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Indigenous *Schizthoracine* Fishes as Bioindicators of Parasitic Infections in Kashmir

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ABSTRACT: Present study was undertaken to study the alterations in blood biochemical indices due to the presence of helminth parasites in *Schizothorax* and carp fishes collected from Dal and Anchar lakes of Kashmir. The prevalence of parasites and other indices were assessed and compared with the alterations in the serum biochemical indices of infected as well as uninfected fishes. During the investigation three helminth parasites viz. *Pomphorhyncus, Neoechinorhyncus* and *Adenoscolex* were recovered from the infected fish specimens examined. The overall prevalence of parasites in *Schizothorax* and carps of Dal Lake was 48.54% and 41.23% respectively, while as in Anchar Lake, it was 53.70% and 50.50% respectively. In Dal Lake, among *Schizothorax* fishes the highest prevalence was of *Pomphorhyncus* parasite (26.21%) followed by *Neoechinorhyncus* (19.42%) and *Adenoscolex* (15.53%). In case of carp fishes the order was *Neoechinorhyncus* (21.93%) followed by *Pomphorhyncus* (19.30%) and *Adenoscolex* (14.04%). In Anchar lake, the highest prevalence among the parasites in *Schizothorax* fishes was of *Pomphorhyncus* (27.78%) followed by *Neoechinorhyncus* (24.07%) and *Adenoscolex* (18.52%). The carp fishes followed a different pattern, the most prevalent parasite being *Pomphorhyncus* (22.77%) followed by *Adenoscolex* (19.80%) and *Neoechinorhyncus* (15.84%). The blood biochemical indices were found altered in parasitized fishes as compared to those of non-parasitized fishes in both the water bodies. Total protein, albumin and bilirubin of infected fishes showed a significant decrease compared to uninfected ones. Globulins, glucose, AST, ALP, and LDH showed a significant increase in infected fishes when compared to uninfected fishes. Significant differences were found between them as regards the alteration in blood biochemical parameters signifying higher eutrophication status of Anchar Lake due to increased levels of pollution as a result of heavy inflow of nutrients and sewage coming out either from SKIMS or households. These stress conditions make fishes more susceptible to parasitic infections. Moreover, *Schizothorax* fishes being more sensitive than carp fishes are more prone to parasitic infections hence depict higher alterations in blood biochemical indices than carp fishes.

Keywords: biochemical indices, Anchar Lake, Dal Lake, Helminth parasites, Fishes, Eutrophication.

INTRODUCTION

Fish represents one of the best foods for human consumption on account of its high protein content, low saturated fats and high proportion of omega-3 polyunsaturated fatty acids (mainly ecosapentanoic acid and docosahexanoic acid). This biochemical composition of fish makes it superior to red meat as the consumption of fish flesh and fish oil is beneficial in reducing the serum cholesterol (Stansby, 1985). Moreover, fish protein has relatively high digestibility in humans as compared to other forms of proteins with 10 essential amino acids in desirable quantity. All these properties brings the fish flesh to be in the same class as chicken protein and is therefore superior to proteins present in milk, beef and egg (Srivastava, 1999). It is due to this reason that fishery has become one of the important sectors aiming at the production of animal protein, elimination of malnutrition, generation of employment and socio-economic upliftment of rural and urban poor. Fish industry, like other live-stock producing sectors suffers loss due to diseases and parasitic infestations. Fishes are prone to various diseases, both in cultural domains as well as under natural environmental conditions. In nature, increase in pollution due to urbanisation has directly affected the inhabitants of aquatic ecosystems. A positive relationship has been reported between eutrophication and fish parasitism (Zargar *et al*., 2011). Rise in anthropogenic stress results in water pollution leading to increased parasitic infestation in fishes due to the increased availability of intermediate hosts which subsequently affect the growth, development and survival of fish (Sures, 2004). Quality of water has a potential to affect the health of a fish directly leading to recruitment of parasites in fishes (MacIntyre, 2008). Water pollution results in eutrophication rendering the fishes immuno-compromised and hence more susceptible to parasitism (Zargar *et al*., 2012).

