have low light penetration and fish production. Good waters Light penetration above 600mm. Satisfactory Light penetration above 300mm. Poor waters Light penetration above 100mm.
Carbonates and bicarbonates	Their Presence in water restores the equilibrium, prevents wide variations in pH of water and does not allow dropping below 4.5 and rising above 8.3.

Pedro *et al*., 2005; Kori-Siakpere *et al*., 2005),. Besites industrial effluent, increase in water temperature (climatic changes) also affects the water quality like concentration of dissolved oxygen (Fernandes and Mazon, 2003; Zaragabadi *et al*., 2009). The water quality of an aquatic habitat determines the productivity and other parameters necessary for fish survival (Menezes *et al*., 2006).

Biomarkers represent change in a biological response, ranging from molecular to cellular and from physiological responses to behavioural changes, which can be related to change of the aquatic habitat (Depledge *et al*., 1995; Menezes *et al*., 2006; Fernandes *et al*., 2008; Das *et al*., 2002). We had observed significant variations in hematological parameters of *C. marulius* during both sampling seasons. Low temperatures in winter season, and higher temperatures in summer directly affect the fish physiology. Our results complement the findings of Collazos *et al*. (1998) who had reported that blood parameter levels were affected by variation in water temperature and oxygen concentration in male and female *Tinca tinca*.

It has been reported that the environmental pollutants, disease causing agents and starvation also alter the blood chemistry **(**Gabriel *et al*., 2004; Anbalagan *et al*., 2008; Ramesh and Saravanan, 2008). Analysis of our results revealed that during both sampling seasons, values of hematocrit (PCV), WBCs, RBCs and MCV were higher during April and had significantly lower values during low temperature months. Because of high body metabolic rate due to high ambient temperature and reproductive activities, most of the hematological parameters show higher values than of other seasons. These results are supported by findings of Adebayo *et al*. (2007), Joshi (1989) and Orun *et al*. (2003). Khadjeh *et al*. (2010) and Kohanestani *et al*. (2013) have reported that some of the blood parameter levels may increase to meet high energy demand of fish. The lowest value, during winter might be due to low ambient temperature and low metabolic rate.

CONCLUSION

In conclusion, our results indicated significant variations in hematological parameters of *Channa marulius* during both sampling seasons that were complementary to the changes in water quality parameters of river Chenab indicating that environmental changes affects the blood chemistry of *C. marulius.*

ACKNOWLEDGMENTS

This project was sponsored by Higher Education Commission (HEC) of Pakistan under 5000 indigenous Ph.D. Programme.

Conflict of interest

Authors declare that they have no conflict of interest of any sort with anyone.

REFERENCES

ADEBAYO, O.T., FAGBENRO, O.A., AJAYI, C.B. AND POPOOLA, O.M., 2007. Normal haematological profile of *Parachanna obscura* as a diagnostic tool in aquaculture. *Int. J. Zool. Res.,* **3**:193-199.

ALI, M., SALAM, A., IRAM, S., BOKHARI, T.Z. AND QURESHI, K.A., 2005a. Studies on monthly variations in biological and physico-chemical parameters of brackish water fish pond, Muzaffargarh, Pakistan. *J. Res. (Sci).,* **16**: 27-38.

ALI, M., IQBAL, F., SALAM, A., IRUM, S. AND ATHAR, M., 2005b. Comparative study of body composition of different fish species from brackish water pond. *Int. J. environ. Sci. Technol*., **2**: 329-332.

ANBALAGAN, T., RAJENDRAN, K., SAMYKKANNU, K., SOUNDARAPANDIAN, P. AND VEERAPPAN, N., 2008. The studies on haematological parameters and enzymes of wild and farmed fish *Labeo rohita* (Ham.) *J. aquat. Biol.,* **23**: 181-184.

APHA, 2005. *Standard methods for the examination of water and waste water*.

BAYIR, A., 2005. *The investigation of seasonal changes in antioxidant enzyme activities, serum lipids, lipoproteins and hematological parameters of siraz fish* (Capoetacapoetaumbla) *living in Hns Stream (Murat Basin).* M.Sc. thesis Dissertation, Atatürk University.

