PARASITISM IN CRUCIAN CARP, *CARASSIUS CARASSIUS* (L.) INHABITING LAKES OF DIFFERENT TROPHIC STATUS

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ABSTRACT

The aim of this study was to analyze the structure of parasite community of crucian carp, *Carassius carassius* (L.) in three lakes of Kashmir, namely Dal, Manasbal, and Khushalsar.Variations in the infection pattern of metazoan parasites in fish were noted in relation to the aquatic habitat, with the highest parasite burden recorded in the fishes from hyper-eutrophic Khushalsar lake. The fishes collected from mesotrophic Manasbal lake were found to be least infected with parasites. The results provide the statistical evidence that the trophic status of the water bodies has a marked impact on the occurrence of parasites in fishes. These data also support the hypothesis that the fish parasites can be used as bioindicators of environmental stress.

Keywords**:** *Carassius carassius,* parasite burden, eutrophication, Kashmir, lakes

INTRODUCTION

Fish parasites are an important part of the freshwater environment. Their presence becomes evident after a massive development causing diseases, leading sometimes to mass mortality, of infested hosts (Klempel *et al*., 2003). Such events are often linked with perturbations in the aquatic environment (Moller, 1987). The physico-chemical habitat of the fish is influenced by natural as well as anthropogenic pressures (Snieszko, 1974) and in turn it may induce changes not only in the fish itself but also in the structure of the parasite community associated with it. Therefore, in addition to their pathological significance, the parasite community of fishes may reflect the ecosystem conditions and thus can be used as bioindicator of environmental quality (Siddall *et al*., 1994; Mackenzie *et al*., 1995; Valtonen *et al*., 1997; Sures *et al*., 1999; Poulin and Valtonen, 2002; Schludermann *et al*., 2003; Sures, 2004). A considerable amount of literature is available on the helminth fauna of freshwater fish in Kashmir waters but studies with regard to impact of pollution on the parasitic community of fish are lacking. In the present contribution an attempt has been made to determine the relationship between the trophic status of lakes and the parasitic infection in crucian carp (*Carassius carassius* L.), a commercially important exotic fish inhabiting the lentic habitats of Kashmir.

MATERIAL AND METHODS

For assessing the impact of trophic conditions on the parasitic community of *C. carassius* (L.) three lentic water bodies of Kashmir, namely Dal, Manasbal, and Khushalsar lakes, depicting different levels of eutrophication, were selected. The assessment of trophic status of these lakes was based on the physico-chemical features of water carried out during June – August, 2003. For this purpose the water samples were collected and analyzed according to the standard methods (APHA, 1998 and CSIR, 1974). Help was also taken from earlier reports on the trophic conditions of these water bodies (Pandit and Yousuf, 2002, 2003). *C. carassius* L. was selected as the fish host for this study because of its occurrence in

all the three water bodies and also because of its diverse diet (Yousuf and Firdous, 1997) due to which it easily becomes the definitive or intermediate host of many parasites. The fish were collected with cast net with the help of local fishermen. A total of 116 specimens of fish were examined for parasites during the period June – August, 2003.

The fishes were carried live to the laboratory where their external surface, including the fins, nostrils, gills and operculum, etc., were examined for ectoparasites. Thereafter, each fish was dissected, its alimentary tract separated from other organs and placed in a petri dish containing physiological saline and opened and examined for endoparasites. The body cavity and other visceral organs like liver, kidneys, etc., were also examined. The number and location of each parasite in/on the host were recorded on a data sheet. The helminth parasites were fixed in Carnoy's fixative (Weesner, 1964) and preserved in 70% ethyl alcohol, whereas leeches were first relaxed in weak alcohol and later fixed in 85% ethyl alcohol. Each group of parasites was classified to the species level using permanent whole mounts.

The level of parasite infection was assessed according to the methods described by Bush e*t al.* (1997) and Margolis *et al.* (1982). The following scale of infestation given by Zander *et al.* (1999) was followed

1 - 1.9 parasites = low infestation,

2 - 4.9 parasites = moderate infestation,

5-19.9 parasites = strong infestation, and

> 20 parasites = mass infestation.

Standard non-parametric test (Kruskal-Wallis test) was performed to compare inter-lake variations in infection intensities of the fish hosts (Zar, 1996 and Morrison, 2002).