Among all diseases of fishes, parasitic infestations caused by helminths are the most important and diversified since they have not only proven detrimental but also led to serious physiological changes in almost all the fish species known till date. About 80% of fish diseases are parasitic especially in warm water (Eissa, 2002). On the basis of a conservative estimate there is an average of 3–4 fish parasites in each existing fish species alone and given the current number of 31,400 described fish species; we can estimate the existence of up to 120,000 fish parasite species, including both protozoans and metazoans (Palm, 2011). It is a matter of concern that helminths attain shelter in fishes, snatch their food, and utilize their energy causing reduction in weight and size of fishes. It has been observed that those helminth parasites which inhabit the intestine mostly cause several pathogenic, biochemical and physiological changes (Vinatha, 2012). Parasitized fishes depict significant changes in their hematological and physiological characteristics (Ruane *et al.,* 2000) and biochemical indices (El- Seify *et al.,* 2011; Ali and Ansari, 2012 and Jaswal *et al*., 2015) which affect their development (Singhal *et al.,* 1990; Ranzani–Paiva and Silva Souza, 2004). Plasma enzyme levels in fish are good indicators of extreme stress and provide information of organ dysfunction (Wells *et al*., 1986; Jiminez and Stegeman, 1990). As such, biochemical and physiological indicators such as enzymes could be used (as biomarkers) to identify possible environmental contamination before the health of aquatic organisms is seriously affected (Barnhoorn and Van Vuren, 2004; Powers, 1989 & Pickering and Pottinger, 1995). Biochemical approach has been advocated to provide an early warning of potentially damaging changes in stressed fish (Casillas *et al*., 1983). Alterations in the level of serum protein, glucose, cholesterol, urea, ALT (alanine aminotransferase) and AST (aspartate aminotransferase) are associated with severity of the parasitic infection. The rate of increase of plasma enzyme activity depends on the concentration of an enzyme in cells, the rate of leakage caused by injury, and the rate of clearance of the enzyme from plasma (Boyd, 1983).

MATERIALS AND METHODS

A. Collection of Fish samples

Fishes were collected on monthly basis from Dal and Anchar Lakes with the aid of local fishermen. A total number of 103 fishes of *Schizothorax* and 114 carp from Dal Lake while as 108 *Schizothorax* and 101 carp fishes from Anchar Lake were randomly collected during this study. Fishes were segregated as per the species and serial number was assigned to each one of them. A strong blow was given on the head of the fishes to kill them. Collection of blood was carried out by cardiac puncture (Lucky, 1977) and the blood drawn was kept in vials for extraction of serum.

B. Isolation of helminth parasites

The helminth parasites collected were classified and grouped according to their phylum. The classification was done according to the keys provided by (Manwell 1961 and Yamaguti, 1959). Parasites were separated, counted and readings noted to calculate their incidence. The prevalence, mean intensity and relative density of helminth parasites were calculated in percentage in accordance with that of (Bhure *et al*., 2007) by the following formulas:

$$\text{Prevalence} = \frac{\text{Infected number of hosts} \times 100}{\text{Total no. of hosts examined}}$$

$$\text{Mean intensity} = \frac{\text{No. of parasites collected}}{\text{Total no. of infected hosts examined}}$$

$$\text{Relative Density} = \frac{\text{No. of parasites collected}}{\text{Total no. of hosts examined}}$$

C. Blood Biochemical parameters of fish

Blood was collected and stored in clot activator vials to extract serum. All the biochemical parameters viz: Serum Glucose, Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Bilirubin, Lactate Dehydrogenase (LDH), Alkaline Phosphatase (ALP), Total Proteins and Albumin were calculated by means of semi-auto analyser (Photometer 5010 V5+, Robert Ryle, Germany) using commercially available kits (Accurex Biomedical Pvt. Ltd.).

D. Statistical analysis

Mann-Whitney U test, Chi-square test and descriptive statistics (mean and S.D.) were calculated using PAST (version 3.0) and SPSS (version 20.0.0) software.