BORKOVIC, S.S., PAVLOVIC, S.Z., KOVACEVIC, T.B., S TAJN, A.S., PETROVIC, V.M. AND SAICIC, Z.S., 2008. Antioxidant defence enzyme activities in hepatopancreas, gills and muscle of spiny cheek crayfish (*Orconectes limosus*) from the River Danube. *Comp. Biochem. Physiol. Part C Toxicol. Pharmacol.,* **147**:122–128.

COLLAZOS, M.E., ORTEGA, E., BARRIGA, C. AND RODRIGUEZ, A.B., 1998. Seasonal variation in hematological parameters in male and female *Tinca tinca. Mol. cell. Biochem.,* **183**: 5-8.

DAS, M.K., DAS, R.K. AND MONDAL, S.K., 2002. Some stress sensitive parameters of young major carp *Labeo rohita. Ind. J. Fish.,* **49**: 73-78.

DE PEDRO, N., GUIJARRO, A.I., LO´PEZ-PATIN˜O, M.A., MARTI´NEZ, A.,´ LVAREZ, R. AND DELGADO, M.J., 2005. Daily and seasonal variations in haematological and blood biochemical parameters in the tench, *Tinca tinca* Linnaeus, 1758. *Aquat. Res.,* **36**: 1185–1196.

DEPLEDGE, M.H., AAGAARD, A. AND GYORKOS, P., 1995. Assessment of trace metal. Toxicity using molecular, physiological and behavioural biomarkers. *Mar. Pollut. Bull.,* **31**: 19–27.

DUA, A. AND KUMAR, K., 2006. Age and growth patterns in *Channa marulius* from Harike Wetland (A Ramsar site), Punjab. India. *J. environ. Biol.,* **27**: 377-380.

FAZIO, F., MARAFIOTI, S., TORRE, A., SANFILIPPO, M., PANZERA, M. AND FAGGIO, C., 2013. Haematological and serum protein profiles of *Mugil cephalus*:effect of two different habitats. *Ichthyol. Res*., **60:** 36–42.

FERNANDES, C., FONTAI`NHAS-FERNANDES, A., ROCHA, E. AND SALGANO, M.A., 2008. Monitoring pollution in Esmoriz-Paramos lagoon, Portugal: liver histological and biochemical effects in *Liza sapiens. Environ. Monitor. Assess.,* **145**: 315–322.

FERNANDES, M.N. AND MAZON, A.F., 2003. Environmental pollution and fish gill morphology. In: *Fish adaptation* (eds. V. AL and B.G. Kapoor), Science Publishers Enfield Press.

GABRIEL, V.V., EZERI, G.N.O. AND OPABUNMI, O.O. 2004. Influence of sex source health status and acclimation on haematological of *Clarias gariepinus*. *Afri. J. Biotech.,* **3**: 463-468.

GUIJARRO, A.I., LOPEZ-PATINO, M.A., PINILLOS, M.L., ISORNA, E., DE PEDRO, N., ALONSO-GOMEZ, A.L., ALONSO-B, M. AND DELGADO, M.J., 2003. Seasonal changes in hematology and metabolic resources in the tench. *J. Fish Biol.,* **62**: 803-815.

IQBAL, F., ALI, M., SALAM, A., KHAN, B.A., AHMAD, S. AND UMER, K., 2004. Seasonal variations of physico-chemical characteristics of River Soan water at Dhoak Pathan Bridge (Chakwal), Pakistan. *Int. J. agric. Biol*., **6**: 89-92.

JOSHI, P.C., 1989. Seasonal changes in the blood parameters of a hill stream teleost, *Channa gochua. Comp. Physiol. Ecol.,* **14**:71-73

KAVADIAS, S., CASTRITSI-CATHARIOS, J. AND DESSYPRIS, A., 2003. Annual cycles of growth rate, feeding rate, food conversion, plasma glucose and plasma lipids in a population of European sea bass (*Dicentrarchus labrax* L.) farmed in floating marine cages. *J. appl. Ichthyol.,* **19**: 29-34.

KHADJEH, G.H., MESBAH, M., NIKMEHR, S. AND SABZEVARIZADEH, M., 2010. Effect of sex on the hematological parameters of reared Shirboat fish (*Barbus grypus*). *J. Vet. Res.,* **65**: 217-224.

