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ORIGINAL ARTICLE

Hematological and serum biochemical parameters of five freshwater snow trout fish species from river Jhelum of Kashmir Himalaya, India

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Abstract

Fish blood is a pathophysiological indicator of the whole body function and is thus considered as an important tool in diagnosing the structural and functional status of fish. However, the blood parameters vary between species to species and it mainly depends upon the favorable environmental conditions where the species live. The purpose of the current study is to evaluate the hematological and serum biochemical indices of five *Schizothorax* species: *Schizothorax labiatus*, *S. plagiostomus, S. esocinus*, *S. curvifrons* and *S. niger* in order to establish the resemblances and variations between these *Schizothorax* species which are inhabiting in river Jhelum. The hematological profile including hemoglobin (Hb), total red blood cell (RBC) count, hematocrit (Hct), white blood cell (WBC) count, erythrocyte sedimentation rate (ESR), and erythrocyte indices: mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), and mean corpuscular volume (MCV) was analyzed from each *Schizothorax* sp. Statistical analysis showed that there were significant differences ($p < 0.05$) in blood parameters among five *Schizothorax* spp. The results showed lowest values of hematological parameters in *S. niger* with respect to other species, while the highest values of hematological parameters were recorded in *S. plagiostomus.* Significant differences ($p < 0.05$) in serum biochemical levels of glucose, protein, cholesterol and urea were also noted in *Schizothorax* spp. The differences found in the hematological profile and serum biochemical composition in these fishes can be attributed to the individual feeding behavior, tolerance and environmentally adjustable capability of the fish. However, further study is required to correlate the present study with some other parameters such as the nutrient status of the river Jhelum where these fishes live.

Keywords *Schizothorax* spp. · Hematological parameters · Biochemical parameters · Jhelum river

Introduction

Fish, as bioindicator species, play a vital role in monitoring water quality because they respond with great sensitivity in the aquatic environment (Borkovic et al. 2008). Knowledge of hematological and serum biochemical parameters is an important diagnostic tool for evaluating the health status of fishes (Coles 1986; Adham et al. 2002; Barcellos et al. 2003; Borges et al. 2004; Akinrotimi et al. 2009; Xiaoyun et al. 2009; Zakes et al. 2016). Periodic blood analysis provides a simple means of assessing chronic stress, reproductive dysfunction, metabolic disorder and diseases by environmental conditions both in field and captivity population of fish species before they are present in clinical settings (Bahmani et al. 2001; Filiciotto et al. 2012; Pradhan et al. 2012). The variations in hematological and serum biochemical parameters of fishes are primarily caused due to many intrinsic and extrinsic factors such as age, nutritional status and reproductive cycles (Svobodova et al. 2001; Svetina et al. 2002; Bayir 2005), species and strain (Langston et al. 2002), stress (Cnaani et al. 2004), diseases (Chen et al. 2005), management (Svobodova et al. 2006) and photoperiod (Bani et al. 2009), which bring major alterations in the blood profile of fish. Hematological and serum biochemical parameters are closely related to the evolution and ecological adaptation of animals to the environment (Yang 2002). These parameters might be helpful in the adaptation mechanism and evolutionary processes (Yakhnenko and Yakhnenko 2006; Francesco et al. 2012). Evaluation of the hemogram involves determining the hemoglobin (Hb) concentration, total erythrocyte count (RBC), hematocrit (Hct), total white blood cell (WBC) count, erythrocyte sedimentation rate (ESR) and erythrocyte indices

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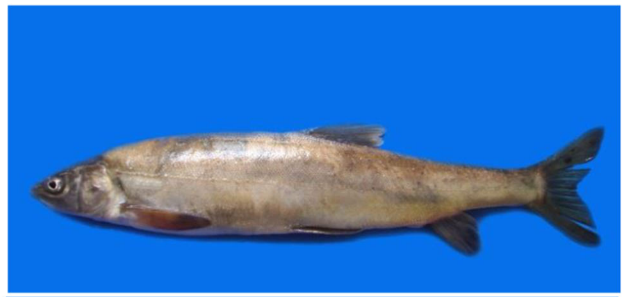
Table 1 Different *Schizothorax* spp. collected from river Jhelum

Species	Key	Photos
Schizothorax esocinus	*Schieso*	
Schizothorax curvifrons	*Schicur*	
Schizothorax labiatus	*Schilab*	
Schizothorax plagiostomus	*Schipla*	
Schizothorax niger	*Schinig*	

(MCH, MCHC, MCV). Hemoglobin concentration, total red blood cell count and hematocrit are most readily determined hematological indices in fishes in both wild and hatchery conditions (Bhaskar and Rao 1990; Witeska 2013). The hematocrit parameter among hematological parameters is not easily varied as per other peripheral blood parameters and should be used in convenience with Hb, erythrocyte and leukocyte counts (Wedemeyer et al. 1983; Pradhan et al. 2012; Sharma et al.

