Prevalence of Myxozoan Parasites Infecting Fresh Water Fishes of Jammu and Kashmir

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Abstract
During the study conducted on fresh water fishes of Jammu and Kashmir, a total of 1,249 fishes belonging to 4 genera were examined for the presence of myxozoan parasites. These included native cyprinid fishes belonging to the subfamily schizothoracines commonly called snowtrouts i.e *Schizothorax niger*, *S. esocinus, S. curvifrons*, *S. richardsonii* and an Indian major carps such as *Labeo rohita* and *Cirrhinus mrigala* and an exotic carp, *Cyprinus carpio*. Gills were found infected in 140 fishes with 11.20% of infection rate. As many as 12 species of myxozoans representing 2 genera, namely, *Myxobolus* (11 species), *Thelohanellus* (01species) were collected and identified. The infection rate was highest in *L. rohita* (18.62%) followed by 15.27% in *Schizothorax curvifrons,*13.49% in *Schizothorax niger,* 12.35% in *Cirrhinus mrigala,*11.76% in *S. richardsonii* and 6.28% in *S.esocinus.*
Keywords: Kashmir, fish, myxozoa

Introduction

Fisheries sector plays an important role in the economic development of the state. It has been recognized as a powerful income and employment source of cheap and nutritious food. Some 44 species of fishes under 14 genera and 5 families have been reported from Jammu and Kashmir. Damage to the fish host can be due to parasites belonging to various groups such as protozoans, helminthes and myxozoans. The infection due to the Suphylum: Myxozoa (Phylum Cnidaria) is worthwhile to note as some are highly pathogenic to their host fish however, some infections are innocuous and have little impact on fish hosts (Shulman, 1990; Lom and Dykova, 1992). Some of the parasites cause severe disease and can have great economic impact on aquaculture sector (Pote *et al*., 2000; Diamant *et al*., 1994).

The valley of Kashmir is situated in the middle of the Himalayas between the north-west and south-east ($33^o01"$ –$35^o00"$ N latitude and $73^o48"$ –$75^o30"$ E longitude) at an altitude >1500 m above sea level. The study was carried out in three valley lakes, namely Wullar Lake (34^0 20N,

74°36E), Dal Lake (34°07"N, 74°52" E) and Manasbal Lake (34°15"N, 74°40"E) and famous River Jhelum which has a length of 725 km harboring tremendous fisheries especially in cold water sector. The study was also carried out in warm water fishes of Jammu in an aquaculture pond (canal road fish farm), which harbor Indian major carps and exotic carps practicing polyculture. Wullar lake is the largest fresh water lake in Asia which harbors tremendous fresh water fish potential. While Mansbal Lake is one of the deepest lake of Kashmir valley and is a rural lake situated at a distance of 32 km from Srinagar city. The lake is situated at the altitudinal zone of 1585 – 1600 m (5200 – 5249 ft) with a maximum depth of 13 m (43 ft). Dal Lake is famous for its scenic beauty and is an urban lake that lies to the east of Srinagar city, at the foot of the Zabarwan Hills, and is situated at an average elevation of 1583 m (5194 ft) above sea level with a maximum depth of 6 m (20 ft). The present investigation was carried out between September 2013 and August 2015. Fish and water samples were collected on monthly basis at different sites in all the three lakes.

Materials and Methods

Fishes were collected from various water bodies of Jammu and Kashmir during the study period of 2013-2016. As many as 24 collection tours were made to various localities such as Wullar Lake, Mansbal Lake, Dal Lake, River Jhelum and from aquaculture ponds located in Jammu. Fish specimens were also collected from the fresh catch as well as from the local fish markets. Different species of fishes were collected and examined for the presence of myxozoan infection. The examined fishes included the famous local snowtrout which is native to Kashmir valley, belonging to the subfamily schizothoracinae such as *Schizothorax niger* Heckel (1838), *S. esocinus* Heckel (1838), *S. richardsonii* Gray (1832), *S. curvifrons* Heckel (1838), Indian major carps such as *Labeo rohita* Hamilton (1882), *Cirrhinus mrigala* Hamilton (1882), and exotic carps such as *Cyprinus carpio* Linnaeus (1758). Prevalence of infection was calculated according to Bush *et al*., (1997) using following formula:

$$\text{Prevalence (\%)} = \frac{\text{Number of infected fish}}{\text{Total number of fish examined}} \times 100$$