RESULTS

A. Overall Levels of infections in fishes

During present study 103 *Schizothorax* and 114 carp fishes were examined in Dal Lake for helminth infections out of which 50 *Schizothorax* and 47 carp fishes were found infected with over all prevalence of 48.54% and 41.23% respectively. In Anchar Lake, 108 *Schizothorax* and 101 carp fishes were examined for helminth infections out of which 58 *Schizothorax* and 51 carp fishes were found infected with over all prevalence of 53.70% and 50.50% respectively (Table 1). However, insignificant differences ($p>0.05$) were found between infected *Schizothorax* and carp fishes in both the water bodies. The overall mean intensity and relative density of *Schizothorax* and carp fish species of Dal and Anchar is given in Table 1.

Table 1: Overall prevalence of parasites in Dal and Anchar lakes.

Water body	Dal lake		Anchar lake	
Fish species	***Schizothorax***	**Carp**	***Schizothorax***	**Carp**
No of fishes collected	103	114	108	101
Fishes infected	50	47	58	51
Chi square	$\chi2$ =1.17; p>0.05		$\chi2$ =0.22; p>0.05	
Pr. %	48.54	41.23	62.64	51.51
M.I.	2.64	2.91	3.62	3.24
R.D.	1.28	1.20	1.94	1.63

Pr.= Prevalence, M.I.= Mean Intensity and R.D. = Relative Density

B. Parasite-wise prevalence

During the present study, three parasites, viz. two acanthocephalans and a cestode were recovered from Dal and Anchar lakes from the examined fishes (Table 2 & 3). Among acanthocephalans, *Pomphorhyncus* and *Neoechinorhyncus* were recovered while as in cestodes, only *Adenoscolex* parasite was recovered.

C. Parasite-wise prevalence in Dal Lake

In Dal Lake, 27 *Schizothorax* fishes out of 103 examined were found to be infected with *Pomphorhyncus* (Prevalence (Pr.) =26.21%, Mean Intensity (M.I.) = 2.41 & Relative Density (R.D.) = 0.63) while as 22 carps out of 114 examined were found infected with *Pomphorhyncus* species (Pr. =19.30%, M.I. = 2.09 & R.D. = 0.40) (Table 2). *Neoechinorhyncus* was found in 20 *Schizothorax* fishes with prevalence of 19.42% (M.I = 1.95 and R.D = 0.38) while as among carps, 25 fishes were found infected with the parasite (Pr. =21.93%, M.I. = 2.32 & R.D. = 0.51) (Table 2).

Table 2: Parasite-wise prevalence of Dal Lake.

Water body	***Pomphorhyncus***		***Neoechinorhyncus***		***Adenoscolex***	
Fish species	***Schizothorax***	**Carp**	***Schizothorax***	**Carp**	***Schizothorax***	**Carp**
No of fishes collected	103	114	103	114	103	114
Fishes infected	27	22	20	25	16	16
Chi square	$\chi2$ =1.48; p>0.05		$\chi2$ =0.21; p>0.05		$\chi2$ =0.0097; p>0.05	
Pr. %	26.21	19.30	19.42	21.93	15.53	14.04
M.I.	2.41	2.09	1.95	2.32	1.75	2.06
R.D.	0.63	0.40	0.38	0.51	0.27	0.29

Pr = Prevalence, M.I = Mean Intensity and R.D. = Relative Density

Adenoscolex was found to infect 16 *Schizothorax* (Pr. = 15.53%, M.I. = 1.75 & R.D. = 0.27) and 16 carp fishes (Pr. = 14.04%, M.I. = 2.06 & R.D. = 0.29) in Dal Lake (Table 2). However, insignificant differences (p>0.05) were found between the infections among infected *Schizothorax* and carp fish species under each parasites category.

D. Parasite-wise prevalence of Anchar Lake

In Anchar Lake, 30 *Schizothorax* fishes out of 108 examined were found to be infected with *Pomphorhyncus* (Pr. =27.78%, M.I. = 3.03 & R.D. = 0.84) while as 23 carps out of 101 examined were found infected with *Pomphorhyncus* species (Pr. = 22.77%, M.I. = 2.96 & R.D. = 0.67) (Table 3).

Table 3: Parasite-wise prevalence of Anchar Lake.

