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Effect of Water Quality Parameters on Isopod Parasite *Alitropus typus* (Aegidae) of Ectotherms in Chashma Lake, Pakistan

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ABSTRACT

Freshwater lakes are sensitive ecosystem and respond to the episodic changes from its surrounding environment. The physico-chemical factors of water and biological processes determine the quality of water which in turn indicates the diversity of fauna and flora that the water would support. However, the ecological factors of lake correlating with parasitic isopods under natural conditions are poorly understood. The aim of this study were: i) assessment of monthly variations in water quality parameters of lake, ii) identification and determination of parasitic Isopod burden (Aegidae: *Alitropus typhus*) on freshwater fishes, iii) impact of water quality parameters in relation to parasitic isopod infestation in freshwater fishes of Chashma Lake, northwest of Pakistan. The results indicated identification of *Alitropus typus*, which was observed on majority of fresh water fishes namely: *Labeo calbasu, Labeo rohita, Cyprinus carpio, Labeo gonius, Crossocheilus lalius, Cirrhinus mrigala, Notopterus notopterus, Wallago attu, Ompok pabda, Sperata sarwari, Chana marulius, Chanda baculis, Xenentodon cancilla, Gudusia chapra* and *Puntius sophore*. The correlation matrix showed perfect significant ($p<0.05$) association between water temperature, hardness, free CO_2 and conductivity. The linear regression model was applied between water quality parameters and isopod infestation, negative trend was observed for turbidity, DO, free CO_2, alkalinity and hardness, while positive trend for water temperature, pH, water clarity and ammonia. On the basis of biological productivity, the lake has been categorized as mesotrophic to hypereutrophic in different seasons. The findings suggested that deterioration of water quality with changing seasons resulted to high stress response in fishes making them vulnerable to parasitic infections. Due to the presence of *Alitropus typus* on majority of freshwater fishes, we are also able to make the judgment that these Isopods have less host specificity. However, further studies on fish parasitological research, disease control and maintenance of health relationship between fishes and water quality parameters should be needed to implement in tropical lakes.

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Authors' Contribution
IA and MQ conceived and designed the study. IA, KA, MR and SH performed the experiments. KA, IA and SSRR analyzed the data. IA, KA and MQ wrote the article.

Key words
Isopods, physicochemical parameters, *Alitropus typus*, ectotherms, oxygen depletion, Chashma Lake,

INTRODUCTION

The most important requirement in aquaculture is production of healthy fish stock. The incidence and rate of infestation of parasites are associated with physico chemical parameters of water and fish health (Hossain *et al.*, 2007). Parasitic infections in fishes enormously disrupt aquaculture production and its economic viability (Rameshkumar and Ravichandran, 2010).

For the sustainable development of aquaculture system, studies on parasitic isopod; Aegidae and its interaction with their fish host in freshwater lakes is of extreme importance. Isopods are allied with various worldwide fishes and cause major economic losses to fisheries (Bunkley-Williams, 2006). The *Alitropus typus* (isopod) found in warm water bodies of south east Asia are attached on the body surface, buccal cavity and gill chamber of fishes (Ravichandran *et al.*, 2009; Rameshkumar and Ravichandran, 2010), which impart atrophy of the gills (Borgea, 1933; Bowman, 1960), mouth deformation, behavioral, feeding and growth changes (Turner and Roe, 1967; Kroger and Guthrie, 1972), and deterioration of general health condition in fishes (Krykhtin, 1951; Petrushevski and Shulman, 1961).

The fish parasite community displays significant variations with sanitary conditions of water in which they live. Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties (Ali *et al.*, 2004). Various physicochemical factors such as water temperature,

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alkalinity, ammonia, free carbon dioxide, dissolved oxygen (DO), pH and total hardness have strong influence on fish health and their resistance against the pathogens (Welch, 1941; Snieszko, 1974; Plumb *et al.*, 1988; Shresta, 1994; Hossain, 1990). The physiological and biological features of the host affect the composition of parasites (Dogiel, 1961). Poor condition of water quality is due to O_2 depletion, excess level of ammonia, free CO_2 and temperature variations. Knowledge of fishes parasitized by isopods in relation to water quality parameters is meagre and vital for effective aquaculture development in Pakistan, as no elaborate studies have been done before; a study on water quality parameters and their effects on isopods parasitizing freshwater fishes of Chashma lake was undertaken.

MATERIALS AND METHODS

Study site

Studies were made on two basins, Dera and Main, located in the Chashma reservoir (32º 25' N, 71º 22' E), the third largest water reservoir of Pakistan after Tarbela and Mangla, situated at River Indus between Mianwali and Dera Ismail Khan. These two basins are found connected to the Indus River with a series of embankments or flood bunds. The Chashma reservoir has a total area of 34,099 ha. The reservoir is divided into five shallow lakes, each of them up to 250 ha in area with 0.2-5.0 m depth, varies in dry and flood season. The depth of the main river channel varies from 4.6 to 8.8 m with pH 6.5-7.2. The economic values of reservoir are in: flood control, storage of water for irrigation, generation of electricity and fisheries production.

Sampling and analytical procedures

Three different locations were selected in each basin for sampling of fish and water. Samplings were carried out every month from October 2010 to August 2011.