Seasonal variation of infection of myxozoan parasites was calculated from fresh water fishes in Jammu and Kashmir during the period from 2013-2016. Seasons were divided as summer, autumn, winter and spring. For variation in infection due to age, sex and size of the host, the prevalence was calculated according to Bush *et al*. (1997) as mentioned above. Identification of myxosporeans was done with the help of key to genera given by Lom and Dykova, (1991), handbook on the myxosporeans of Indian fishes given by Kalavati and Nandi, (2007) and research papers reporting myxosporean species regionally and globally.

Results

A total of 1,249 fishes belonging to 4 genera were examined for the presence of myxozoan parasites. Gills were found to be infected in 140 fishes with a prevalence rate of 11.20%. 12 species of myxozoans representing 2 genera were identified and characterized on the basis of morphological characters **Table 1**. During the present study, *Schizothorax niger* exhibited maximum species diversity (4 species) followed by *S. esocinus, S. curvifrons, C. mrigala* (2 species) each and one species each in *S. richardsonii* and *Labeo rohita*. The prevalence of myxozoan parasites at 3 study sites are given in **Table 2, 3 & 4**. No infection was recorded in *Cyprinus carpio.* The present study is the first study conducted so far on myxozoan infections in the cold water fish in the state of J&K.

Number of species found in Wullar lake=6

Number of species found in Dal lake=2

Number of species found in Mansbal lake=1

Table 1. Prevalence of Myxozoan parasites infecting fresh water fishes of Jammu and Kashmir

Hosts	Examined Fish	Infected Fish	Prevalence of infection (%)	Parasites
Schizothorax niger (chush)	213	28	13.14%	*M. nigerae* n. sp. *M. diversus* (Nie and Li, 1973) *M. chushi* n. sp. *M. ghaffari* n. sp.
Schizothorax esocinus (chirruh)	414	26	6.28%	*M. kashmirensis* n. sp. *M. eirasi* (Kaur and Singh, 2009)
Schizothorax richardsonii (algaad)	51	6	11.76%	*M. richardsonii* n. sp.
Schizothorax curvifrons (sattar)	203	31	15.27%	*M. wullarensis* n. sp. *M. diversicapsularis* (Slukhai, 1966)
Cirrhinus mrigala (mrigal)	178	22	12.35%	*Thelohanellus boggoti* (Qadri, 1962)
Labeo rohita (rohu)	145	27	18.62%	*M. rocatlae* (Basu and Haldar, 2002) *M. chittalii* (Kaur and Singh, 2011)
Cyprinus carpio (common carp)	45	-	-	-
TOTAL	1249	140	11.20%	

Table 2. Prevalence of myxozoan parasites in Wullar Lake

Prevalence of myxozoan parasites in Wullar Lake			
Year	**No. of fishes Collected**	**No. of fishes infected**	**Season**
Sep. 2013 2014	14 10	4 0	**Total=85 Infected=4 Prevalence=4.70%**
Oct. 2013 2014	16 12	0 0	
Nov. 2013 2014	17 16	0 0	
Dec. 2013 2014	10 8	0 0	**Total=53 Infected=2 Prevalence=3.77%**
Jan. 2014 2015	8 10	2 0	
Feb. 2014 2015	9 8	0 0	
Mar. 2014 2015	10 9	2 4	**Total=71 Infected=17 Prevalence=23.94%**
Apr. 2014 2015	18 12	4 0	
May 2014 2015	12 10	3 4	
June 2014 2015	10 8	2 1	**Total=70 Infected=13 Prevalence=18.57%**
Jul. 2014 2015	13 17	4 2	
Aug. 2014 2015	8 14	4 0	
Total number of fishes collected =279 Total number of fishes infected=36 Prevalence=12.90%			