RESULTS

Abiotic Environment

The three lakes differed in depth as well as water quality (Table 1). All the inter-lake variations were found to be statistically significant (Kruskal-Wallis test, $P<0.05$). The depth of the water bodies revealed large differences. The maximum depth was recorded in Manasbal lake (11.88 m) and minimum in Khushalsar lake (1.15 m). The water temperature, however, showed only slight variations in the three lakes with the highest value (28.7^{o}C) recorded in Khushalsar lake and lowest (26.9^{o}C) in Manasbal lake. The transparency values exhibited variations in the three lakes with the minimum value observed in the Khushalsar (0.40m) and the maximum in the Manasbal (2.58m). The pH of the water was on alkaline side in all the three lakes, with the average values as 8.00, 8.42 and 7.41 for Dal, Manasbal, and Khushalsar lakes respectively. The conductivity recorded the highest value (608μS) in Khushalsar followed by Dal (319.7μS) and Manasbal (274.3μS) lakes. The concentration of dissolved oxygen also varied appreciably among the three lakes. The lowest value was recorded at Khushalsar lake (1.7 mgl^{-1}) in comparison to Dal (6.9 mgl^{-1}) and Manasbal (7.7 mgl^{-1}) lakes. The amount of free CO_2 in Khushalsar was markedly higher than that of Dal and Manasbal lakes. The amplitude of other parameters also revealed a clear gradation (Table 1) from the Manasbal through the Dal to the Khushalsar.

Table 1: Physico-Chemical characteristics (average values ± SD) of the three lakes (June – August 2003)

S. No	Parameters	Manasbal	Dal (Hazratbal Basin)	Khushalsar
1.	Water temp (^{0}C)	26.9 (±0.4)	27.8 (±0.15)	28.7 (±0.68)
2.	Depth (m)	11.88 (±0.15)	2.41 (±0.03)	1.15 (±0.04)
3.	Transparency (m)	2.58 (±0.03)	1.57 (±0.03)	0.04 (±0.02)
4.	pH	8.42 (±0.13)	8.00 (±0.16)	7.41 (±0.13)
5.	Conductivity (μS)	274 (±3.06)	320 (±5.03)	608 (±8.19)
6.	Diss. Oxygen (mgl^{-1})	7.7 (±0.85)	6.9 (±0.95)	1.7 (±1.70)
7.	Free CO_2 (mgl^{-1})	0.6 (±1.04)	2.7 (±0.80)	22.9 (±3.5)
8.	Alkalinity (mgl^{-1})	118 (±7.09)	131 (±3.06)	225 (±5.03)
9.	Chloride (mgl^{-1})	20 (±4.58)	31 (±2.08)	41 (±1.53)
10.	Ammonia –N (μgl^{-1})	140 (±0.52)	192 (±0.93)	352 (±3.36)
11.	Nitrate –N (μgl^{-1})	173 (±4.38	330 (±5.8)	520 (±7.30)
12.	Orthophosphate P (μgl^{-1})	47 (±4.73)	85 (±12.58)	185 (±4.11)
13.	Total Phosphate P (μgl^{-1})	176 (±5.75)	386 (±5.75)	683 (±11.55)

Community Structure of Parasites

Four parasite taxa were found in C. carassius from the three lakes. These included Clinostomum schizothoraxi, Diplozoon kashmirensis (Trematoda), Bothriocephalus achielognathi (Cestoda) and Helobdella stagnalis (Hirudinea), the last one being found only in specimens from Khushalsar lake. No nematode and acanthocephalan parasites were found. The prevalence, mean intensity and mean abundance values for each parasite are presented in Table 2. The prevalence of each parasitic species in the fish was found to be higher in the Khushalsar, followed by the Dal, and the Manasbal in a decreasing order. These differences were statistically significant (Kruskal-Wallis test, $P < 0.05$). With regard to differences in the intensity of the parasite species, the Kruskal-Wallis test showed significantly different values for the parasites in the three lakes ($P< 0.05$), the intensity recording significant increase with prevalence. According to the scale of infestation, strong infestation (intensity>5) was found in host-parasite combinations of Khushalsar lake, whereas a moderate infestation (2-4.9) was recorded in Manasbal lake. However, in Dal lake infestation was found to be strong for *C. schizothoraxi* and *D. kashmirensis*, whereas that for B. achielognathi it was moderate. The mean abundance values recorded for the parasite species were also found to be statistically significant (Kruskal-Wallis test, $P<0.05$) with higher values recorded in Khushalsar lake, followed by Dal lake, and decreasing to the lowest in Manasbal lake.