For water quality analysis random samples of water were collected on fortnightly basis in first week of every month. Water samples were collected with the help of water Kemmerer sampler from 9-20 feet depth, taken by Eco Sounder (Model, JFE-680) fitted on motor boat. Water and air temperatures of respective sites were measured by thermometer. Dissolved Oxygen (mg/L), Salinity (ppt), Conductivity (uS/cm) and Total dissolved solids TDS (mg/L) were taken with help of portable DO meter (Lutron, DO-5510) and pH of water samples were measured by pH meter (YSI-E-300). Alkalinity (mg/L), hardness (mg/L), CO_2 (mg/L), chlorides (mg/L), ammonia (mg/L) and nitrite (mg/L) were measured with the help of HATCH kit. Total phosphate (mg/L) and phosphorus (mg/L) were measured by using standard kit (Hanna, Taiwan). Water clarity was determined with the help of Secchi disk and turbidity with turbidity meter (Orion, AQ-4500). The quality of the analytical data was ensured through careful standardization, procedural blank measurements and triplicate samples.

Parasitic isopods on freshwater fishes

Fish hosts including carps, cat fishes, snake headfish and trash fishes were collected from Chashma Lake by using gill net (1.5" x 1.5" mesh) and brought to laboratory for examination of Isopod parasites. The fish species infected with Isopods were identified by using keys and morphological description given by Mirza and Sandhu (2007).

The isopods attached on the body surface of fishes were counted and preserved in 70% ethanol (Bunkley-Williams *et al*., 2006). The identification of parasitic isopods was done by descriptions given by Milne Edwards (1840).

Statistical analyses

Data recorded from all fishes were analyzed for Infestation rate and mean intensity of parasitic Isopod. Pearson correlation matrix was calculated to show relationship between physico-chemical parameters with parasite infestation on the fish host. The level of significance was determined at alpha = 0.05. The time plots were constructed to observe the monthly variation in the various measures of water quality parameters.

In order to make predictions of relation between the water quality parameters and fish isopods, linear regression analysis was performed. The trend line were constructed from the one year data, based on linear regression in the form Y= a+bX, where Y is a response variable and X is explanatory variable. The "a" and "b" are regression coefficients, which are determined by using sample data, where "a" is intercept correspond to value of Y when X=0, "b" is slope that indicates change in Y with a unit change in X. The sign of "b" indicates the direction of relationship between the X and Y variables. If b is positive its mean direction of relationship is also positive, if b is negative its mean direction of relationship is negative. The analysis was carried out by using Minitab V.16.

RESULTS

Water quality parameters

The basic statistics of lake water quality are based on 84 total water samples (2 sampling sites x 3 replications) summarized in Table I, which gives the range, mean and the standard deviation of the results for each of the 20 parameters. The dissolved oxygen concentration in most of the sampling period was ranged between 5.1-10.8 mg/L at water temperature range between 10.8-32.4°C.

Table I.- Physico-chemical condition of water of Chashma Lake, Pakistan.

Parameters	Mean ± SD	Range
Elevation (m)	190.36 ± 3.25	181.05-195.07
Depth (m)	4.35 ± 0.82	2.77-6.12
Air temperature (°C)	25.49 ± 9.36	8.70-46.20
Air oxygen (%)	19.32 ± 2.17	14.50-20.90
Water Temperature(°C)	22.66 ± 7.36	10.80-32.40
Dis. oxygen (mg/L)	7.84 ± 1.62	5.10-10.80
pH	8.09 ± 0.54	7.23-9.14
Salinity (ppt)	0.13 ± 0.05	0.10-0.20
Conductivity (uS/cm)	248.17 ± 58.44	160.60-393.80
TDS (mg/L)	0.17 ± 0.05	0.07-0.25
Turbidity (NTU)	7.34 ± 7.09	0.87-34.80
Secchi depth (cm)	157.60 ± 84.16	35.00-332.50
Alkalinity (mg/L)	113.59 ± 19.19	85.50-153.90
Hardness (mg/L)	118.89 ± 25.32	68.40-153.90
CO_2 (mg/L)	10.36 ± 3.89	5.00-15.00
Chlorides (mg/L)	79.76 ± 15.69	60.00-120.00
Ammonia (mg/L)	0.01 ± 0.19	0.00-0.96
Nitrite (mg/L)	0.03 ± 0.05	0.00-0.26
Total phosphate (mg/L)	0.22 ± 0.24	0.00-0.80
Phosphorus (mg/L)	0.07 ± 0.08	0.00-0.26

The time plot of measures of water quality parameters varies in different months is given in Figure 1. The turbidity of water was increased in the months of April-May and significant rise in water temperature was during the months of June-August. The decrease in water clarity was observed during the month of July due to floods and concentration of dissolved oxygen was also decreased in the months of July-August.

Alitropus typus infestation on freshwater fishes

The results of the present study revealed that *Alitropus typus* parasitic isopod infects majority of freshwater fish species (Fig. 2) of Chashma reservoirs, showing less host specificity. The infestation rate and intensity of *Alitropus typus* (isopod) observed on carps, catfishes, snakehead fish and trash fishes are listed in Table II. The highest intensity was recorded on *Xenentodon cancilla, Cirrhinus mrigala* and *Crossocheilus lalius,* respectively and lowest on *Chanda baculis* and *Gudusia chapra.*

Effect of water quality in relation to isopod parasite

In the correlation matrix (Table III) there are some perfect significant ($p<0.05$) correlations among the water quality parameters. For example, there is significant ($P<0.05$) correlation between temperatures (air and water) and *Alitropus typus* (isopod) infestation. Furthermore, infestation rate had also perfect significant ($p<0.05$) correlation with conductivity, hardness and free CO_2.