Table 2 Description of fish source, feeding behavior, and feeding habitat

Species	Author	Feeding behavior	Feeding habitat
Schizothorax esocinus	Heckel, 1838	Herbivores	Surface feeder
Schizothorax curvifrons	Heckel, 1838	Herbivores/illiophagic	Column feeder
Schizothorax labiatus	McClelland, 1842	Herbivores	Bottom feeding
Schizothorax plagiostomus	Heckel, 1838	Herbivores	Bottom feeding
Schizothorax niger	Heckel, 1838	Herbivores/detritus	Bottom feeding

2017). Leukocyte count (WBC) is repeatedly used as indicator of health status in fish (Pradhan et al. 2012). These leukocytes are an important component of the innate immune system and are mainly involved in nonspecific defense mechanisms in aquatic organisms including fish (Prasad and Charles 2010). Erythrocyte indices and erythrocyte sedimentation rate are used to measure the functional status of the blood stream and have been used as biomarkers of metal pollution in the aquatic environment (Shah and Altindag 2005; Satheeshkumar et al. 2012).

Apart from hematological parameters, the serum biochemical study is an important component of disease diagnosis in human and veterinary medicine. Many pathological alterations are reflected in serum well before clinical diseases appear and are thus useful as one of ancillary diagnostic techniques (Tripathi 2003). Serum biochemical parameters can provide imperative information on the internal environment of animals including fish (Edsall 1999; Masopust 2000; Anver 2004; Wagner and Congleton 2004). Nowadays, both hematological and serum biochemical data are of immense importance in monitoring the health status of fish species in both captive and wild populations, especially for fisheries management programs (Gul et al. 2011; Sharma et al. 2017). In fishes, serum proteins which are present in a complex combination are involved in a wide range of physiological functions in both healthy and diseased states, and have an importance in understanding the various physiological parameters of fish (Fazio et al. 2012). In contrast, glucose and Hct concentrations in blood are considered as an important tool for the identification of secondary stress conditions in fishes (Barton and Iwama 1991). It has been reported that fluctuations in the concentration of serum protein, glucose, cholesterol and other activities in serum might be due to specific indicators of sympathetic activation in response to handling and hypoxic stress (Santos and Pacheco 1996; Adham et al. 1997; Svobodova et al. 2001; Lermen et al. 2004; Velisek et al. 2009).

The hepatosomatic index (HSI) value provides information about the health condition of fish as well as the quality of water where the fish live, because a higher HSI value means fishes are growing rapidly and have a good aquatic environment, while a low HSI value means the fish are not growing well and are facing an unconducive environment (Kareem et al. 2015). The condition factor (K) involves quantitative parameters of the well-being of the fish and reflects feeding conditions. Variations in Fulton's condition factor also give information about gonad development, fat depot and environmental adaptation. This aspect differs according to influence of physiological factors, fluctuating according to different stages of the development.

Lot of work related to hematological and serum biochemical parameters in fishes have been reported by different workers in the past, and information about the normal range and best range for determining the health status of fish species has been established. However, very scattered/incomplete information is available on hematological and serum biochemical parameters of *Schizothorax* fish species of Kashmir Himalaya. Therefore, in the present study, an attempt has been made to establish complete data on hematological and serum biochemical parameters of these fish species inhabiting in water bodies (river Jhelum) of Kashmir Himalaya.

Table 3 Biometric and basic biological indices of *Schizothorax* spp. (mean ± SD) in river Jhelum

Species	Biometric parameters		Biological indices	
	Weight	Total length	HSI (%)	K
Schizothorax esocinus	310 ± 0.23	31.0 ± 1.12	2.14 ± 0.24	0.92 ± 0.11
Schizothorax curvifrons	318 ± 1.32	33.6 ± 1.12	2.25 ± 0.18	1.0 ± 0.01
Schizothorax labiatus	330 ± 1.21	36.1 ± 1.61	3.12 ± 0.22	1.08 ± 0.07
Schizothorax plagiostomus	335 ± 0.92	38.7 ± 0.72	2.93 ± 0.17	1.12 ± 0.04
Schizothorax niger	290 ± 0.85	28.2 ± 1.21	2.05 ± 0.12	1.01 ± 0.03

Table 4 Showing physiochemical parameters of river Jhelum

Parameters	Mean ± SD	Range
Water temperature (°C)	9.58 ± 3.26	6.67–16.67
pH	7.29 ± 0.20	7.23–8.30
DO (mg l^{-1})	8.59 ± 0.32	7.87–10.2
DCO_2 (mg l^{-1})	11.83 ± 1.00	8.60–12.6
Total alkalinity (mg l^{-1})	163.02 ± 10.09	139.33–179.23
Hardness (mg l^{-1})	198.04 ± 12.34	198.04–94.34

Material and methods

Physico-chemical parameters were analyzed such as water temperature, pH, dissolved oxygen, dissolved carbon dioxide, total alkalinity and hardness (APHA 1998). Temperature and pH were analyzed in situ by field instruments such as mercury thermometer and digital pH meter. The Winkler azide modified method was used for the estimation of dissolved oxygen and free carbon dioxide was determined by the titrimetric method, while total alkalinity was determined by acid titration using methyl orange as the end point.