Table 2: Prevalence, mean intensity and mean abundance of parasitic communities of *C. carassius* (L.) from Dal, Manasbal, and Khushalsar lakes

Name of Parasite	*Site*	NP	P (%)	MI (±SD)	MA (± SD)
Diplozoon kashmirensis	Manasbal	14	11.9	2.8 (± 0.40)	0.3 (± 0.15)
	Dal	77	23.9	7 (± 3.57)	1.7 (± 1.79)
	Khushalsar	184	67.9	9.7 (± 4.96)	6.6 (± 3.19)
Clinostomum schizothoraxi	Manasbal	24	21.4	2.7 (±0.15)	0.6 (±0.15)
	Dal	92	37.0	5.4 (± 4.05)	2 (±1.36)
	Khushalsar	174	60.7	10.2 (±3.55)	6.2 (±3.10)
Bothriocephalus achielognathi	Manasbal	16	16.7	2.3 (±0.25)	0.4 (±0.1)
	Dal	43	23.9	4.1 (±0.81)	0.9 (±0.21)
	Khushalsar	78	42.9	6.5 (±0.67)	2.8 (±0.60)
Helobdella stagnalis?	Manasbal	0	---	---	---
	Dal	0	---	---	---
	Khushalsar	18	20	9 (±5.20)	0.6 (±1.04)

NP = number of parasites; P (%) = Prevalence; MI = mean intensity; MA = mean abundance

C. carassius populations from the three lakes recorded significant differences in respect of parasitic infection. 85.7% fish sampled from Khushalsar lake were infected, with 17.9% having 3 parasite taxa, 57.1% 2 parasite taxa and the remaining 10.7% having 1 parasite species. In case of fish from Manasbal only 31% were infected, with 23.8% having two parasite taxa and 7.2% having only one parasite species. Triple infections were not reported from Manasbal lake. In case of Dal lake, 45.7% fish sampled were infected, of which 4.4% had three parasite taxa, 30.4% two parasite taxa and 10.9% had only a single parasite species (Fig.1).