Table II.- Infestation rate of *Alitropus typus* (lsopoda; Aegidae) in freshwater fishes of Chashma Lake, Pakistan.

Freshwater fishes	Host exa-mined	Infestation rate	Intensity	Range
Carps				
Labeo calbasu	4	20	5.0	1-2
Labeo rohita	2	9	4.5	3-6
Cyprinus carpio	7	32	4.5	3-11
Labeo gonius	4	20	5.0	2-7
Crossocheilus lalius	9	139	15.4	3-45
Cirrihinus mrigala	1	25	25.0	0-25
Notopterus notopterus	3	9	5.0	1-2
Catfish				
Wallago attu	6	41	6.8	5-16
Ompok pabda	3	20	6.6	5-9
Sperata sarwai	1	5	5.0	0-5
Snake headfish				
Chana marulies	3	11	3.67	2-6
Trash fish				
Chanada baculis	2	3	1.5	1-2
Xenentodon cancilla	3	105	35.0	15-70
Gudusia chapra	2	3	1.5	1-2
Puntius sophore	5	23	4.60	3-6

*__Infestation rate__ refers to the state of being invaded by number of Isopods on fishes.

The water temperature, which is the co-determinant of most of the water quality parameters, shows statistically significant correlation ($P<0.05$) with dissolved oxygen, hardness and free carbon dioxide.

Regression analysis was also carried out to measure the relationship among various water quality parameters with *Alitropus typus* (isopod) infestation on freshwater fishes. The findings are narrated below.

Turbidity (NTU)

The negative relation was observed between turbidity and *Alitropus typus* (isopod) infestation (Fig. 3a), which indicates that infestation rate decreases with a unit increase in turbidity. The estimated change is -0.8302, mean value of isopod infestation rate with a unit increase in turbidity of water.