Water body	***Pomphorhyncus***		***Neoechinorhyncus***		***Adenoscolex***	
Fish species	***Schizothorax***	**Carp**	***Schizothorax***	**Carp**	***Schizothorax***	**Carp**
No of fishes collected	108	101	108	101	108	101
Fishes infected	30	23	26	16	20	20
Chi square	$\chi2$ =0.69; p>0.05		$\chi2$ =2.20; p>0.05		$\chi2$ =0.056; p>0.05	
Pr. %	27.78	22.77	24.07	15.84	18.52	19.80
M.I.	3.03	2.96	2.62	2.63	2.55	2.75
R.D.	0.84	0.67	0.63	0.42	0.47	0.54

Pr.= Prevalence, M.I.= Mean Intensity and R.D. = Relative Density

Neoechinorhyncus was found in 26 *Schizothorax* fishes with prevalence of 24.07% (M.I=2.62 and R.D = 0.63) while as among carps, 16 fishes were found infected with the parasite (Pr. =15.84%, M.I. = 2.63 & R.D. = 0.42) (Table 3). *Adenoscolex* was found to infect 20 *Schizothorax* (Pr. = 18.52%, M.I. = 2.55 & R.D. = 0.47) and 16 carp fishes (Pr. = 19.80%, M.I. = 2.75 & R.D. = 0.54) in Anchar Lake (Table 3). Again, as in case of Dal Lake, there were insignificant differences (p>0.05) between the infections among infected *Schizothorax* and carp fish species under each parasite category.

E. Biochemical parameters of fishes

Various blood biochemical parameters like total protein, albumin, globulin, glucose, bilirubin, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase and lactate dehydrogenase were analyzed from all the collected fishes. The blood biochemical indices were found altered in parasitized fishes as compared to those of non-parasitized fishes from both the water bodies.

(a) Effect of parasites on serum protein, albumin and globulin levels: The total protein content was found significantly decreased ($p \leq 0.01$) in parasitized *Schizothorax* (2.24±0.08 g/dL) and carps (2.82±0.15g/dL) in Dal Lake as compared to the non-parasitized ones (Table 4). In Anchar Lake, the same pattern of significantly decreased ($p \leq 0.01$) protein levels was noticed in parasitized *Schizothorax* (1.91±0.11g/dL) and carp (2.54±0.1g/dL) fish species when compared to uninfected ones (Table 5). Serum albumin of *Schizothorax* and carp species of both lakes was also found significantly decreased ($p \leq 0.01$) from the normal depicting the biochemical effects of helminths in fishes (Table 4, 5). The globulin, in contrast to total protein and serum albumin, was found significantly increased ($p \leq 0.01$) in parasitized fishes. The increase in globulin content of parasitized fishes was found in both lakes with mean values of 1.80±0.15g/dL & 1.60±0.10g/dL in *Schizothorax* and 1.78±0.08g/dL & 1.61±0.08g/dL in carps of Dal and Anchar lakes respectively (Table 4 & 5).

(b) Effect of parasites on serum bilirubin and serum glucose of fishes: The serum bilirubin of both infected *Schizothorax* as well as infected carp fishes was significantly decreased (Table 4) in Dal Lake and the levels were 2.58±0.15 mg/mL in infected *Schizothorax* and 2.87±0.12 mg/mL in infected carp fishes (Table 4) while as in Anchar Lake, it was 2.28±0.17 mg/mL in infected *Schizothorax* and 2.35±0.26 mg/mL in infected carp fishes depicting a significant decrease ($p \leq 0.01$) (Table 5). In Dal Lake, the serum glucose levels were significantly higher ($p \leq 0.05$) in infected *Schizothorax* fishes as well as in infected carp fishes ($p \leq 0.01$) when compared with uninfected ones. The mean values being 132.45±8.22 mg/dL in infected *Schizothorax* fishes and 131.67±6.89 mg/dL in infected carp species (Table 4). On the other hand, in Anchar Lake, the mean values of glucose was 153.46±12.46 in *Schizothorax* and 150.39±7.64 mg/dL in carps, depicting a significant increase ($p \leq 0.01$) in parasitized fishes as compared to non-parasitized ones (Table 5).