Live specimens of *Schizothorax* species (*S. esocinus*, *S. curvifrons*, *S. labiatus*, *S. plagiostomus* and *S. niger*) used in this work were caught from river Jhelum during the study period of February 2017 to February 2018 as shown in Table 1. Fifteen to twenty individuals of *Schizothorax* species were collected from the river Jhelum from the study sites. The fish samples were transported live from collection sites to a wet laboratory along with water collected from the same habitat and were stocked in a 70-l plastic trough containing water filled from the same collection sites. After overnight acclimatization, blood samples were collected from the caudal vein of these live fishes using a sterile plastic disposable 22-gauge heparinized syringe, transferred into a heparinized vial immediately on ice (Orun et al. 2003; Lavanya et al. 2011), and stored for further analysis. For hematological analysis, the following hematological parameters like hemoglobin (Hb), total erythrocyte count (RBC), hematocrit (Hct), total leukocyte count (WBC), erythrocyte sedimentation rate (ESR), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular volume (MCV) were analyzed.

Hemoglobin concentration was determined by the cyanmethemoglobin method (Lavanya et al. 2011). The total erythrocyte and total leukocyte counts were done by using an improved Neubauer hemocytometer by using Natt–Herrick's diluent (Natt and Herrick 1952). The number of cells was determined as described by Pal et al. (2008) and Parida et al. (2011). The total RBC count per cubic millimeter was $200 \times 50 \times N = 10{,}000$ N (N = number of RBCs counted, dilution factor = 200) and the total WBC count per cubic millimeter was obtained as $20 \times 1 \times L/0.4$ cells = $50 \times L$ (L = number of WBCs counted, dilution factor = 50).The determination of hematocrit was performed according to Adebayo et al. (2007). Hct was estimated by using micro-hematocrit capillaries and centrifuged at 12000 rpm for 5 min in a micro-centrifuge (REMI RM-12C BL, India), and the values were expressed in percentage. ESR was measured by using the Wintrobe tube method (Wedemeyer et al. 1983). Erythrocyte indices were evaluated as per formula of Dacie and Lewis (1975).

$$\mathrm{MCH} = \mathrm{hemoglobin} \times 10/\mathrm{erythrocyte\ count}$$
$$\mathrm{MCV} = \mathrm{PCV} \times 100/\mathrm{erythrocyte\ count}$$
$$\mathrm{MCHC} = \mathrm{hemoglobin} \times 100/\mathrm{Hct}$$

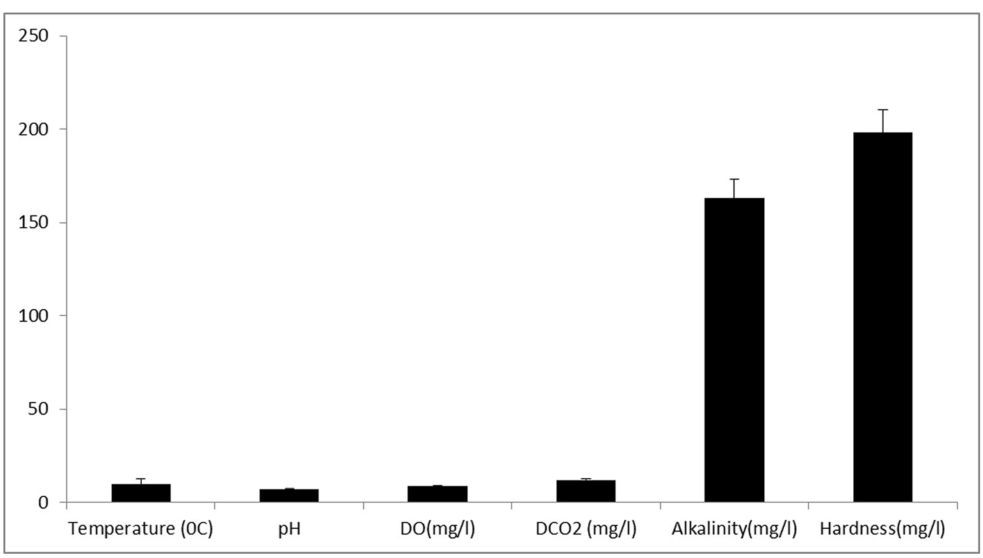


Fig. 1 Physico-chemical parameters of water from the study area

Table 5 Comparative hematological parameters of five *Schizothorax* species from Kashmir valley (mean ± SD)