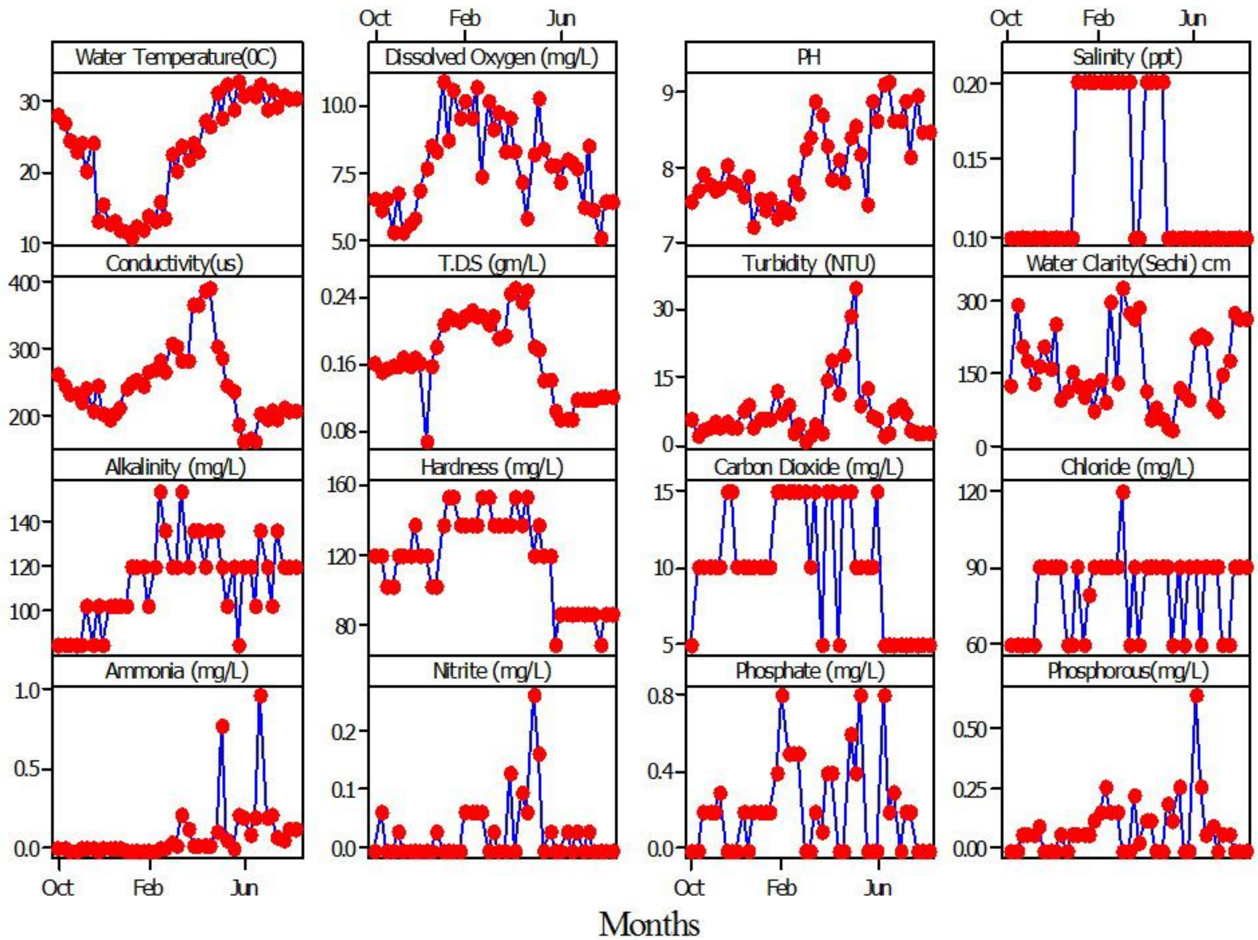


Fig. 1. Time plot of monthly observed data of physico-chemical parameters of Chashma lake, Pakistan.

Water temperature (°C)

The positive relation was observed between the water temperatures and *Alitropus typus* infestation of isopod (Fig. 3b), indicating isopod infestation increases with a unit increase in water temperature. The estimated change is 0.8571, in the mean value of isopod infestation rate with a unit increase in water temperature.

Dissolved oxygen, DO (mg/L)

The *Alitropus typus* infestation has negative relationship with dissolved oxygen, indicating a decrease in infestation rate with a unit increase in dissolved oxygen (Fig. 3c). The estimated change in the mean value of isopod infestation is -3.259 with a unit increase in dissolved oxygen of water.

pH (Hydrogen ion concentration)

The positive trend line has been observed between *Alitropus typus* infestation and pH of lake water (Fig. 3d). This positive relationship indicates infestation rate increases with a unit increase in pH and 2.031 is the estimated change in the mean value of isopod infestation with a unit increase in pH of water.

Water clarity (cm)

The positive relationship between water clarity and *Alitropus typus* infestation was observed, which indicates more clarity in water the infestation rate increases (Fig. 3e). The estimated change in the mean value of isopod infection rate is 0.02745 with a unit increase in water clarity.

Alkalinity (mg/L)

The negative relationship of alkalinity indicates isopod infestation decreases with increase in alkalinity of water and -0.0182 is the estimated change in the mean value of isopod infestation with a unit increase in alkalinity of water (Fig. 3f).

