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SPECIES RICHNESS, DISTRIBUTION PATTERN AND HABITAT USE OF FISHES IN THE TRANS-HIMALAYAS, INDIA

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Abstract
The cold desert of Ladakh is a catchment of the Indus river, which contains three major sub-basins: the Indus, Shyok and Zanskar of the higher Himalayas. A survey on lotic water fishes was conducted between April and September 2001 and covered a wide altitude ranging from 2750 m to 5386 m above mean sea level. In total, 41 streams and six rivers were sampled. A total of 32 species of fishes were recorded in the streams and rivers of Ladakh landscape: of which, five were exotic species primarily confined to some sites in the Indus subcatchment. Species richness in the Indus subcatchment was higher (29 species) than other two catchments. The Zanskar (10 species) had the fewest species. The current distribution pattern of fish in the Ladakh indicates that this landscape is a transient zone between the palearctic and oriental realms. Fishes in the Trans-himalayas highly used the streams which have more algal growth on the substratum. Snowtrout *Diptychus maculates*, which occur in abundant in the Ladakh waters would be useful for fisheries.

Keywords: fish, snowtrout, Ladakh, Trans-Himalayas, stream fishes

Introduction

The study of fish and fisheries has had a long and distinguished history in India (Hora 1951), but relatively little attention has been paid to fish conservation here. Large number of freshwater fishes are threatened due to the fragile nature of freshwater habitats and the pressure, which they are under in all parts of the world from human activities (Le Cren 1964; Maitland 1993; Primack 1998). In India, there are an estimated 670 species of freshwater fishes and 227 of these are threatened (Anon 1997). The high percentage (35%) of endemic species being threatened is perhaps due to their localised distribution with other man-induced threats (Primack 1998). Threats to Indian freshwater fishes include habitat destruction, fragmentation, poisoning, pollution, pesticides, destructive fishing unsustainable harvest, poor scientific practices in fishing and an ever-growing demand. In India, freshwater fishes are a poorly studied group, and most of the information available is from a few studies confined to few localities that too focus on commercial fishes.

Habitat changes in Himalayan waters have been reviewed (Shrestha 1990) and have had a major impact on the distribution and abundance of native fishes in mountain streams. The migration routes of important native fishes such as mahseers (*Tor putitora* and *Tor tor*), snow trout (*Schizothorax spp*), and Rheophilic species (*Psilorhynchus pseudochensis*, *Balitora brucei* etc) have been impeded because of reservoirs across rivers. In India, extensive surveys and research on fresh water fishes have been carried out in Kerala, Tamilnadu, Maharashtra and the North Eastern states (Buceros 2000), however, no information exists on the status, distribution pattern and ecology of fishes in Ladakh. Despite the highly interesting ecological and geographical features of the Kashmir Valley and Ladakh (Nath 1994), its fauna have been very inadequately explored (Hora 1951). In this connection an inventory on fishes in

Ladakh was thought to be carried out to understand the distribution pattern of fishes and their habitat so that a workable conservation action plan could be prepared. In this paper the spatial distribution pattern and habitat use of Ladakh fishes are discussed.

Materials and methods

Study area

This study was conducted in three major subcatchments of Ladakh: Indus, Shyok and Sanskar. Ladakh represents the Trans-Himalayas sector of the Himalayan mountain chain (79°27'16" to 79°26'01" E and 34°35'37" to 35°24'33" N, Figure 1). Trans-Himalayas is a fragile biome, characterised by extremes of both climatic and biotic factors. Very low productivity and a high degree of resource seasonality and unpredictability give rise to a unique diversity of life that is persistently prone to any kind of disturbance. Flora and fauna of this cold desert are adapted themselves to extreme conditions and have low population abundance (Anon 2001).

