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DISTRIBUTION PATTERN, DENSITY AND MORPHOMETRIC CHARACTERISTICS OF *SCHIZOTHORACINES* (SNOW TROUTS) IN LIDDER RIVER, KASHMIR

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ABSTRACT

During present study three Schizothoracines viz *Schizothorax plagiostomus, S. esocinus* and *S. labiatus* (snow trouts) were found to be inhabiting the Lidder river along with *Salmo trutta fario*, *Crosscheilus diplochilus*, *Glyptosternon reticulatum* and *Triplophysa kashmirensis*. The study was carried at three Zones (upstream, midstream and downstream) of varied topography and physical characteristics. The distributional pattern of these Schizothoracines varied at different zones though present throughout the year. *S. plagiostomus* was the dominant fish in the River, upstream the number of fishes of all the three *Schizothorax* species was low but the specimens were heavier and older and the trend was reverse downstream. *Triplophysa kashmirensis* and *C. diplochilus* were recorded only in the downstream of the River. *Salmo trutta fario* and *G. reticulatum* were present in the midstream and upstream only. The value of "n' in Schizothoracine fishes fluctuated between 2.9467 and 3.0997. The maximum caudal fin length, head length, maximum body depth with respect to total length was observed in *S. plagiostomus*, *S. esocinus* and *S. labiatus* respectively. The variations in various morphometric parameters of the three species were statistically significant. Based on geographical characteristics and bio-ecological nature, the Lidder can be divided into upper trout zone and the lower carp zone.

INTRODUCTION

The rivers of the Kashmir Valley harbour a number of indigenous fishes like *Schizothorax* spp., *Glyptothorax* spp., *Triplophysa* spp. etc. and are also famous throughout the world for the exotic brown trout (*Salmo trutta fario*) and rainbow trout *(Onchorhynchus mykiss*). The trouts were introduced into the Valley at the beginning of the 20th century and have played an important role in the sport fishery of the Valley, attracting the visitors from all over the world. *Schizothorax* (Schizothoracine) also popularly called snow trout or Himalayan trout is an important food fish of Kashmir Himalaya. The fish inhabits the entire network of snow and spring fed cool water rivers and streams. The fish is believed to have migrated into the waters of Kashmir from Central Asiatic watershed, bordered by inner and southern slopes of Hindkush, Karakorum and the inner ends of north-western Himalayas and Sulaiman ranges. In this part of Himalayas the fish evolved into a number of species some of which are endemic in nature (Das and Subla, 1964; Jhingran, 1991). A wealth of literature is available on the limnology and fisheries of the aquatic habitats of Kashmir. However, most of these works pertain to Fishery biology in lentic habitats and the lotic environs have received less attention (Kumar and Bhagat, 1977; Vass *et al.,* 1977; Qadri and Yousuf, 1979, 1980, 1988; Qadri *et al.*, 1981; Raina *et al.,* 1982; Yousuf and Shah, 1988; Yousuf, 1996; Kullander *et al.*, 1999; Pandit *et al.,* 2001; Bhat and Yousuf, 2002, Yousuf *et al.*, 2003 and Bhat and Yousuf, 2004; Bhat *et al.*, 2005).

Aquatic habitat features have been identified as major determinants in the distribution and abundance of fishes from earlier times (Shelford, 1911). In world over a lot of work has been carried out on the fish distribution and their assemblages in riverine systems. Individual fish species as well as entire assemblage was studied for the patterns of distribution by Smart and Gee, 1979; Baker and Ross, 1981. Fish species diversity has been correlated with habitat complexity (Gorman and Karr, 1978; Schlosser, 1982) depth, flow and substrate types. Mathew and Hill (1980) and Leveque (1997) have studied the influence of these habitat attributes on the structure and function of fish assemblage in the streams in detail at different latitudes. Munshi and Srivastava (1988); Menon (1992); Jayaram (1999) have extensively studied on freshwater fishes in India, but most of their works were concerned with taxonomical studies. Studies on fish assemblage structure and their requirements in Indian streams are lacking, though few initiatives were started in the 1980's in south India by Arunachalam *et al*. (1998 and1997a), in Sri Lanka streams by Moyle and Senanayake (1984); Wickramanayake (1990), in Western Himalaya by Johal *et al*. (2002), Yousuf *et al*. (2001) and Bhat *et al*. (2010) and in Kumaon Himalaya by Negi *et al*. (2007). Fish habitat indicates the physical and chemical characteristics of the environment, excluding biological attributes. Habitats for fish is place or for migratory fishes, a set place in which a fish population or fish assemblage can find the physical and chemical features needed for life, such as suitable water quality, migration routes, spawning grounds, feeding sites, resting sites and shelter from enemies and adverse weather. It was with this background that the present work regarding habitat structure and its availability to fish assemblage, as well as habitat use and habitat suitability preference in Lidder river of Kashmir Himalaya of Jammu and Kashmir State, India, was undertaken.