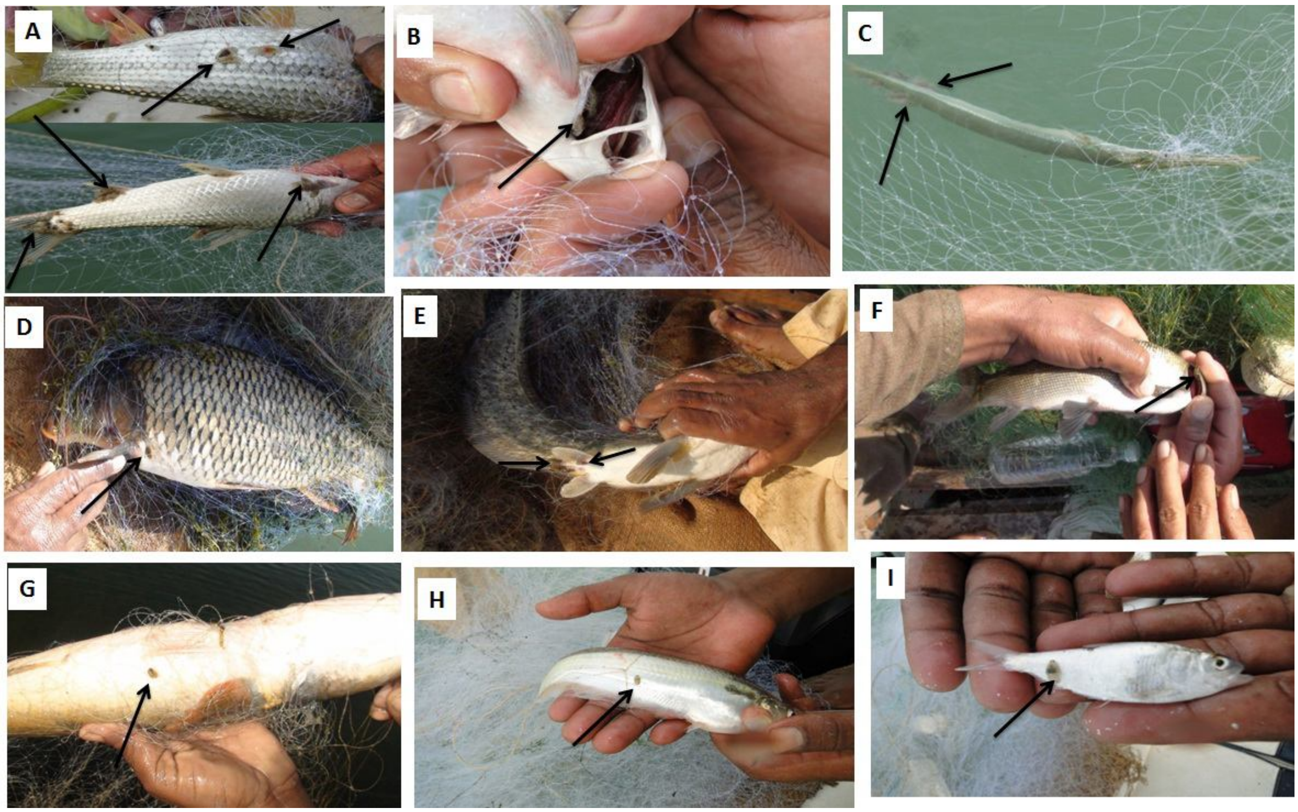


Fig. 2. *Alitropus typus* (lsopoda: Aegidae) attach on the body surface of freshwater fishes of Chashma Lake, A, *Cirrhinus mrigala;* B, *Labeo rohita;* C, *Xenentodon cacancilla;* D, *Cyprinus carpio;* E, *Wallago attu;* F, *Labeo gonius;* G, *Channa marulius;* H, *Onpok pabda;* I, *Gudusia chapra*.

Ammonia (mg/L)

The positive relation was observed between ammonia and isopod infestation (Fig. 3g), indicating increase in ammonia level causes more infestation of isopod. The estimated change in the mean value of isopod infection rate is 19.30 with a unit increase in ammonia.

Free CO_2 (mg/L)

The isopod infestation has negative relationship with free carbon dioxide (Fig. 3h), which indicates decrease in infestation rate with increase in free carbon dioxide. The -0.3952 is the estimated change in the mean value of isopod infestation with a unit increase in free CO_2 level in lake water.

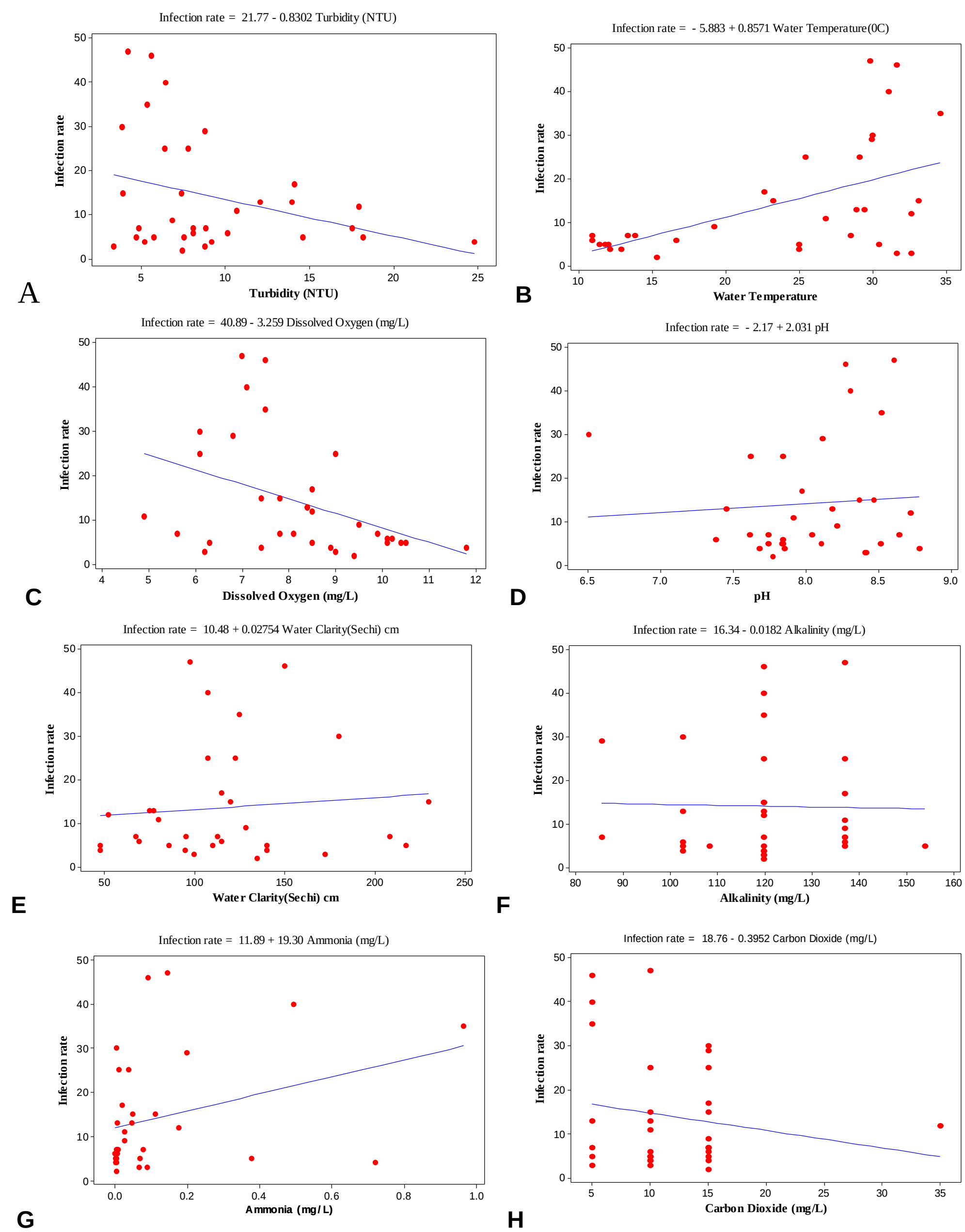
Hardness (mg/L)

The negative relationship between isopod infestation and hardness was observed (Fig. 3i) indicating decrease in isopod infestation with hardness of water. The estimated change in the mean value of isopod infestation is -0.3563 with a unit increase in hardness of water

DISCUSSION

Chashma Barrage was constructed on the River Indus near the village of Chashma, about 35 miles downstream of Jinnah Barrage. It was constructed to divert the water released from Tarbela into River Jhelum through the Chashma-Jhelum Link Canal. The barrage was also designed to feed the Paharpur canal that is located on the right side.