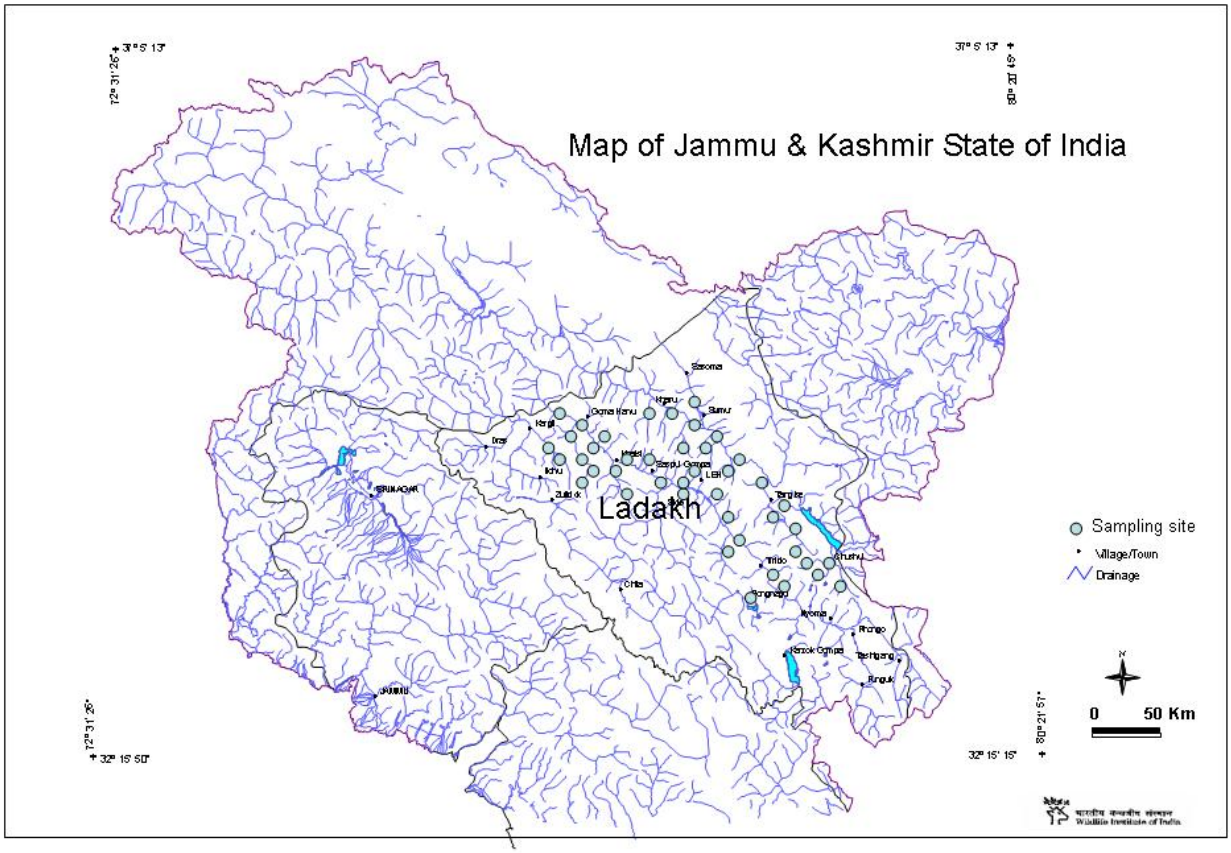

Figure 1. Study area showing the sampling sites in Ladakh.

The river valleys are characterised by riverbed vegetation communities mostly dominated by *Hippophae* sp., *Myricaria* sp., and *Caragana* sp. In the recent past, large scale plantations of dwarf willow *Salix daphnoides* have been raised along the stretch of river valleys. The area receives less than 100-mm annual rainfall with little snow and is recognised as cold desert. Most rivers, streams and lakes of the Ladakh are of glacial origin and are frozen from November to March. Ladakh has several major river systems including the shyok and Nubra rivers along the Karakoram range to the north; the Indus river system passing from east to west in the entire central Ladakh; and three smaller river systems of the Zanskar, Suru and Dras with a large number of tributaries in the Zanskar.

The entire Ladakh region is in the catchment of the river Indus, however, this large catchment can be divided into three smaller sub-basins/catchments: Shyok, Indus and Zanskar. Shyok and Nubra rivers and its tributaries (streams) along the Karakoram range to the north are collectively called the Shyok catchment. In the Shyok catchment, streams originate from very steep slopes. Three smaller river systems (Zanskar, Suru and Dras) are collectively called as Zanskar catchment. Zanskar catchment is a transient zone between the Trans-Himalayas and Greater-Himalayas, which is reflected by its own unique vegetation communities that do not occur in the other two catchments The Indus catchment covers the area of downstream of the Shyok and the Zanskar catchments. Indus catchment has heterogenous landscape, which includes undulating terrain to flat valley (Anon 2001).