Parameters	Fish species				
	S. esocinus	*S. curvifrons*	*S. labiatus*	*S. plagiostomus*	*S. niger*
Hemoglobin (g/dl)	9.21 ± 1.37d	10.08 ± 0.66c	10.78 ± 0.31b	11.88 ± 1.54a	8.1 ± 0.51e
RBC ($\times 10^6$ mm^3)[1]	1.40 ± 0.23b	1.47 ± 0.78b	1.67 ± 0.66a	1.72 ± 0.89a	1.32 ± 0.44c
WBC ($\times 10^3$ mm^3)[2]	4.57 ± 0.86b	3.43 ± 1.06c	3.25 ± 0.97cd	3.02 ± 1.84cd	4.97 ± 1.87a
Hct (%)[3]	37.4 ± 2.50a	35.0 ± 3.0b	39.4 ± 2.20a	40.6 ± 1.34a	30.66 ± 1.57c
RBC/WBC ratio	0.642 ± 0.40b	0.721 ± 0.08b	0.74 ± 0.04b	0.60 ± 0.06b	0.82 ± 0.20a
ESR (mm h^{-1})[4]	1.12 ± 0.21a	0.85 ± 0.23b	0.62 ± 0.34b	0.60 ± 0.45b	1.22 ± 0.55a
MCH (fl)[5]	66.82 ± 2.47b	68.32 ± 1.38b	72.82 ± 4.57a	82.56 ± 4.62a	58.75 ± 2.41c
MCV (pg)[6]	241.12 ± 13.33b	248.96 ± 9.10a,b	259.21 ± 17.24a	253.31 ± 15.6a	220.31 ± 12.34c
MCHC (%)[7]	28.02 ± 3.24c	32.17 ± 1.77b	34.76 ± 1.28a	38.54 ± 3.48a	26.49 ± 3.50c

Mean values in rows sharing the same lowercase letters are not significantly different ($p > 0.05$)

[1] Red blood cell count (RBC)

[2] White blood cell count (WBC)

[3] Hematocrit

[4] Erythrocyte sedimentation rate (ESR)

[5] Mean corpuscular hemoglobin (MCH)

[6] Mean corpuscular volume (MCV)

[7] Mean corpuscular hemoglobin concentration (MCHC)

Serum biochemical parameters

Blood in non-heparinized Eppendorf tubes was centrifuged at 5000*g* for 5 min to undergo biochemical analysis. The collected serum was stored at − 20 °C for further analysis. Total protein estimation was based on the Biuret method as described by Henry et al. (1974) and the amount of protein is expressed in grams per deciliter. The blood glucose levels were estimated by the GOD/POD method using a kit, and the amount is expressed in milligrams per deciliter (Triander 1969). The cholesterol level was determined by the CHOD/PAP method using a kit, and the amount is expressed as milligrams per deciliter (Triander 1969). Urea estimation was done by using the method as described by Coulombe and Favreau (1963) and the amount was expressed in milligrams per deciliter.

Biological indices

The liver was removed and weighed to the nearest 0.1 mg. The hepatosomatic indices of each fish were calculated using the following formulas (Rajaguru 1992; Richter et al. 2000):

$$\mathrm{HSI}(\%) = (\text{Liver weight}/\text{Total body weight}) \times 100$$

$$\text{Condition factor} = (\text{Weight} \times 100/\text{Length})$$

Statistical analysis

Statistical analysis was performed by using SPSS (version 7.5 for Windows 2010). Data were analyzed by two-way analysis of variance.

Table 6 Blood biochemical parameters of five *Schizothorax* species (mean ± SD)

Biochemical parameters	*S. esocinus*	*S. curvifrons*	*S. labiatus*	*S. plagiostomus*	*S. niger*
Glucose (mg/dl)	65.73 ± 2.01b	68.43 ± 1.01b	72.37 ± 1.92a	75.23 ± 3.2a	62.34 ± 1.90c
Protein (g/dl)	5.82 ± 1.24b	5.72 ± 0.92b	6.69 ± 0.75a	7.74 ± 1.87a	5.07 ± 0.85c
Cholesterol (mg/dl)	267.12 ± 4.14b	220.34 ± 1.96c	261.65 ± 2.05b	286.41 ± 1.85a	265.78 ± 3.0b
Urea (mg/dl)	6.65 ± 0.74a	5.63 ± 0.66b	4.76 ± 0.34c	5.00 ± 0.75c	5.72 ± 0.55b

Mean values in rows sharing the same lowercase letters are not significantly different ($p > 0.05$)