In Pakistan, relatively very little is known about the harmful effects of parasitic isopods on fresh water fisheries. The *A. typus* has been recorded during the present study from the gill chambers, buccal cavity and body surface of many freshwater fishes. In the current investigation, it was recorded that *A. typus* does not have host specificity and it attack wide variety of fish species. The low specificity of this parasite makes it highly harmful for fish infections. Previously, parasitic isopods were supposed as being absolutely host specific so that hosts were expected to harbour a distinctive species of parasite (Baer, 1952). However, further studies made on host specificity discovered that the host-parasite



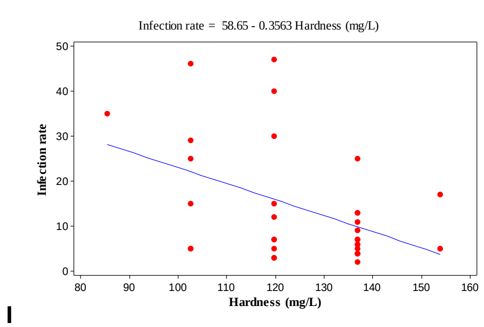


Fig. 3. Regression plots showing correlations of *Alitropus typus* (Isopoda: Aegidae) infection in freshwater fishes of Chashma Lake with a) Turbidity (NTU); b, water temperature (°C); c, dis. oxygen (mg/L); **d,** pH; **e,** water clarity (cm); **f,** alkalinity (mg/L); **g,** ammonia (mg/L); **h,** CO_2 (mg/L); **i,** hardness (mg/L).

Table III.- Correlation matrix between Isopod infestation and different water quality parameters in Chashma Lake, Pakistan.

	Inf Rate	Elv (Ft)	Depth (m)	Air Temp (°C)	Air O_2 (%)	W Temp (°C)	Dis O_2 (mg/L)	pH	Salinity (ppt)	Cond (US)	T.D.S gm/L)	Turb (NTU)	W Clar (Se)	Alk (mg/L)	Hard (mg/L)	CO2 mg/L)	Chlor (mg/L)	Amm (mg/L)	Nitrite (mg/L)	PO_4^{-3} (mgL)	P (mg/L)
Inf Rate	1.00																				
Elv (Ft)	0.12	1.00																			
Depth (m)	0.08	0.65**	1.00																		
Air Temp (°C)	0.36*	0.33*	0.19	1.00																	
Air O_2 (%)	0.04	0.08	0.26	-0.08	1.00																
W Temp (°C)	0.53**	0.28	0.08	0.87**	-0.022	1.00															
Dis O_2 (mg/L)	-0.19	-0.17	0.05	-0.272	0.241	-0.484**	1.00														
pH	0.19	0.58**	0.74**	0.353*	0.416*	0.238	0.140	1.00													
Salinity (ppt)	-0.14	0.44**	0.76**	-0.058	0.395*	-0.250	0.346*	0.807	1.00												
Cond (us)	-0.4*	-0.38*	-0.42**	-0.107	0.106	-0.167	0.158	-0.38*	-0.204	1.00											
T.D.S (gm/L)	-0.15	0.44**	0.76**	-0.057	0.386*	-0.215	0.348*	0.806**	1.00**	-0.190	1.00										
Turb (NTU)	-0.17	0.06	-0.02	0.148	-0.043	0.194	0.069	-1.24	-0.069	0.471**	-0.05	1.00									
W Clar (Se)	0.04	0.12	0.14	0.003	0.090	-0.152	0.145	0.438*	0.325	-0.321	0.32	-0.7**	1.0								
Alk (mg/L)	-0.15	-0.48**	-0.54**	-0.116	0.136	0.083	-0.044	-0.45**	-0.50**	0.504**	-0.49**	0.20	-0.21	1.0							
Hard (mg/L)	-0.54**	-0.47**	-0.33	-0.57**	0.000	-0.689**	0.505**	-0.36*	0.060	0.726**	0.072	0.24	-0.10	0.27	1.00						
CO2 (mg/L)	-0.56**	-0.15	-0.02	-0.35*	0.099	-0.489**	0.481**	-0.13	0.214	0.397*	0.219	0.257	-0.03	0.17	0.60**	1.00					
Chlor (mg/L)	-0.32	-0.11	0.20	0.055	0.133	-0.126	0.084	0.126	0.230	0.135	0.227	-0.076	0.13	-0.08	0.118	0.48**	1.00				
Amm (mg/L)	-0.08	0.45**	0.79**	0.053	0.389*	-0.109	0.322	0.864**	0.966**	-0.278	0.96**	0.005	0.27	-0.48**	0.057	0.11	0.186	1.0			
Nitrite (mg/L)	-0.13	0.46**	0.77**	-0.016	0.392*	-0.208	0.337*	0.825**	0.997**	-0.208	0.99**	-0.023	0.30	-0.49**	0.034	0.20	0.216	0.97**	1.00		
PO_4^{-3}(mgL)	-0.15	0.46**	0.75**	-0.03	0.358*	-0.239	0.428*	0.768**	0.959**	-0.216	0.95**	-0.006	0.25	-0.44**	0.065	0.25	0.203	0.93**	0.96**	1.00	
P (mg/L)	-0.15	0.48*	0.77**	-0.017	0.385*	-0.202	0.346*	0.825**	0.988**	-0.261	0.987**	-0.061	0.32	-0.48**	0.009	0.239	0.228	0.96**	0.98**	0.96**	1.00