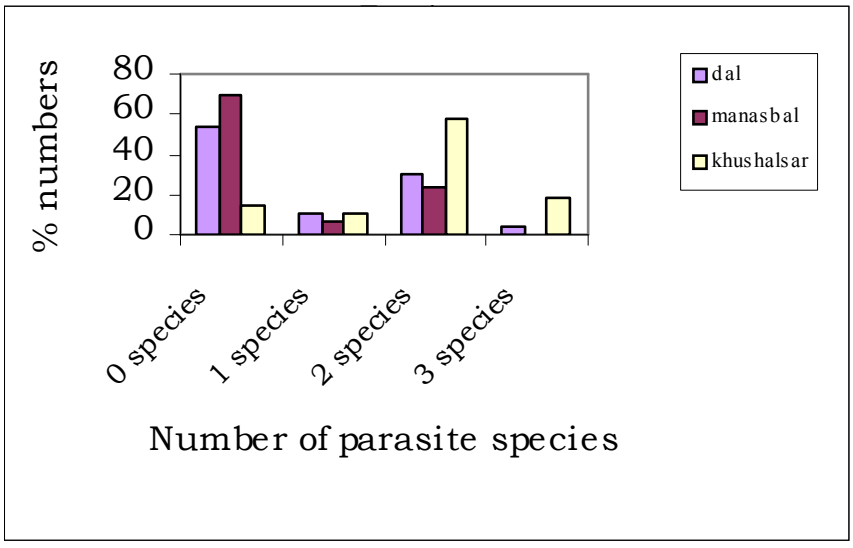

Fig. 1. Infra-communities of *C. carassius* from the three lakes

DISCUSSION

The physico-chemical features revealed significant differences in the water quality of the three lakes. On the basis of transparency, Khushalsar lake has more turbid water than either Dal or Manasbal lakes. Increased turbidity indicates the presence of high amount of suspended organic and inorganic matter. The specific conductivity is an indicator of the total nutrient level of a water body and is, therefore, used to indicate the trophic status. Using specific conductivity as an index of enrichment (Rawson, 1960), values more than 200 μS show higher enrichment level. The conductivity values in the present study reflect high ionic concentration of the lakes. The low dissolved oxygen content in the Khushalsar (1.7 mgl^{-1}) is a clear indication that this water body has high load of autochthonous as well as allochthonous oxidisable organic matter. This is further substantiated by the data on chloride content. Thresh *et al.* (1944) attributed high chloride content of water to organic pollution of animal origin. The alkalinity recorded in Khushalsar lake was comparatively higher than that of Dal and Manasbal lakes. Spence (1964) categorized lakes with more than 60 mgl^{-1} alkalinity as nutrient rich. The water bodies under investigation, having more than this value, can be considered as nutrient rich. Nitrogen and phosphorus are important factors in aquatic system because they play a key role in the productivity of water. Comparatively higher values of inorganic nitrogen and phosphorus in Khushalsar lake are a clear indication of its higher nutrient status due to heavy anthropogenic pressures in the catchment area.

Though on the basis of water quality all the three lakes were found to be eutrophic, yet they differed in the levels of eutrophication. Khushalsar lake recorded the highest enrichment, thereby indicating its advanced stage of eutrophication. The second place was taken by the Dal lake, while the Manasbal lake was the least eutrophic among the three (Pandit and Yousuf, 2002). The difference in the water quality of the three lakes reflects the varied anthropogenic stresses in their catchment.

The infection dynamics of the parasites showed inter-lake variations in the fish hosts. The higher population density of the pseudophyllidean cestode *B. achielognathi* in Khushalsar lake seems to be related to the higher trophic status of the lake. The lake is characterized by very low dissolved oxygen levels due to heavy input of organic matter which may be providing a more suitable habitat for the intermediate hosts. Further, temperature also seems to play an important role in *Bothriocephalus* infection. This is in agreement with the findings of Riggs and Esch (1987) who observed higher prevalence of *B. achielognathi* in polluted waters characterized by high temperatures.

Significant inter-lake variations were also observed in the infra-community structure of metacercarial cysts of *C. schizothoraxi.* The higher infection of this trematode in Khushalsar lake can be explained by the shallow depth, small size and abundance of macrophytes in the lake. According to Sandland *et al.* (2001) variations in the depth, size of lakes and presence of macrophytes affect differences in water temperature and snail densities and thereby influence transmission rate of cercaria. Mackie *et al*. (1983) also observed high incidence of metacercariae in shallow waters. Similar findings were reported by Morley *et al*. (2003) in polluted habitats.

The level of infection by the ectoparasite *D. kashmirensis* in *C. carassius* also revealed significant variations among the lakes. The fish exhibited a marked difference in the pitch

of parasitism with the individuals from the Khushalsar being more heavily infected than those from the other waters. Anderson (1974) reported that the number of parasites increases with increase in water temperature. According to Chubb (1977) water temperature is the most important abiotic factor that influences the reproductive activity of monogenean trematodes. The present study indicates that the differences in water temperature as well as ammonia and chloride concentration in the water bodies affect the parasite density. This view is also supported by Lafferty (1997) who reported that monogeneans respond positively to eutrophication by exhibiting a high degree of resistance to environmental pollution. Skinner (1982) also reported an increase in the number of *D. paradoxum* in response to pollutants mainly ammonia.

The presence of ectoparasitic leech *H. stagnalis* on the fish was restricted to the Khushalsar lake population only. It seems to be related to the increased turbidity and high organic load vis-à-vis nutrient richness. In muddy waters with growth of macrophytes, conditions are particularly favourable for the leech to multiply (Sawyer and Hammond, 1973). The higher incidence of multiple infections in the Khushalsar lake as compared to the other two water bodies can be attributed to the environmental stress on the fish in the lake. These results are in agreement with Kadlee *et al*. (2003) who proposed that increase in water pollution lowers fish resistance and makes them more susceptible to parasitic infection, leading to greater parasite acquisition. Poor water quality has also been reported to promote increased parasitism in fish due to decreased host immune response (Khan and Thulin, 1991; Poulin, 1992). While comparing the rate of parasitization, the fish population of Manasbal lake was found to be least infected with parasites and hence in a better state of health followed by that of Dal lake. On the other hand, the fish population of the Khushalsar was found to be highly infected with parasites and diseased.

On the basis of the present data on parasitic infection in *C. carassius*, it may be concluded that the trophic status of a water body has a marked influence on the rate of parasitization in fishes. Conversely, the present data clearly support the view that the pattern of parasitic infection can reflect the health status vis-à-vis environmental quality of the fish host and, therefore, can be used as indicator of trophic condition of the ecosystem in which the fish live.

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