Fish sampling

From April to September 2001, 41 streams and six rivers were sampled and represented altitudes ranging from 2750 m to 5386 m above mean sea level. A total of 17 streams found in the Indus were approachable to do sampling which was the 65% of the total available perennial streams in this subcatchment and hence, equal percentage of streams were sampled in the other two subcatchments. Of the 41 streams, 17 were of the Indus subcatchment, 13 of Zanskar and 11 of Shyok subcatchment. Three sites in 100 m intervals, which starts from the mouth of the stream were sampled in each stream. Different kinds of nets such as cast net, gill net, mosquito net and lines were used for sampling to maximise the catch and cover as much species as possible. Each sampling point was located using a GPS. Species and number of individuals of each species of fish were noted.

Both omnivorous and herbivorous fishes were caught using lines with *atta* (wheat paste) as bait and carnivorous fishes were caught using lines with small fish or meat. In small streams, mosquito nets were used to catch fish, but in the fast flowing stream both mosquito nets and 1x1 cm mesh sized fishing nets were used. In fast flowing streams, fishes were disturbed and forced to seek stone shelter and then collected with bare hands. This method was extremely effective and was used to catch snowtrouts and suckers.

Habitat observation

Microhabitats observations were made from all rivers and streams wherever sampling took place. For each observation, fish were identified to species, their standard length and weight was measured using vernier calliper and Pasola spring balances, and the following microhabitat variables were measured: maximum depth of water column, water velocity at the surface and at the substratum. A pygmy type current meter was used to measure velocities and depths of water[10]. Each substratum category (from 1 to 14) was scored in percentage based on a modified Wentworth particle scale where: 1= boulders, 2 = boulder with gravel, 3 = boulder with sand, 4 = cobble, 5 = pebble, 6 = pebble with boulder, 7 = pebble with gravel, 8 = pebble with sand, 9 = gravel, 10 = gravel with pebble, 11 = gravel with sand, 12 = sand, 13 = silt, and 14 = rocky.

Water temperature and turbidity were measured using thermometer and Secchi disc respectively. Nearby vegetation types and channel slopes were also recorded. Discriminant analysis was used to identify suitable habitat characters for fish. Non-parametric tests were used to explore differences in variation in microhabitat characters between catchments, and also to identify the differences in distribution patterns of fishes among catchments.

Data analysis

Status of the fishes were assessed based on their abundance. Species occurring at fewer than 15 sampling stations (total number of sampling stations includes 41 streams and 6 rivers) was called 'rare', if it was found in 16 to 30 sampling stations was considered 'not common' and if it occurred in more than 31 sampling stations then it was assessed as 'common'.

Length weight relationship were assessed from measurement of total weight (W) and total length (L), and the curves parameters ***a*** and ***b*** were determined by Log 10 transformation of raw data, following (Woottan 1991). The relationship between length and weight provides an index frequently used. This index is the condition factor (Lagler 1952), $K_{TL}=(100000 \times W)/L^3$. The degree of adjustment of the model studied was assessed by the correlation coefficient of Pearson (r) for the logaritmized data of the length weight relationship.

Results

Status.-Of the 32 species recorded, 10 were rare, 9 were not common, and another 9 were common. Remaining 4 species were not assessed due to their alien nature. These alien species were restricted to fishery farms except *Oncorhynchus mykiss* which was also found in natural habitats (Table 1).

Distribution pattern of fishes.-Average species richness at any sampling site in Ladakh was 2.1± 0.3, and there was little difference in the species richness across sampling stations (Kruskall Wallis test, χ^2 =0.242, d.f, = 46, p = 0.886). However, species richness across catchments was varied, for example, Indus catchment had highest number of 29 species, followed by the Shyok catchment which had 18 species and 10 species were present in Zanskar (Figure 2). Of the 32 species, a total of eight species *Diptychus maculatus, Diptychus Schizothoraichthys stoliczkae, Triplophysa microps, Triplophya tenuicauda* etc were common and distributed in all three catchments (Table 1).

Apart from exotic species, *Nemacheilus arafi, Schizothoraichthys labiatus* and *Schizothorax richardsonii* were some of the species exclusively caught in the Indus catchments. Indus snowtrout *Ptychobarbus conirostris* occurred in Indus and Zanskar, but not in Shyok. Zanskar did not have any species exclusive to this catchment. However, Shyok had three species, which were exclusively present there. All three species are under the process of identification. The most common fish in the catchments of Indus and Zanskar was *Diptychus maculatus* but its population size was very small in the Shyok catchment where *Schizopygoposis stoliczkae* was dominant.