* Correlation is Significant at the 0.05 level, ** Correlation is significant at the 0.01 level.

relationship was not as highly specialized as was previously expected. The relationship was found particularly ecological as these parasites attack on appropriate hosts that appeared within a given biotope. The results of current investigation are found in agreement with Nair *et al.* (1981). The experiments performed on host-specificity of *A. typus* revealed that it does not show any host preference, and that it would attach readily to any fish that is found within reach. Both, the speed and the level at which fish swim appear to influence the parasitic attack (Nair *et al.*, 1981).

The minimum and maximum values of all physico-chemical parameters of water samples collected from Chashma Lake are compared to the permissible limits required for life of organisms in freshwater lakes. Air and water temperatures showed a very characteristic annual cycle, with higher values during the summer and lower values in the winter season. The increasing temperature of water bodies in summer is normal feature. The present work also indicated isopod infestation rate increases with increasing water temperature.

The monitoring of oxygen concentration in aquatic system is very important (Galal-Gorchev *et al.*, 1993), as many biological, chemical and physical processes are involved in the increase or decrease of oxygen level of lake. These processes are so frequent and multifaceted that there is no model that could be used without a careful analysis of local characteristics (Kazi *et al.*, 2009). The higher DO concentration was determined in current study. Dissolved oxygen measurements determine the amount of oxygen available in the water for fish and act as important aquatic environmental factor, which influences the health of an aquatic ecosystem. The higher values of DO observed in the current study may be due to the influence of run-off water from monsoon rain. Atmospheric aeration and photosynthetic production of O_2 by the phytoplankton may be low during monsoon and higher during post-monsoon season. DO levels between 5.3 and 8.0 mg/L are satisfactory for survival and growth of aquatic organisms (Chennakrishnan *et al.*, 2008). Low oxygen levels may restrict where fish can go within a lake and limit the types and numbers of fish in the lake's bottom waters (Illinois Environmental Protection Agency, 1998).

The results also indicated that decrease in DO lead to increase in isopod infestation rate. The plausible explanation may be prolonged exposure to low concentrations of DO can be harmful to fish life because they will die at a level of 1 mg/L. Growth and feeding decreases at 1-5 mg/L of DO and growth and production is optimum at more than 5 mg/L (Jhingran, 1988). Under such conditions fishes may prone to parasites.

In present work, the infestation rate decreases with increase in turbidity, and water clarity measured with Secchi disk showed positive relation to isopod infestation. High turbidity of the lake water during flooded period can also cause unfavorable conditions for the growth of phytoplankton, decrease in amount of submerged macrophytes and density of attached algae and lower radiation levels (Dokulil, 1993; Ikusima *et al.*, 1982). The results also indicated significant relationship between total dissolved solid and ammonia during wet season, which is due to flow of flooded water of Indus River contribute to high suspended solid (TSS and turbidity) and ammonia-N to the Chashma Lake depend on the level of the flood in the lake.

However, in present study the depth of Secchi disk was found less than 3 feet which could classify lake as hypereutrophic from May-August and mesotrophic (between 8-13 feet) from January- April based on water clarity. The water clarity was observed high in the months of December-March and less in summer season. Formerly studies indicated that seasonal variations in weather conditions such as temperature, wind, and amount of rainfall are also closely linked with a lake's water clarity. These seasonal changes can affect water clarity by influencing both algal levels and color levels within a lake (Brown *et al.*, 1998).

Parameters that describe the ionic makeup of lake water include alkalinity, conductivity, and pH. They generally reflect the lake's watershed geology and soil characteristics (Illinois Environmental Protection Agency, 1998).

The high values for alkalinity were obtained in present study. The higher values of alkalinity by itself are not harmful to human beings, but it still delimits the water for domestic uses. The higher alkalinity values may be due to the discharge of municipal sewage, domestic sewage and urban wash off into the freshwater bodies. The increase in alkalinity may come from rocks, soil, salts and due to certain plant activities. If an area's geology contains large quantities of calcium carbonate ($CaCO_3$, limestone), water bodies tend to be more alkaline (Addy *et al.*, 2004). As the concentration of $CaCO_3$ increases, the alkalinity increases and the risk of acidification decreases. The desirable limit of alkalinity prescribed is 20 to 200 mg/L $CaCO_3$ (Illinois Environmental Protection Agency, 1998). An increase in the free CO_2 may result in the increase in alkalinity (Singhal *et al.*, 1986).

The results also indicated that decrease in alkalinity may increases the isopod infestation rate. The other studies also reported that the water with less than 5ppm $CaCO_3$ equivalent causes slow growth, distress and eventual death of fishes. Fishes are prone to attack of parasites and diseases in acidic waters (Hossain *et al.*, 2007).