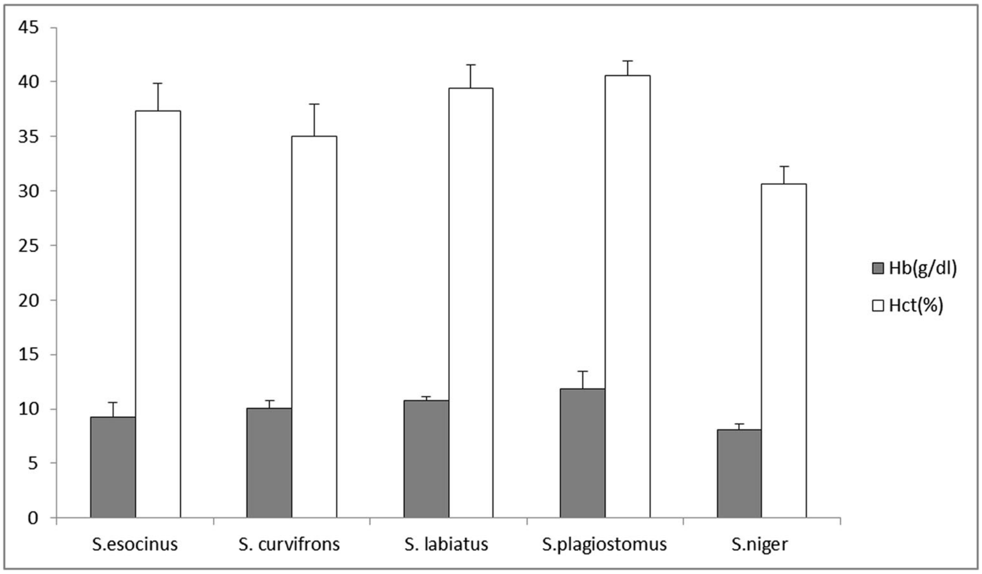


Fig. 2 Comparison between Hb (g/dl) and Hct (%) of *Schizothorax* spp.

Results

Feeding habitat and feeding behavior of five snow trout, *Schizothorax* species are presented in Table 2. Biometric data and biological indices of snow trout species recorded in the present study are presented in Table 3. Physicochemical parameters of water samples collected from river Jhelum showed a significant fluctuation with respect to each other and the data are presented in Table 4. In the present study, it was observed that the water temperature of sampling sites (9.58 ± 3.26) was reported from 6.67 to 16.67 °C, and dissolved oxygen concentration (8.59 ± 0.32) fluctuated from 7.87 to 10.2 mg l^{-1}. The pH value (7.29 ± 0.20) varied from 7.23 to 8.30. The dissolved free carbon dioxide concentration (11.83 ± 1.0) ranged from 8.60 to 12.6 mg l^{-1}. Similarly, total alkalinity and hardness concentration were estimated C163.02 ± 15.09; 198.04 ± 44, in the range from 139.33 to 179.23 mg l^{-1} and from 94.4 mg l^{-1} to 198.04 as shown in Fig. 1. The hematological and serum biochemical analysis data of all the five snow trout fishes are given in Tables 5 and 6. The results showed significant variations in hematological parameters in all five *Schizothorax* species (Figs. 2, 3 and 4). The hemoglobin concentration was recorded highest in *S. plagiostomus* followed by *S. labiatus*, while other species showed lower Hb values with the lowest Hb concentration recorded in *S. niger*. RBC count was found highest in *S. plagiostomus* followed by *S. labiatus*. However, the other fish species showed slightly lower values of RBC count with lowest RBC count noted in *S. niger*. The Hct values of *Schizothorax* species were estimated between 30 to 40% with

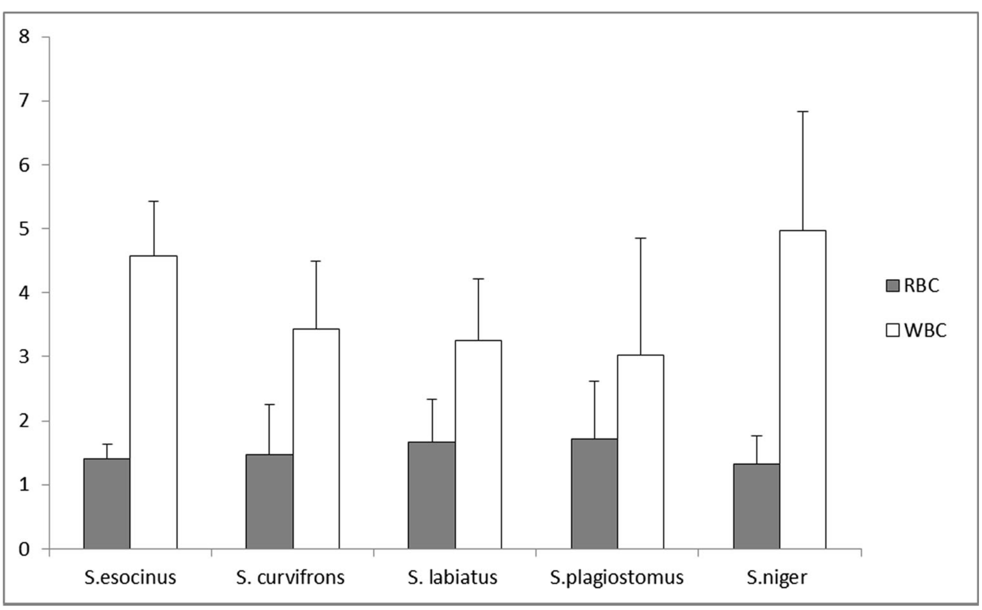


Fig. 3 Comparison between RBC ($\times 10^6$ mm^3) and WBC ($\times 10^3$ mm^3) of *Schizothorax* spp.