Table 3. Prevalence of myxozoan parasites in Dal Lake

Prevalence of myxozoan parasites in Dal Lake			
Year	**No. of fishes Collected**	**No. of fishes infected**	**Season**
Sep. 2013 2014	12 9	0 4	**Total=60 Infected=4 Prevalence=6.66%**
Oct. 2013 2014	10 12	0 0	
Nov. 2013 2014	7 10	0 0	
Dec. 2013 2014	12 10	2 0	**Total=68 Infected=3 Prevalence=4.41%**
Jan. 2014 2015	14 12	0 1	
Feb. 2014 2015	8 12	0 0	
Mar. 2014 2015	12 9	3 1	**Total=70 Infected=13 Prevalence=18.57%**
Apr. 2014 2015	12 11	6 0	
May 2014 2015	12 14	0 3	
June 2014 2015	10 13	2 6	**Total=63 Infected=15 Prevalence=23.80%**
Jul. 2014 2015	8 11	4 0	
Aug. 2014 2015	7 14	2 1	
Total number of fishes collected =261 Total number of fishes infected=35 Prevalence=13.40%			

Table 4. Prevalence of myxozoan parasites in Mansbal Lake

Prevalence of myxozoan parasites in Mansbal Lake			
Year	**No. of fishes Collected**	**No. of fishes infected**	**Season**
Sep. 2013 2014	8 7	0 0	**Total=52 Infected=1 Prevalence=1.92%**
Oct. 2013 2014	12 9	0 0	
Nov. 2013 2014	7 9	1 0	
Dec. 2013 2014	6 8	0 0	**Total=53 Infected=0 Prevalence=0%**
Jan. 2014 2015	9 11	0 0	
Feb. 2014 2015	11 8	0 0	
Mar. 2014 2015	7 9	0 0	**Total=58 Infected=3 Prevalence=5.17%**
Apr. 2014 2015	8 12	1 0	
May 2014 2015	12 10	2 0	
June 2014 2015	9 13	0 0	**Total=68 Infected=4 Prevalence=5.88%**
Jul. 2014 2015	11 16	3 1	
Aug. 2014 2015	8 11	0 0	
Total number of fishes collected =231 Total number of fishes infected=8 Prevalence=3.46%			

During the present study, native carps in J&K were found more susceptible to myxozoan parasites in comparison to exotic carps. In total, all the 12 species were found infecting gills of

native carps. Furthermore, no myxozoan gill infection was recorded in the exotic carps i.e. *Cyprinus carpio*. (**Figure 1**).

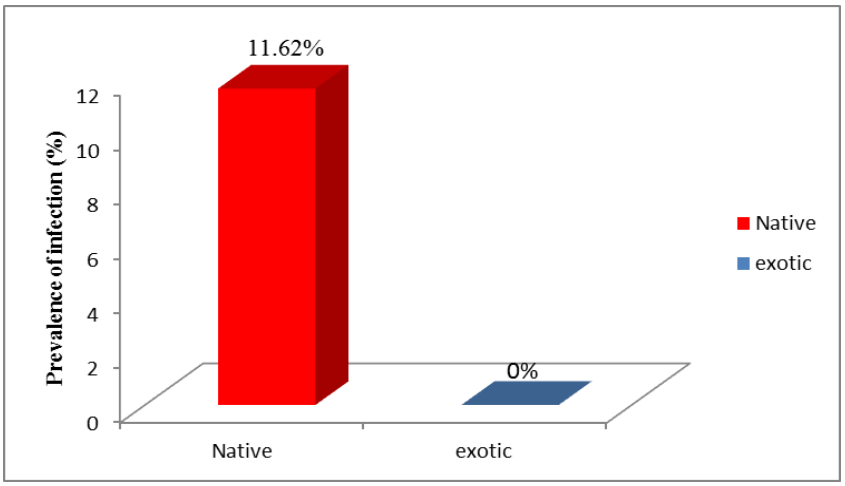

Figure 1. Prevalence of infection in native and exotic fish

During the present study, seasonal-wise analysis of prevalence of infection indicated maximum (16.84%) in the season of summer and minimum (7.29%) was observed in the season of winter. The present study indicated that the prevalence of infection varies with variation in temperature and could be an important factor for the development and transmission of myxozoan life cycle stage (**Table 5**).