(c) Effect of helminth parasites on enzymes (ALT, AST. ALP & LDH): Significantly increasing ($p \leq 0.01$ to $p \leq 0.05$) trends of the enzyme concentrations was observed in fishes of both the lakes infested with parasites. The mean values of ALT, AST, ALP and LDH were found 817.53±47.10 IU/L, 1011.76±52.73 IU/L, 178.36±17.30 IU/L and 696.48±71.74 IU/L in infected *Schizothorax* and 791.21±50.19 IU/L, 986.95±57.85 IU/L, 166.00±32.8 IU/L and 674.12±43.21 IU/L in infected carp fishes of Dal Lake (Table 4). In Anchar, similar trend in the concentrations of ALT, AST, ALP and LDH was observed with mean values of 893.11±63.18 IU/L, 1076.46±9.96 IU/L, 211.55±25.11 IU/L and 819.28±29.99 IU/L in infected *Schizothorax* and 877.24±58.81IU/L, 1061.08±53.63 IU/L, 200.89±17.46 IU/L and 764.48±55.10 IU/L in infected carp fishes respectively (Table 5).

Table 4: Biochemical indices of uninfected and infected fishes of Dal Lake.

S.No.	Parameter	Schizothorax		Carp	
		Uninfected	Infected	Uninfected	Infected
1.	Total Protein(g/dL)	2.83±0.10	2.24±0.08**	3.36±0.22	2.82±0.15**
2.	Albumin (g/dL)	1.98±0.10	0.44±0.11**	2.86±0.16	1.03±0.07**
3.	Globulin(g/dL)	0.85±0.08	1.80±0.15**	0.50±0.11	1.78±0.08**
4.	Bilirubin (mg/mL)	3.02±0.13	2.58±0.16**	3.05±0.12	2.87±0.12*
5.	Glucose(mg/dL)	121.12±4.10	132.45±8.22*	116.05±4.94	131.67±6.89**
6.	ALT(IU/L)	698.46±58.68	817.53±47.10**	689.11±48.02	791.21±50.19**
7.	AST (IU/L)	909.17±48.66	1011.76±52.73**	889.57±53.04	986.95±57.85*
8.	ALP(IU/L)	121.18±16.09	178.36±17.30**	111.61±12.27	166.00±32.80*
9.	LDH (IU/L)	595.67±35.80	696.48±71.74*	582.90±34.82	674.12±43.21**

**p<0.01: Significant difference between uninfected and infected groups.
*p< 0.05: Significant difference between uninfected and infected groups.

Table 5: Biochemical indices of uninfected and infected fishes of Anchar Lake.

S.No.	Parameter	Schizothorax		Carp	
		Uninfected	Infected	Uninfected	Infected
1.	Total Protein(g/dL)	2.67±0.15	1.91±0.11**	3.20±0.27	2.54±0.10**
2.	Albumin (g/dL)	1.88±0.09	0.31±0.04**	2.82±0.15	0.93±0.06**
3.	Globulin(g/dL)	0.79±0.18	1.60±0.10**	0.38±0.14	1.61±0.08**
4.	Bilirubin (mg/mL)	2.85±0.19	2.28±0.17**	3.16±0.11	2.35±0.26**
5.	Glucose(mg/dL)	121.34±6.80	153.46±12.46**	120.43±4.01	150.39±7.64**
6.	ALT(IU/L)	723.35±52.26	893.11±63.18**	696.06±51.46	877.24±58.81**
7.	AST (IU/L)	920.23±48.36	1076.46±9.96**	899.57±60.45	1061.08±53.63**
8.	ALP(IU/L)	116.40±10.43	211.55±25.11**	128.40±10.28	200.89±17.46**
9.	LDH (IU/L)	585.74±47.08	819.28±29.99**	579.43±46.15	764.48±55.10**

**p<0.01: Significant difference between uninfected and infected groups.

F. Comparison of biochemical indices of Schizothorax and carp fishes between Dal and Anchar Lakes

A comparison, as regards the blood biochemical indices, was made between the collected uninfected as well as infected *Schizothorax* and carp fishes of the two lakes. No statistically significant difference was found when each of the uninfected fish species was compared between the two lakes (Table 6 & 7). This indicates that the health status of uninfected fishes in both the water bodies is similar and hence no alterations in any blood biochemical parameter were observed. Interestingly, when infected fishes of the two lakes were compared, statistically significant differences ($p \leq 0.01$ to $p \leq 0.05$) was seen in all the parameters. This indicates higher stress conditions in Anchar Lake due to its higher trophic status (Table 6, 7).