Microhabitat of different catchments.-The microhabitat parameters such as water velocity, water temperature, altitude and algae were selected as the important determining factors of fish distribution, and these microhabitat variables that explained 99.1 % of variance in Discriminant Analysis test. Water depth, and turbidity were not included in the analysis since these factors were varied within a day in a sampling point and depends upon the intensity of sun light. During morning hours, stream water was clear with less depth, however, in afternoon, water level goes up due to snow melt. Turbidity also changed due to this changes in the water flow. The discriminant analysis identified algae and temperature as factor 1, and water velocity and elevation as factor 2. Sites with low algae and low temperature were not suitable places for the fish whereas sites with lower water velocity and more algae had more fish (Figure 3). The discriminant analysis also shows that the Indus has more sites suitable for fish than other two catchments .

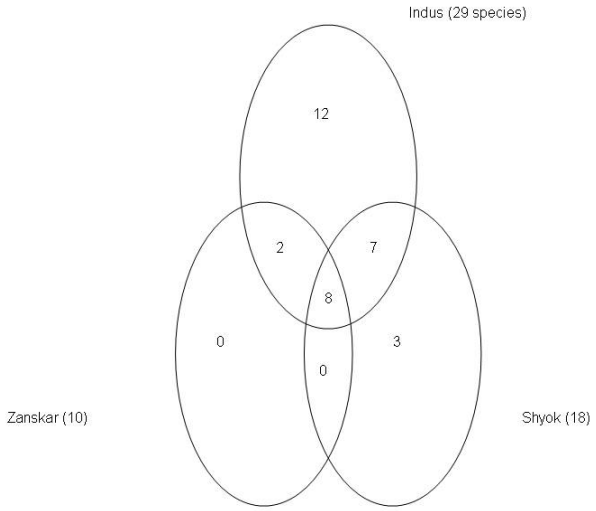

Figure 2. Fish species richness in the different catchments of Ladakh was heterogeneous. Indus had more number of species than other two catchments.

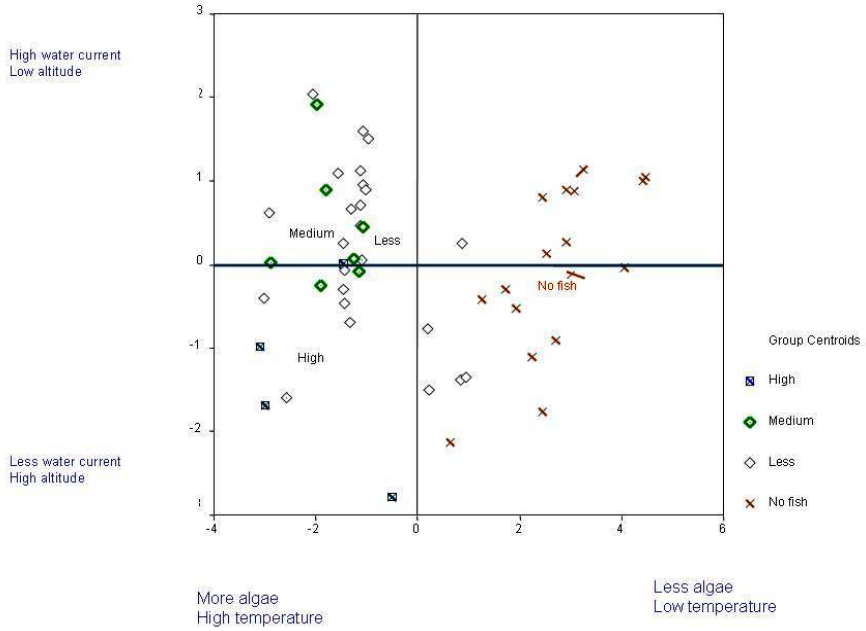

Figure 3. In Ladakh, fish species richness was very high in the habitats of high altitude with less water current, more algae and high temperature. The predicted model shows that fishes will not occur in the streams which has less algae and low temperature. Each data point in the graph is representing a sampling site. (Less = 1 to 3 species, medium = 4 to 6 species, high = 7 to 10 species).

Table 1. Status and distribution of lotic fishes in Ladakh.