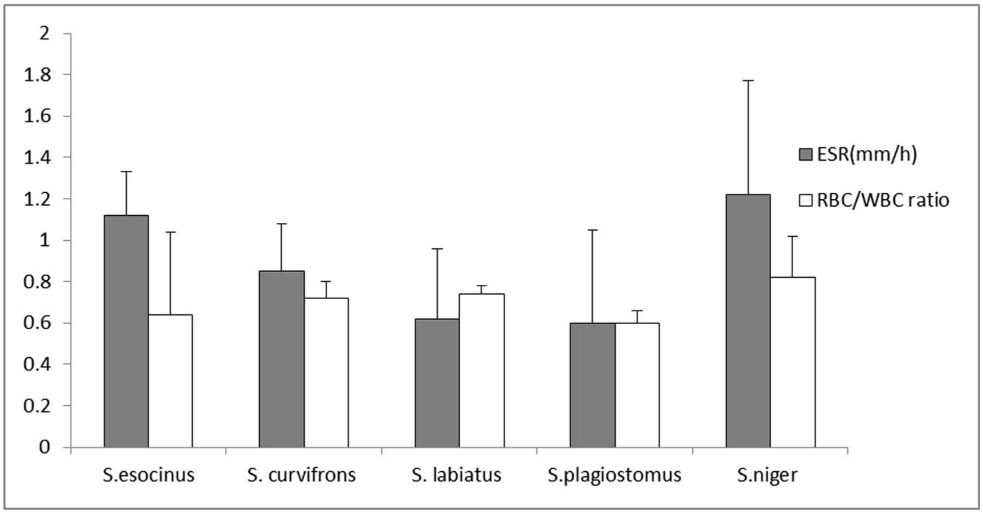


Fig. 4 Comparison between RBC/WBC ratio and ESR (mm/h) of *Schizothorax* spp.

the highest Hct values recorded in *S. plagiostomus* followed by *S. labiatus* and the lowest values noted in *S. niger*. The highest level in the RBC/WBC ratio was found in *S. plagiostomus* and the lowest ratio was recorded in *S. niger*. In the present study, an inverse relationship in RBC and WBC was noted in all five *Schizothorax* species. The highest count of WBC was recorded in *S. niger* followed by *S. esocinus*, while the lowest count was noted in *S. plagiostomus* followed by *S. labiatus*. The erythrocyte sedimentation rate (ESR) was found highest in *S. niger* and the lowest ESR was recorded in *S. plagiostomus*, while intermediate values of ESR were recorded in other *Schizothorax* species. Erythrocyte indices MCH, MCV and MCHC values showed significant differences among all the species. Serum biochemical parameters of *Schizothorax* spp. also showed significant differences ($p < 0.05$). It is observed among each species (Figs. 5, 6 and 7) that the highest values of glucose and protein occurred in *S. plagiostomus* and the lowest value was observed in *S. niger*. Serum cholesterol was found maximum in *S. plagiostomus* and minimum in *S. curvifrons* followed by *S. labiatus.* The serum urea content was recorded highest in *S. esocinus* followed by *S. niger* and the lowest urea content was observed in *S. labiatus* and *S. plagiostomus*, respectively.

Discussion

Assessment of hematological and blood biochemical parameters can provide a valuable approach for evaluating the health status of many organisms including fishes, and these indices provide reliable information on metabolic disorders,

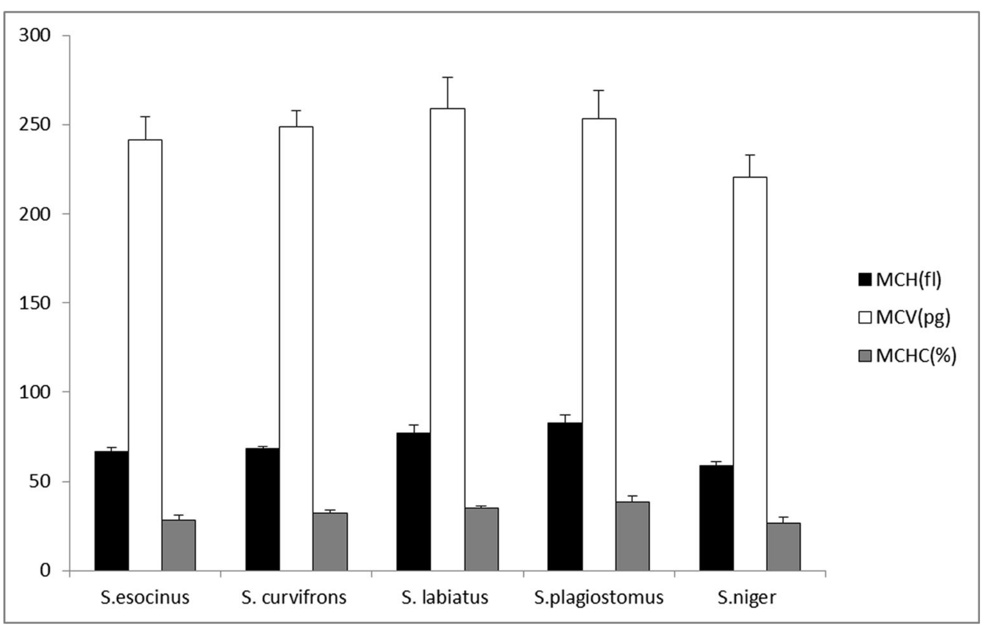


Fig. 5 Comparison between erythrocyte indices (MCH, MCV, MCHC) of *Schizothorax* spp.