Table 6: Comparison between biochemical parameters of *Schizothorax* fishes collected from Dal and Anchar lakes.

S.No.	Parameter	Schizothorax		Carp	
		Uninfected	Infected	Uninfected	Infected
1.	Total Protein(g/dL)	2.83±0.10	2.67±0.15NS	2.24±0.08	1.91±0.11*
2.	Albumin (g/dL)	1.98±0.10	1.88±0.09NS	0.44±0.11	0.31±0.04* 3
3.	Globulin(g/dL)	0.85±0.08	0.79±0.18NS	1.80±0.15	1.60±0.10*
4.	Bilirubin (mg/mL)	3.02±0.13	2.85±0.19NS	2.58±0.16	2.28±0.17*
5.	Glucose(mg/dL)	121.12±4.10	121.34±6.80NS	132.45±8.22	153.46±12.46**
6.	ALT(IU/L)	698.46±58.68	723.35±52.26NS	817.53±47.10	893.11±63.18*
7.	AST (IU/L)	909.17±48.66	920.23±48.36NS	1011.76±52.73	1076.46±9.96*
8.	ALP(IU/L)	121.18±16.09	116.40±10.43NS	178.36±17.30	211.55±25.11*
9.	LDH (IU/L)	595.67±35.80	585.74±47.08NS	696.48±71.74	819.28±29.99*

NS : Insignificant differences between uninfected groups between the lakes.
**p<0.01: Significant difference between infected groups between the lakes.
*p< 0.05: Significant difference between infected groups between the lakes.

Table 7: Comparison between biochemical parameters of carp fishes collected from Dal and Anchar lakes.

S.No.	Parameter	Schizothorax		Carp	
		Uninfected Dal	Infected Anchar	Uninfected Dal	Infected Anchar
1.	Total Protein(g/dL)	3.36±0.22	3.20±0.27NS	2.82±0.15	2.54±0.10**
2.	Albumin (g/dL)	2.86±0.16	2.82±0.15NS	1.03±0.07	0.93±0.06*
3.	Globulin(g/dL)	0.50±0.11	0.38±0.14NS	1.78±0.08	1.61±0.08*
4.	Bilirubin (mg/mL)	3.05±0.12	3.16±0.11NS	2.87±0.12	2.35±0.26*
5.	Glucose(mg/dL)	116.05±4.94	120.43±4.01NS	131.67±6.89	150.39±7.64*
6.	ALT (IU/L)	689.11±48.02	696.06±51.46NS	791.21±50.19	877.24±58.81*
7.	AST (IU/L)	889.57±53.04	899.57±60.45NS	986.95±57.85	1061.08±53.63*
8.	ALP(IU/L)	111.61±12.27	128.40±10.28NS	166.00±32.80	200.89±17.46*
9.	LDH (IU/L)	582.90±34.82	579.43±46.15NS	674.12±43.21	764.48±55.10

NS : Insignificant differences between uninfected groups between the lakes.
**p<0.01: Significant difference between infected groups between the lakes.
*p< 0.05: Significant difference between infected groups between the lakes.

DISCUSSION

In present study, the prevalence of helminths was found high in Anchar Lake (53.70%) as compared to Dal Lake (48.54%). It is due to the fact that Anchar Lake is more polluted as compared to Dal and has been categorised as hypertrophic lake (Zargar *et al*., 2011) while as Dal Lake is less eutrophic as compared to Anchar. High trophic status of the lake may enhance the incidence of helminth parasites in fishes as fishes are rendered immunologically weak (Zargar *et al.,* 2012) due to prevailing stress conditions and parasites get an easy chance to attack and get attached to fish body. Our findings are in agreement with (Bhat *et al*., 2001; Pandit and Yousuf, 2002; Zargar *et al*., 2011 & 2012) who reported high trophic status of Anchar Lake due to deteriorated water quality. In the present study, the total protein was found to be decreased indicating hypo-proteinaemia, in both *Schizothorax* and carp fishes infected with parasites when compared to those of uninfected ones. The decrease in total protein content in fishes collected from Anchar Lake was more so, as compared to fishes collected from Dal Lake. Moreover, the *Schizothorax* fishes were found to have more decreased serum protein values (2.24±0.08) as compared to carp fishes (2.82±0.15) infected with parasites. The decrease in total protein content in *Schizothorax* fishes is attributed to their sensitive nature as compared to carps which depict alterations in any biochemical parameter due to stress, parasitic infestation or disease. The findings are in accordance with (Jaswal *et al*., 2015) who reported decrease in total protein content in *Schizothorax* fishes affected with parasites from River Sindh and Shallabugh Wetland. The serum albumin levels in this study were found significantly (p≤0.05) decreased in parasitized carps and *Schizothorax* fishes in both the water bodies as compared to non-infected fishes. The decrease in serum albumin is concomitant to the decrease in total protein content of fishes and is reported by several workers in case in parasitized carp fishes.