S.l #	Species	Name	Indus	Zanskar	Shyok	Status
1	*Amblyceps mangois* (Hamilton, 1822)	Cat fish	1	0	0	Rare
2	*Catla catla* (Hamilton, 1822)	Catla	1	0	0	Not accessed (Exotic)
3	*Cyprinus communis* (Linnaeus, 1758)	Scale carp	1	0	0	Not accessed (Exotic)
4	*Cyprinus specularis* (Lacep¨de, 1803)	Mirror carp	1	0	0	Not accessed (Exotic)
5	*Gymnocypris biswasi* (Talwar, 1977)	Ladakh snow-trout	0	0	1	Rare
6	*Diptychus maculates* (Steindachner, 1866)	Tibetan snow-trout	1	1	1	Common
7	Diptychus spp with two yellow band*	Tibetan snow-trout	1	0	1	Common
8	*Diptychus spp with one yellow band**	Tibetan snow-trout	1	1	1	Not common
9	*Labeo calbasu* (Hamilton, 1822)	Rohu	1	0	0	Not accessed (Exotic)
10	*Nemacheilus arafi (*Mirza & Banarescu, 1981)	Loach	1	0	0	Rare
11	*Nemacheilus botia* (Hamilton, 1822)	Loach	1	1	0	Rare
12	*Nemacheilus fascimaculatus (*Mirza & Nalbant 1981)	Loach	1	0	1	Not common
13	*Nemacheilus gracilis (*Day, 1877)	Snow Loach	1	0	0	Rare
14	*Nemacheilus hutchinsoni (*Hora,1936)	Snow Loach	1	0	0	Rare
15	*Nemacheilus microps* (Steindachner, 1866)	Snow Loach	1	1	1	Common
16	*Nemacheilus montanus (*McClelland, 1839)	Loach	1	0	1	Not common
17	*Nemacheilus rupecola* (McClelland, 1838)	Loach	1	0	0	Rare
18	*Nemacheilus stolliczkae* (Steindachner, 1866)	Snow Loach	1	1	1	Common
19	*Nemacheilus tenuicauda* (Steindachner, 1866)	Snow Loach	1	1	1	Common
20	*Oreinus sinuatus* (Gray, 1832)		0	0	1	Rare
21	*Ptychobarbus conirostris* (Steindachner, 1866)	Indus snow-trout	1	1	0	Not common
22	*Salmo gairdnerii gairdnerii* (Walbaum, 1792)	Rainbow trout	1	0	0	Not common

23	*Schizopygopsis species (banded)**		0	0	1	Not common
24	*Schizopygopsis stoliczkae* (Steindachner, 1866)	Kinnaur snowtrout	1	1	1	Common
25	*Schizothoraichthys labiatus (*McClelland, 1842)	Kunar snow-trout	1	0	0	Rare
26	*Schizothorax richardsonii* (Gray, 1832)	Alwan snow-trout	1	0	0	Rare
27	Triplophysa choprai *(Hora, 1934)*	Snow Loach	1	0	1	Not common
28	*Triplophysa gracilis* (Day, 1877)	Snow Loach	1	0	1	Not common
29	*Triplophysa griffithi* (Günther, 1868)	Snow Loach	1	0	1	Not common
30	*Triplophysa ladacensis* (Günther, 1868)	Snow Loach	1	0	1	Common
31	*Triplophysa microps* (Steindachner, 1866)	Snow Loach	1	1	1	Common
32	*Triplophysa tenuicauda* (Steindachner, 1866)	Snow Loach	1	1	1	Common

1=presence, 0=absence, *= Unidentified species

Table 2. Legnth-Weight relationship and condition factor (K_{TL}) of two most common and commercially important fishes *Diptychus maculates* and *Schizopygopsis stoliczkae* of Ladakh.

Catchements	*Diptychus maculatus*				*Schizopygopsis stoliczkae*			
	Length-weight relationship	Average K_{TL} value	N	r	Length-weight relationship	Average K_{TL} value	N	r
Indus	$Log_{10}W$=-3.967+2.563 $Log_{10}L$	1.41	15	0.96	$Log_{10}W$=-3.560+2.367 $Log_{10}L$	1.14	14	0.98
Zanskar	$Log_{10}W$=-5.594+1.984 $Log_{10}L$	1.48	10	0.94	$Log_{10}W$=-3.461+2.334 $Log_{10}L$	1.28	98	0.97
Shyok	$Log_{10}W$=-3.808+2.436 $Log_{10}L$	1.22	31	0.96	$Log_{10}W$=-6.157+3.644 $Log_{10}L$	1.49	19	0.99
Over all	$Log_{10}W$=-3.667+2.411 $Log_{10}L$	1.32	56	0.96	$Log_{10}W$=-3.523+2.361 $Log_{10}L$	1.30	131	0.97

Table 3. Information about the sampling sites and their habitats.