KHAN, M. A., KHAN, S. AND MIYAN, K., 2012. Length–weight relationship of giant snake head, *Channa marulius* and stinging catfish, *Heteropneustes fossilis* from the River Ganga, India. *J. appl. Ichthyol.,* **28**: 154–155.

KOHANESTANI, Z.M., HAJIMORADLOO, A., GHORBANI, R., YULGHI, S., HOSEINI, A. AND MOLAEE, M., 2013. Seasonal variations in hematological parameters of *Alburnoides eichwaldii* in Zaringol Stream-Golestan Province, Iran. *World. J. Fish. Mari. Sci.,* **5**: 121-1262.

KORI-SIAKPERE, O., AKE, J.E.G. AND IDOGE, E., 2005. Hematological characteristics of the African snake variables on the hematology of pinfish and striped head, *Parachacnna obscura*. *Afri. J. Biotechnol.,* **4**: 527-530.

MENEZES, S., SORAES, A.M.V.M., GUILHERMINO, L. AND PECK, M.R., 2006. Biomarker responses of the estuarine brown shrimp *Crangon crangon* L. to non-toxic stressor: temperature, salinity and handling stress effects. *J. exp. Mar. Biol. Ecol.,* **335**:114–122.

ORUN, I., DORUCA, M. AND YAZLAK, H., 2003. Hematological parameters of three Cyprinid fish species. *Online J. biol. Sci.,* **3**: 320-328.

OSMAN, A.G.M., MEKKAWY, I., VERRETH, J. AND KIRSCHBAUM, F., 2007a. Effects of lead nitrate on the activity of metabolic enzymes during early developmental stages of the African catfish *Clarias gariepinus* (Burchell, 1822). *Fish Physiol. Biochem.,* **33**:1–13.

OSMAN, A.G.M., WUERTEZ, S., MEKKAWY, I.A., EXNER, H.I. AND KIERSCHBAUM, F., 2007b. Lead induced malformations in embryos of the African catfish *Clarias gariepinus* (Burchell, 1822). *Environ. Toxicol.,* **22**:375–389.

QADIR, S., LATIF, A., ALI, M. AND IQBAL, F., 2014. Effects of imidacloprid on the hematological and Serum biochemical profile of *Labeo rohita. Pakistan J. Zool.,* **46**: 1085-1090.

RAFIQUE, M. AND KHAN, N.H., 2012. Distribution and status of significant freshwater fishes of Pakistan. *Rec. Zool. Surv. Pakistan,* **21**: 90-95.

RAHIM, N.A.A., 2009. *Health benefits of the Haruan fish: Aids Wound Healing after Surgery*.

RAMESH, M. AND SARAVANAN, M., 2008. Haematological and biochemical responses in freshwater fish *Cyprinus carpio* exposed to chloropyrifos. *Int. J. integr. Biol.,* **3**: 80-86.

SALAM, A. AND RIZVI, M.S., 1999. *Studies on biodiversity and water quality parameters of river Chenab, Muzaffargarh*. Semi. Aquat. Biol., Karachi, Pakistan.

SANDNES, K., LIE, O. AND WAAGBO, R., 1988. Normal ranges of some blood chemistry parameters in adult farmed Atlantic salmon, *Salmo salar. J. Fish Biol.,* **32**: 129-136.

STEINHAGEN, D., KRUSE, P. AND KORTING, W., 1990. Some hematological observations on carp *Cyprinus carpio* L., experimentally infected with *Trypanoplasma borelli* (Laveran and Mesnil, 1901, Protozoa: Kitenoplastida). *J. Fish Dis.,* **14**: 157-162.

SVOBODA, M., KOURH, J., HAMACKOVA, J., KALAB, P., SAVINA, L., SVOBODOVA, Z. AND VYKUSOVA, B., 2001. Biochemical profile of blood plasma of tench (*Tinca tinca*) during pre and post spawning period. *Acta Vet. Brno,* **70**: 259-268.

ZARAGABADI, M.A., JALALI, M.A., SUDAGAR, M. AND POURALI-MOTLAGH, S., 2009. Hematology of great sturgeon (*Huso huso* Linnaeus, 1758) juvenile exposed to brackish water environment. *Fish. Physiol. Biochem.,* **36**: 655-9.

(Received 24 April 2015, revised 15 May 2015)