In the current study the globulin content of carps and *Schizothorax* fishes was found increased significantly (p≤0.05) when compared to non-parasitized fishes. This increase can be attributed to the fact that due to immunological reaction to parasitic infestation, fishes exhibit greater levels of immunity as defensive strategy and release more globulins in the blood. *Schizothorax* fishes being more sensitive respond peculiarly and exhibit greater immunological response as compared to carps.

Decrease in bilirubin concentrations was observed in the present study depicting liver damage in fishes as a

result of parasitic infestations. The results are in agreement with results reported by (Ali and Ansari 2012) who also reported hypobilirubinemia in *Cyprinus carpio* infected with monogenean parasites. The serum glucose was found significantly ($p \leq 0.05$) elevated in fishes infested with parasites as compared to non-parasitized fishes in both the water bodies. The increase in blood sugar level fishes may be due to increase in the breakdown of liver glycogen or due to decreased synthesis of glycogen from glucose. The enzyme levels were found significantly elevated in both carps and *Schizothorax* fishes infected with parasites as compared to those uninfected ones. This increased level of serum transaminases is related to disruption of normal metabolism which is due to extensive alterations in the liver histology and indicates liver damage. Similar results were obtained by (Ali and Ansari, 2012) while studying the alterations in hematological and biochemical indices in healthy and monogenean infected Common Carp, *Cyprinus* carpio. (Kopp *et al.*, 2014) studied the biochemical parameters of common carp and found that the total protein and albumin decreases in infected fishes, whereas globulin, ALT and AST increases in fishes infected with cyanobacteria. Osman *et al*., (2009) found by clinical examination of naturally infected catfish (*Clarias gariepinus*) which showed a marked decrease in total protein, albumin and quite significant increase in globulin, ALT and AST. (Ali and Ansari, 2012) showed the increase of serum AST and ALT activities in infected fish. The alkaline phosphatase levels in the present study showed as increase which is in accordance with (Elnemaki, 2003. ;El-seify *et al*., 1998) also reported increase in the enzyme level due to injury to liver and bile ducts in fishes due to high incidence of parasites. In the present study the LDH levels were found increased in both the fish species infected with helminth parasites in Dal and Anchar lakes. The increase in LDH levels were found significantly ($p \leq 0.05$) higher as compared to fishes not infected with parasites. The main reason for LDH increase is attributed to the hepatic damage caused due to parasitic infestation which results in damage of hepatocytes. Similar results were obtained by (El-seify *et al*., 1998 and Elnemaki, 2003) who investigated the effect of naturally infected *Tilapia* with different parasites species. A significant difference between biochemical indices of infected fishes was observed in the present study. Increased alterations in the biochemical indices in fishes of Anchar Lake may be attributed to the increased levels of pollution in the lake due to heavy inflow of nutrients and sewage coming out either from SKIMS or households. In comparison to Dal Lake, the deterioration in the water quality of Anchar Lake is more vivid as has been reported by several authors (Bhat *et al*., 2001; Pandit and Yousuf, 2002; Zargar *et al*., 2011 & 2012) which is primarily responsible for inducing stress in fish species. These stress conditions make fishes more susceptible to parasitic infections. Moreover, *Schizothorax* fishes being more sensitive than carps are more prone to parasitic infections hence depict more alterations in blood biochemical indices than carps.

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