Catchment	Site (nearest village name)	Location (E & N)		Altitude (MSL in meter)	Temperature (o C)	Water Depth (m)	Substratum	Shore vegetation	Turbidity	Species Richness	Total fish in catch
Indus	Chilling	34.02.239	77.12.055	3214	21	0.5	Rocky and pebble	riverine forest	Clear	0	0
Indus	Choglamsar	34.06.264	77.35.218	3235	18	2.8	Pebble with sand	No vegetation	very high	1	24
Indus	choglamsar	34.06.268	77.35.213	3235	25	0.1	pebble	No vegetation	clear	1	21
Shyok	Chushul	33.35.957	78.38.638	4385	6	0.4	boulders with gravel	No vegetation	not clear	3	9
Shyok	Deskit	34.33.615	77.32.510	3115	13	0.75	sandy	grasses	clear	10	210
Indus	Hemis Cheng	34.18.924	77.04.782	3746	8	1.3	pebble	No vegetation	clear	8	14
Shyok	Hundur	34.35.186	77.27.775	3169	4	0.4	pebble	No vegetation	clear	0	0
Zanskar	Kargil	34.33.190	76.08.185	2750	18	3	boulders with sand	No vegetation	very high	2	18
Indus	Keshar	33.25.014	78.13.511	4004	9	0.6	pebble with boulders	No vegetation	clear	0	0
Indus	Khardongla	34.15.779	77.36.906	4805	4	0.3	rocky with boulders	No vegetation	clear	0	0
Shyok	Khardung	34.22.513	77.39.622	4140	5	1.25	boulders with sand	grasses	clear	0	0
Shyok	Khardungla	34.16.719	77.36.274	5386	4	0.4	rocky with boulders	No vegetation	clear	0	0
Indus	Likir	34.16.736	77.12.155	3513	16	0.93	rocky with sand	plantation	clear	4	18
Indus	Mahi	33.15.930	78.28.127	4096	25	0.3	boulder	some bushes	clear	2	18
Indus	Nimu	34.09.824	77.19.167	3119	8	5	Sandy	No vegetation	very high	0	0
Shyok	Noth pullu	34.19.745	77.38.669	4663	5	0.6	gravel with mud	grasses	clear	0	0
Shyok	Panamik	34.47.567	77.31.586	3232	12	1.8	boulders with sand	No vegetation	clear	10	17
Shyok	Panamik	34.47.363	77.31.988	3244	4	0.75	pebble	No vegetation	clear	0	0
Zanskar	Penzila	33.50.880	76.23.635	4087	2	0.5	pebble with gravel	No vegetation	clear	2	6
Indus	phey	34.08.025	77.28.816	3197	14	3	gravel with sand	No vegetation	clear	2	15
Indus	Phey	34.08.025	77.28.534	3197	11	1	pebble with gravel	No vegetation	not clear	10	15
Indus	Phyang	34.12.152	77.30.620	3735	4	0.65	rocky with boulders	No vegetation	clear	1	15
Shyok	Rungchuk	34.27.152	77.44.165	3232	16	1.2	gravel with pebble	No vegetation	very high	4	33
Zanskar	Rungdum	34.02.804	76.20.744	4004	8	1.2	gravel with sand	No vegetation	not clear	1	21
Indus	Sankar	34.10.887	77.35.305	3415	3	0.37	cobble	No vegetation	clear	0	0
Indus	Sankar	34.10.938	77.35.204	3415	3	0.37	cobble	No vegetation	clear	0	0
Zanskar	Sankra	34.13.244	75.58.322	3142	8	0.4	rocky with pebble	No vegetation	clear	0	0
Indus	Saspu Chey	34.17.991	77.09.648	3597	7	1.25	rocky with boulders	shrubs	clear	2	48
Shyok	Satoo	33.51.677	78.17.861	4399	3	0.8	sand with pebbles	marsh with grasses	clear	4	27
Shyok	Satoo	33.51.677	78.17.952	4399	3	0.8	sand with pebbles	marsh with grasses	not clear	2	28