The high level of conductivity, due to significant amount of dissolved salt, was observed in dry winter. The annual rainfall of the area is 385 mm, high variation was obtained in values of conductivity in the rainy season (July-September). High conductivity in dry winter season (November-February) represents water with high electrolyte concentration due to evaporation. The results are consistent with Kazi *et al.* (2009). Lakes with high alkalinity often have high conductivity and vice versa (Illinois Environmental Protection Agency, 1998).

The pH was found higher during summer which may be due to dumping of garbage and inflow of sewage water. A lake's pH will fluctuate somewhat each day and from season to season in response to photosynthesis by algae and other aquatic plants, watershed runoff, and other factors. Like dissolved oxygen concentrations, pH may change with depth, primarily due to various chemical reactions and a decrease in photosynthesis (Illinois Environmental Protection Agency, 1998).

The results also indicated that the isopod infestation rate increases with increasing pH. When pH values rises over 11, the gills, lens and cornea of fish eyes are destroyed (Jhingran, 1988). As a result the fishes become weak and infected by parasites (Hossain *et al.*, 2007). The desirable limit of pH of lakes, typically remain within the range of 6.5 to 9.0 described by US EPA. Outside of this range, organisms become physiologically stressed. Reproduction can be impacted by out-of-range pH, and organisms may even die if the pH gets too far from their optimal range (Addy *et al.*, 2004).

In current study, negative relationship was observed between isopod infection and free CO_2. Fish releases CO_2 through its skin and gills. This activity is hampered if the amount of this gas is more in the water, and as a result fish suffers from suffocation leading to death (Jhingran, 1988). Miller and Rabe (1969) reported that the highest concentration of free CO_2 was recorded in August and in winter months. Sahai and Singha (1969) also observed high levels of free CO_2 in June and lower levels in January. Roy *et al.* (1966) reported similar conditions of some water bodies. According to Swingle (1967), free CO_2 at a concentration of more than 15ppm is detrimental for pond fishes.

In present study, the hardness was found higher in dry winter season when more salt in water due to water evaporation. In particular, it is due to the concentration of multivalent metallic ions of calcium and magnesium. Any increase in hardness causes scale deposition and crust formation. The desirable limit of hardness is 300 mg/L (Chennakrishnan *et al.,* 2008). The results of current investigation indicated that isopod infection decreases with increase in hardness. It was recorded that primary production of pond decreases if hardness rises over 300 ppm (Verma, 1969).

Chloride concentration was higher during March. High chlorinity would reduce the DO content of water, which turns harmful for aquatic organisms. The salinity values decrease during rainy season may be due to rainwater (Chennakrishnan *et al.*, 2008).

In present study, ammonium level (0.00-0.96) was below the lethal level. And a positive relation was observed between isopod infestation and ammonium level. The ammonium concentration level higher than 1 mg/L indicates the considerable level of water pollution (Erkmen and Kolankaya, 2000). Excess ammonia may accumulate in gill filaments and causes alteration of metabolism or increase in blood pH. Experimental effects of ammonia on various fishes have been carried out by many researchers (Erkmen and Kolankaya, 2000; Avella and Bornancin, 1989; Frances *et al.,* 2000; Benli *et al.,* 2008) and found that exposure to un-ionized ammonia concentrations as low as 0.002 mg/L for few days can causes hyperplasia of gill lining and further lead to secondary infection like bacteria and fungus.

In this work, increase in concentration of nitrite level up to 0.26 mg/L was recorded in month of May, indicated poor water quality. The acceptable level of nitrite in freshwater fish pond should range between 0.001 and 0.004 mg/L (Boyd, 1982).

Phosphate concentrations of lake water contamination resulting from domestic wastage and agricultural sources where frequent use of the phosphate fertilizers is common.

Phosphate concentrations were also found higher than the mean which is >0.04 mg/L According to EPA (1976), phosphate concentration that exceeded 0.025 mg/L may stimulate excessive growth of algae and other aquatic plants, which can be a nuisance.

In present study, the values of Phosphorus ranges between 0.00 and 0.26, which regulates algae growth in the lake. For many lakes, additional phosphorus loadings will stimulate additional algae growth. Because phosphorus is so important to the growth of algae and aquatic plants, many lake and watershed management activities focus on reducing phosphorus availability in the lake water. TP concentrations above 0.030 mg/L are enough to stimulate nuisance algae growth (Illinois Environmental Protection Agency, 1998).

The results of present study indicated the deterioration of water quality parameters leads to fish isopod infestation, which may results in lower fish population and eventual death of the fishes. The result also indicated that stress due to water quality influences the outbreak of fish isopods which are consistent with studies reported by Phillips and Keddie (1990). The parasitic community of fish shows considerable variation with the environmental conditions in which fish live (Hossain *et al.*, 2007).

It has been concluded that Chashma Lake is a sensitive ecosystem and responded to the changes, episodes from its surrounding environment. The deterioration of water quality in Chashma Lake with changing seasons may lead to high stress response in fishes making them vulnerable to parasitic infections. The parasitic isopod infections in fishes are of highest significance in aquaculture, hence to achieve healthy fish stock one should implement programme like fish parasitological research, control of diseases and maintenance of health relationship between fishes and their environment.

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