Table 5. Seasonal prevalence of Myxozoan parasites infecting fresh water fishes of Jammu and Kashmir

Seasons	**Prevalence (%)**
Autumn	12.90%
Winter	7.29%
Spring	12.00%
Summer	16.84%

During the present study, a total of 1249 fishes were examined. Fishes were divided into different age and size groups to study the effect of myxozoan parasites on the host. Fishes were arranged into three groups' i.e fishes with age group 5-8 months and size 10 cm; 8-11 months with size 15 cm; 11-16 months with size 25cm.

In the present study, fishes 11-16 months with size 25 cm were most susceptible to the myxozoans (14.03%) followed by the group having 8-11 months with size 15 cm (11.8%) and the least prevalence was found in fish age group of 5-8 months with size 10 cm (**Table 6** and **Figure 2**).

Table 6: Prevalence of Myxozoan infection due to age and size of the fish

Age of host	Size of host (cm)	Prevalence of infection (%)
5-8 months	10.0	9.33
8-11 months	15	11.8
11-16 months	25	14.03

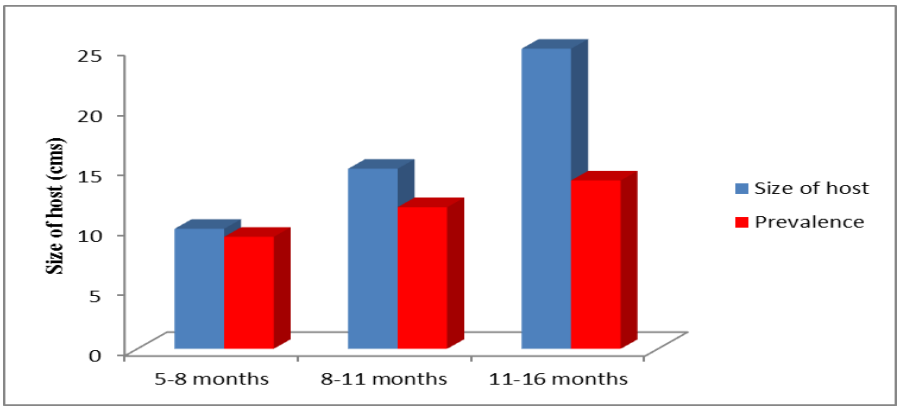

Figure 2: Showing effect of age on the prevalence of infection caused by Myxozoan parasites in fresh water fishes of Jammu and Kashmir

During the present study, a total of 1249 fishes were examined with 499 male fishes and 750 female fishes. 110 female fishes and 30 male fishes were found infected with myxozoan parasites (**Table 7**). Female fishes were more infected with infection rate 14.66% as compared to male fishes with infection rate 6.01% **(Figure. 3).**

Table 7. Prevalence of Myxozoan infection due to sex of the host fish

Sex of the host	Fishes examined	Fishes infected	Prevalence of infection (%)
Female	750	110	14.66
Male	499	30	6.01
Total	1249	140	11.20%