Shyok	Semur	34.37.156	77.37.550	3156	5	0.5	pebble	No vegetation	clear	0	0
Indus	Shaboo	34.08.065	77.37.985	3559	8	0.3	boulder	No vegetation	clear	1	24
Indus	Shang	33.51.675	77.41.970	3758	16	0.4	boulders with gravel	No vegetation	not clear	5	60
Indus	Shey			3235	16	2	marsh with soil	grasses	very high	5	18
Zanskar	Shila (Pipiting)	33.28.695	76.53.563	3535	12	1.5	boulders with sand	No vegetation	very high	1	1
Shyok	Spanmik	33.54.575	78.27.727	4263	13	>2	gravel with sand	No vegetation	clear	0	0
Indus	Sumdo Do	34.06.280	77.12.288	3202	16	0.43	rocky and pebble	riverine forest	clear	1	0
Shyok	Tirith	34.32.854	77.39.322	3263	15	0.6	gravel with pebble	No vegetation	clear	2	2
Indus	Tok Po	34.18.894	77.07.196	3690	8	0.68	rocky with boulders	shrubs	clear	1	1
Indus	Unknown	34.04.751	78.07.205	5265	4	0.4	boulders with pebble	No vegetation	clear	0	0
Indus	Unknown	34.02.051	78.12.640	4004	14	0.6	sandy	grasses	clear	2	6
Shyok	Unknown	33.50.741	78.33.928	4266	14	>3	gravel with sand	aquatic plants	clear	0	0
Shyok	Unknown	33.55.557	78.15.966	4327	4	0.7	boulders with gravel	No vegetation	clear	3	3
Shyok	Unknown	33.50.077	78.21.865	4512	4	0.8	boulder	No vegetation	clear	5	83
Shyok	Unknown	33.42.104	78.28.023	4817	4	0.5	boulder	No vegetation	clear	2	12
Shyok	Unknown	33.24.445	78.48.068	4586	11	0.3	boulder	No vegetation	clear	0	0
Indus	Unknown	33.15.400	78.24.110	4302	22	0.6	gravel with boulders	No vegetation	clear	3	32
Indus	Unknown	34.18.490	76.37.558	3607	18	0.5	Gravel with pebble	No vegetation	not clear	2	12
Zanskar	Unknown	34.11.011	75.55.835	3192	6	0.8	pebble with gravel	grasses on bank	clear	1	3
Zanskar	Unknown	33.42.477	76.32.742	3791	2	0.3	boulders with gravel	No vegetation	clear	4	81
Indus	Upshi	33.49.730	77.48.957	3245	8	2	pebble with sand	No vegetation	very high	1	9

Substratum was not important in the discriminant analysis, but a separate analysis was carried out on this habitat variable because earlier studies reported that substratum is an important microhabitat variable for freshwater fishes (Wikramanayake 1989). Highest species richness occurred in water bodies which had the substratum composition of pebble with gravel (13 species), sand (10 species), pebble (9 specise), boulder with gravel (8 species) and boulders (7 species). No fishes were recorded where the substratum was made up of only cobble and rock. The most commonly occurred species *D. maculatus* was found in nine substrates and another common species *S. stolickae* was found in eight substrates. In general, there was no specific substrate preference by the fishes in Ladakh (Kruskal Wallis test, $\chi^2 = 9.259$, $p = 0.508$, see also Table 3).

Size and condition factor of common fishes of Ladakh. -Legnth-Weight relationship and condition factor (K_{TL}) of two most common as well as commercially important fishes *Diptychus maculates* and *Schizopygopsis stoliczkae* of Ladakh was assessed (Table 2). The relative condition of both the species were almost similar in the Ladakh (Table 2), however, the condition factor of Shyok population of *Diptychus maculates* was comparatively low among all three catchments. But the condition factor of Shyok population of *Schizopygopsis stoliczkae* was better than other catchments populations. In general, Zanskar appears to be a better place for *D. maculates* but for *S. stoliczkae* the Shyok was better.

Discussion

***Status and distribution pattern of lotic fishes* in Ladakh**. - Habitat changes in Himalayan waters have had a major impact on the distribution and abundance of native fishes (Shrestha 1990). More than 30% of the lotic water fishes of Ladakh were assessed as rare. This might be due to habitat destruction and anthropogenic pressure on the breeding sites i.e. streams.. In Ladakh, snow-trout are known to migrate towards the upstream for spawning during the summer season. Fry and fingerlings grow in the clean water of the streams during the summer. During winter, when streams get frozen fingerlings start to migrate towards large rivers, where they settle down in little running water to survive. Since stream water flow was diverted into agriculture fields in Ladakh, the migration of fishes between upstream and river was completely stopped. This could be a major factor, which was responsible for threatening of several species of fishes in Ladakh.