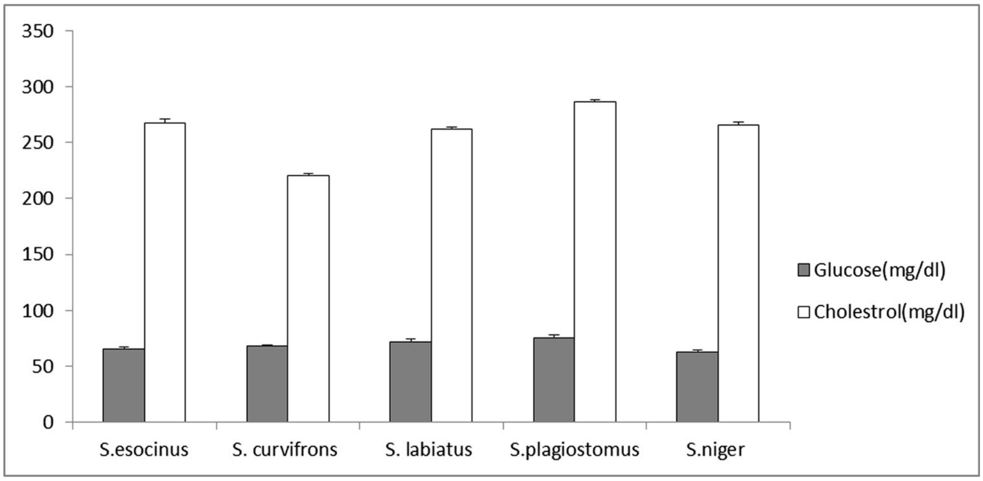


Fig. 6 Comparison between glucose and cholesterol (mg/dl) of *Schizothorax* spp.

deficiency and chronic stress state before they are present in clinical settings (Bahmani et al. 2001; Pradhan et al. 2012). In fishes, hematological and biochemical parameters are considerably influenced by many intrinsic and extrinsic factors i.e., fish size, age, stress, nutrition, management, season, reproductive cycle, diseases, temperature, photoperiod, strain species and genetic variations (Svobodova et al. 2001; Langston et al. 2002; Cnaani et al. 2004; Magill and Sayer 2004; Silverira-Coffigny et al. 2004; Bayir 2005; Chen et al. 2005; Vazquez and Guerrero 2007; Francesco et al. 2012; Pradhan et al. 2014a, b; Yousefzadeh and Khara 2014). Although a lot of work on hematological and serum biochemical parameters of different fish species has been reported from different parts of the world, knowledge regarding hematological and serum biochemical parameters of *Schizothorax* species is scarce. Therefore, the objective of the present work was to characterize the hematological and serum biochemical parameters of *Schizothorax* species inhabiting in the Kashmir Himalayan region.

In the present study, generally higher values of Hb, RBC, and Hct were observed in *S. plagiostomus* followed by *S. labiatus* and the lowest values of these parameters were recorded in *S. niger*, which can be attributed due to high and low biometric parameters. Similar findings have also been observed by other workers in different fish species (Das 1965; Raizada et al. 1983; Jawad et al. 2004). Moreover, this study further attributes higher values of Hb, RBC and Hct in *S. plagiostomus* and *S. labiatus* because of high activity of fishes with streamlined body and high metabolic rate, while the lowest values of Hb, RBC and Hct reported in *S. niger* might be due to low activity of fish and low metabolic rate. Similar observations were also reported in the past by many