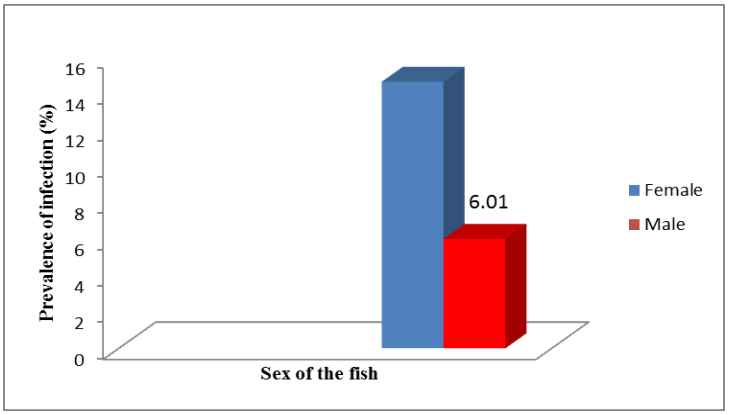

Figure. 3. Effect of host sex on the prevalence of Myxozoan parasites

Discussion

During the present study infection was recorded only in the gills and no infection could be detected in intestine, air bladder, coelomic cavities, buccal cavity, muscles, fins, scales and beneath skin. Longshaw *et al.,* (2005) also made similar findings and reported that majority of infections with *Myxobolus* sp. were found in the gills in cyprinids. Similarly Martins *et al.,* (1997) also reported 79.2% of infection in the gills of Pacu (*Piaractus mesopotamicus*) with *M. colossomatus* and *Henneguya piaractus* in Brazil. Kalavati and Nandi, (2007) discussed that gill myxoboliosis was the most widely distributed disease infecting various species of carps in many states in India. Molnár and Békesi, (1993) observed cysts with myxospores of *M. colossomatis* in juvenile tambaqui, which also parasitized different organs (the fins, gills, heart, and intestinal membrane).

During the present study, native carps were more infected with a percentage of 11.20% and no infection was recorded in exotic carps. These observations were in conformity with White and Perkins (2012), who reported that invasive/exotic populations frequently harbour a reduced parasite community as compared with their native counterparts. Also, similar observations were made by Torchin *et al*., (2003) who reported 53% fewer helminth in non-native host species as compared to native ones. Blossey and Nötzold, (1995) therefore discussed that the invaders in the absence of parasites, reallocate energetic resources away from unnecessary defense mechanisms into fitness and growth, potentially leading to a mechanism explaining invader's success and evolution of increased competitive ability. Kaur and Katoch (2016), have also reported as many as 7 myxozoans parasites infecting gills of native carps in polyculture systems and interestingly no infection was recorded in the gills of exotic carps in the same culture system.

During the present study infection rate was varied with variation in temperature as also reported by Gbankoto *et al*., (2003), that the fluctuations in the prevalence of infection caused

by *Myxobolus* spp. in *Tilapia ziili* were due to changes in temperature in the different months of season. Lawrence (1970) suggested that seasons as with most ecological parameters, have varied effects on parasitic infection also, depending on the species considered and the combination of the parameters in any given area. Majumder *et al*., (2013) suggested that the prevalence of the protozoan parasites was very much dependent on seasonal changes of temperature and reported that *Thelohanellus* infection have been mostly found during July-October months while, the *Myxobolus* infection was detected more in March to June rather than *Thelohanellus* in West Bengal, India.

In the present study fishes 11-16 months with size 25 cm were most susceptible to the myxozoans (14.03%) as compared to other groups. These observations were in conformity with Siddiqui (2014), who reported that the higher prevalence had been recorded in adults and large fishes as compared to the younger and smaller ones. Earlier to this, Dogiel (1961) and Bashirullah (1973) reported that the invasion index is directly related with the increase in size (length) and age of the host due to the high metabolic activity in adult large fish which may be related to the volume of food ingested by large fishes.

During the present study, female fishes were more infected in comparison to male fishes. These observations were in conformity with Smith (1969) besides Sanwal and Agarwal, (1974) reported that the incidence of protozoan infection in ornamental fish was comparatively higher in the female hosts than in males because of the strong immunity system carried by the male fish than female and also, due to biochemical changes in quantity and quality of the steroid hormone presumably of male and female hosts. Therefore they inferred that the impact of seasons, host age, size and sex have important role in the prevalence of protozoan parasites of some ornamental fishes.

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