The Indus catchment had more ideal microhabitats these were highly preferred by the fishes either for spawning or survival. This could be a reason as to why there was a large number of species occurred in this catchment. Apart from these habitats, Indus is comparatively larger than the other two catchments and as already mentioned that Shyok and Zanskar are part of the Indus catchement if seen out a landscape level. It is assumed that area of the catchment could also be an important factor that determining the species richness (MacArthur & Wilson 1963) which relates to the finding of this study that larger area of Indus catchment had a large number of species. The most common species of *Diptychus maculates* and *Schizothoraichthys stoliczkae* are feed by scraping the surfaces of stones and rocks. Algae including benthic diatoms are the most important food materials obtained in this way (Hutchinson 1936). This might be an another reason for the presence of more species in algal rich areas.

Condition factor of fishes in Ladakh. - The relative condition of adults of two commonly occurred species *D. maculatus* and *S. stolickae* was smilar in the Ladakh, however, *S. stolickae* was in better condition in Shyok but *D. maculatus* was not. Zanskar appears to be a better place for *D. maculates* but for *S. stoliczkae* the Shyok was better. Reason for this difference was not arrived due to one seasonal data. However, this study shows that the Zanskar is good for *D. maculates* angling during the summer season

and the Shyok is better for *S. stoliczkae* angling.

Conservation. -Exotic fishes were introduced into the Ladakh fishery farms to meet the local fish protein requirement. However, nowadays these farms are not playing major role in protein supply since majority of the local people do not eat fish. Predatory alien species *Oncorhynchus mykiss* may grow on fry and fingerlings of native species. This is the only alien species found outside the fishery farms, however, impact of this species on the native fish needs to be studied. Species richness in the Indus catchment was higher (29 species) than in the other two catchments. It would be better to give more attention in Indus catchement while planning for Protected Area Network and its management. During the summer, brooders start migrate to the upstream where the temperature is ideal for spawning. Fry, fingerlings, young and adult seen together in streams during this period. In Ladakh, most of the villages are located at the mouth of the down stream in order to divert stream flow to agricultural fields. Stream flow was diverted placing stones across the streams. These kinds of bundh (barrier) stopped the migration of fishes and it also noticed that there was no water connection between streams and river due to complete diversion of stream flow into agriculture fields. Construction of trout friendly weirs in selected streams will allow snowtrouts to migrate feely and breed successfully. Since *Diptychus maculatus* and *S. stoliczkae* are successful fishes in the streams and rivers of Ladakh, a careful research on breeding biology of these species would be useful for aquaculture.

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References

Anon. (1997). Conservation assessment and management plan for freshwater fishes of India. Technical report. National Bureau of Fish Genetic Resources, Lucknow. 46 pp.

Anon. (2001). Conservation biodiversity in the Trans-Himalaya: New initiatives of field conservation in Ladakh. First Annual Technical Report (1999-2000). Wildlife Institute of India. 169 pp.

Buceros. (2000). Bibiliography of papers from wetlands. Bombay Natural History Society. 45 pp.

Hora, S. L. (1951). Knowledge of the ancient Hindus concerning fish and fisheries of Indian. J. of Asiatic Soc. **17**: 145-169.

Hutchinson, E. G. (1936). Ecological observations on the fishes of Kashmir and Indian Tibet. Ecological Monographs. **9**(2):145-182.

Lagler, K. F. (1952). Freshwater fishery Biology. (Second edition), W.M.C. Brown Company Publishers, Iowa. 421 pp.

Le Cren, E. D. (1964). The interaction between freshwater fishes and nature conservation IUCN publications, New series. **3**: 431-437.

MacArthur, R.H. and Wilson, E.O. (1963). An equilibrium theory of insular zoogeography. Evolution. **17**: 373-387.

Maitland, P. S. (1993). Conservation of freshwater fish in India in *Advances in fish research* (ed. R. B. Singh). **1**: 349-364.

Nath, S. (1994). The Ichthyogeography of Jammu Province (Jammu and Kashmir state) India. Rec. Adv. Fish. Eco. Limn. Eco-conserv. **3**: 103-119.

Primack, R. (1998). Essentials of Conservation biology. Sinauer Associates, Sunderland, Mass. 559 pp.

Shrestha, T. K. (1990). Rare fishes of Himalayan waters of Nepal. J. of Fish Biology. **37**A: 213-216.

Wikramanayake, E. D. and Moyle, E.D. (1989). Ecological structure of tropical fish assemblages in wet-zone streams of Sri Lanka. J. Zoo. London. **218**: 503-526.

Woottan, R. J. (1991). Ecology of Teleost Fishes. Chapman and Hall, London-Newyork. 404 pp.