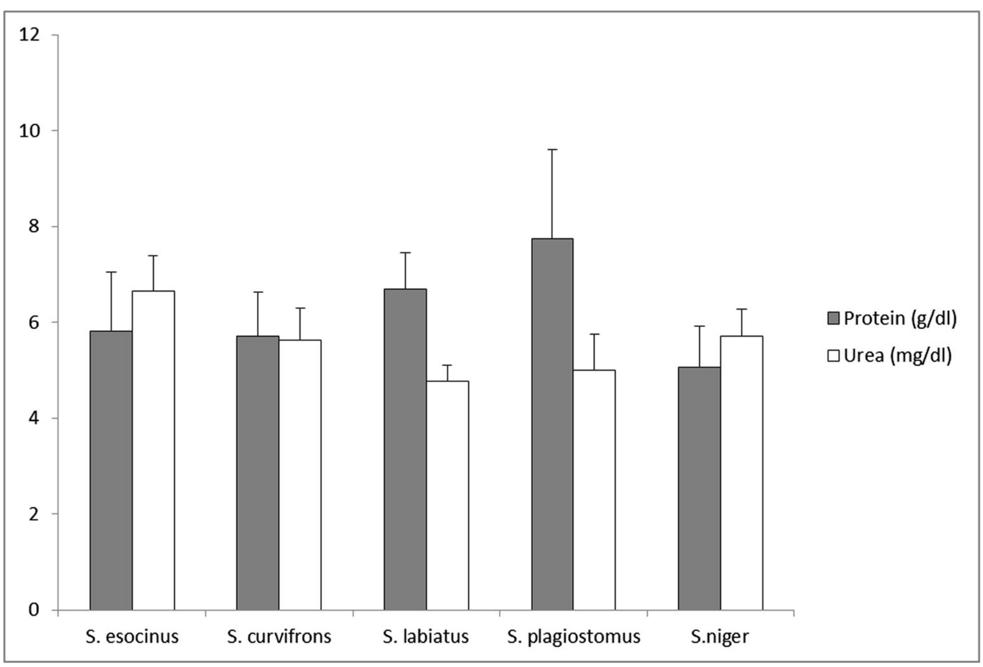


Fig. 7 Comparison between protein and urea (mg/dl) of *Schizothorax* spp.

workers (Chaudhuri et al. 1986; Rambhaskar and Srinivasa Rao 1986; Svobodova et al. 2008; Pradhan et al. 2012; Witeska 2013). WBCs are defensive cells of the body because WBCs are a key component of innate immune defense and involved in the regulation of immunological function in aquatic organisms (Duthie and Tort 1985; Gallardo et al. 2003; Ballarin et al. 2004; Satheeshkumar et al. 2012; Sharma et al. 2017). Fishes with higher leukocyte count (WBC) will fight infection more efficiently than other species. Our finding observed an inverse relationship between WBC and RBC counts and showed highest values of WBC count in *S. niger* followed by *S. esocinus* and lowest values recorded in *S. plagiostomus.* The same inverse relationship between WBC and RBC count was also reported by Satheeshkumar et al. 2012 in four different teleost fishes.

The ESR level may be the consequence of changes in blood plasma of different fish species or may be due to stress conditions (Joseph John 2007). The general reflection of the present finding shows that the erythrocyte sedimentation rate is found highest in *S. niger* which is negatively associated with total erythrocyte count; i.e., the lower the total erythrocyte count, the higher will be the erythrocyte sedimentation rate. The differences observed in erythrocyte indices may be due to the overall oxygen consumption rates and swimming routine activity under normal conditions (Stillwell and Benfey 1995).

Blood biochemical parameters varied from species to species and can be influenced by many endogenous and exogenous factors (Zarejabad et al. 2010). In *Schizothorax* spp., *S. plagiostomus* was recorded with the highest protein and glucose level in serum; this may probably be due to an increased depletion of liver glycogen (Robertson et al. 1961; Svobodova 1977; Zuim et al. 1988; Ojolick et al. 1995; Satheeshkumar et al. 2012; Sharma et al. 2017). Moreover, an increase in serum glucose concentration in *S. plagiostomus* might be due to an increase in measurement of environmental stressors, hypoxia environment, starvation and high temperature. Similar observations were also reported by many workers in a variety of fishes (Barton et al. 1987; Hardy and Audet 1990; Barton and Iwama 1991; Torres et al. 1991; Cech et al. 1996; Santos and Pacheco 1996; Wendelaar Bonga 1997; Barton 2000; Bahmani et al. 2001; Svobodova et al. 2001; Yin et al. 2005; Bayir et al. 2007; Porchas et al. 2009). In contrast, a decrease in glucose concentration in *S. niger* could be correlated with lowest biometric parameters, age, food deprivation, and hormonal and behavioral response, which is in line with the findings of Coz-Rakovac and Teskeredzic (2000), Hrubec et al. (2001), Pradhan et al. (2014a, b) and Bartonkova et al. (2016). The serum protein level is often associated with nutritional and physiological status and is affected by starvation and stress which can be triggered by structural liver alteration reducing aminotransferase activity, with associated reduction in deamination capacity and impaired control of fluid balance (Burtis and Ashwood 1996; Coz-Rakovac et al. 2005; Rehulka and Minarik 2005; Peres et al. 2014). The decrease in serum protein concentration could be recognized due to protein catabolism; i.e., the process of altering blood and structural proteins to energy to meet the higher request on exposure to different pH values (Das et al. 2006). Serum cholesterol concentration was estimated to be high in *S. plagiostomus*, which has high biometric parameters and high metabolic rate than other *Schizothorax* spp. Previous studies by various researchers also observed that fishes with high biometric parameters and high metabolic rate have high serum cholesterol in different fish species (Hill 1982; Svobodova et al. 2001; Satheeshkumar et al. 2012). A cholesterol level increase in serum can be the result of damage to liver or kidney and also due to the administration of pesticides (Bano 1985; Kavya et al. 2015). The highest blood urea concentration was recorded in *S. esocinus* and is likely related to the indicator of stress associated with increase in the cortisol level (Borges et al. 2004).

In conclusion, the data generated in the present study may provide initial information on health assessment based on hematological and serum biochemical parameters for *Schizothorax* spp. We suggest that hematological data on fishes have assumed a great role in increasing the importance of pisciculture and awareness about the environmental conditions. Finally, the outcome of the current study will help environmental and aquaculture officials to take future decisions in the management and rearing of fish used for human consumption.

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