MATERIALS AND METHODS

Study sites

Lidder River is one of the important right bank tributary of Jhelum River and flows through Lidder valley before joining the Jhelum. Lidder valley, with an area of 1246km^2, lies to the north of Anantnag district (Jammu and Kashmir, India) with the geographical coordinates of 33º04' – 34º15' N latitude and 75º05' – 75º32' E longitude. The valley is 50km long and has a varied topography with the altitudinal extremes of 1588 – 5215m above sea level. Lidder River is one of the important trout river formed by the confluence of east and west Lidder at Pahalgam. The former gets its origin from the Sheshnag Lake while the latter gets its water from the Tarsar Lake and Lidderwat glaciers. From Pahalgam below it traverses a distance of 35 kms. to join the Jhelum. Below Pahalgam, Lidder gets additional water from some small tributaries on its left and right banks. All along from its origin up to the mouth, its bottom is rocky with gravel and sand. Three study zones were selected along the course of the combined Lidder (Fig. 1). Zone I (upstream zones) is located 7km below the confluence of east and west Lidder (Pahalgam) near Langanbal Bridge, here the bottom is almost rocky and the velocity of water is very high as this part of river flows through gorge. The Latitude and Longitude of this zone are 33º58′ 08.2″ and 75º18′ 37.7″ respectively with an Altitude of 2035m. Zone II (midstream) is 14km downstream of the Zone I, near the Kathsoo village; here the bottom is having boulders, gravel and sand. The stream is less torrential here as compared to upstream. The Latitude and Longitude of this zone are 33º05′ 26.2″ and 75º15′ 54.0″ respectively with an altitude of 1768m. Zone III (downstream) is located near the Akura Bridge, about 10km downstream of Zone II and about 4km above the place, where Lidder joins the Jhelum River. The velocity of water here is comparatively slower and the bottom includes boulders, gravel, sand and clay. The Latitude and Longitude of this zone are 32º45′ 32.6″ and 75º 08′ 33.0″ respectively and the Altitude of this zone is 1594m.

Fishes

The fishes at the study sites were collected on monthly basis with the help of local fisherman (who mainly used cast net and Dip net) as well as by Electrofisher (Bagenal, 1978; Rousenfell, 1985). Whole fishes were preserved in a solution of formaline. Live fishes were generally fixed in such a solution to obtain best result, as they died in the solution with all the fins expanded. This solution was made by diluting one part of commercial formaline or commercial formaldehyde with 9 parts of water. The solution was neutralized with 5-10g of Borax per litre. The fishes were left in this solution at least for four to five hours for proper fixation. Fish less than 10cm were immersed in a formaline solution without any incision, while fish 10-30cm in length were given a narrow cut ventrally through abdominal wall a little to one side of mid ventral line. Care was taken to avoid damage to the intestine or alimentary canal. Fishes longer than 30cms were injected with undiluted concentrated formaline in several places and the belly was split in two or three places.

Freshly caught specimens were used for the measurement of various morphometric parameters. Length-weight relationship of fishes was determined by using the formula given by Le Cren (1951) *i.e.* $W = CL^n$. Identification of the fishes was done with the help of taxonomic studies made by Day (1877) and Kullander *et al.* (1999). The growth rate of different body regions in comparison to Total length (TL) and Head length (HL) was studied by regression analysis using formula $Y = a + bX$ and Correlation coefficient (r) between TL, HL with rest of the body parameters was calculated by using SPSS 13 software. Shannon diversity index was calculated as given by Shannon and Weaver (1949).

RESULTS

Fish species diversity

During the present survey a total of 7 species of fishes were collected. The taxonomic positions of these fishes are:

Order Cypriniformes family Cyprinidae

1. *Schizothorax plagiostomus* Heckel, 1838
2. *Schizothorax esocinus* Heckel, 1838
3. *Schizothorax labiatus* McClelland, 1842
4. *Crossocheilus diplochilus* Heckel, 1838

Family Balitoridae (Sub family Nemacheilinae)

5. *Triplophysa kashmirensis* Hora, 1922

Order Siluriformes family Sisoridae

6. *Glyptosternon reticulatum* McClelland, 1842

Order Salmoniformes family Salmonidae

7. *Salmo trutta fario* Linnaeus, 1758

Shannon Diversity Index in the River increased downstream and on average was minimum at Zone I (1.18), followed by Zone II (1.49) and maximum at Zone III (1.56). In Zone I, the minimum and maximum Diversity Indices were recorded in the months of May (0.64) and December (2.05) respectively. In Zone II, the Diversity Index ranged from 0.80 (October) to 2.17 (December). In Zone III, the Diversity Index was found minium in the month of October (0.74) and maximum in the month of December (2.14) (Fig. 2).

Catch composition

Out of 34 species of *Schizothorax* reported so far from the world and 12 from Kashmir (Yunfei, 1987; Jhingran, 1991; Yousuf, 1996) valley only three Schizothoracines viz *Schizothorax plagiostomus, S. esocinus* and *S. labiatus* were found to be inhabiting the Lidder river along with *S. t. fario*, *C. diplochilus*, *G. reticulatum* and *T. kashmirensis*. The distribution and contribution of these fishes to total catch varied spatially and temporally in different zones. The mean percent catch composition by number and weight of various species are presented in Table 1. All the three *Schizothorax* species were the main contributors to the fish catch in Zones II and III (downstream) while in Zone I (upstream) *S. plagiostomus* was the major dominant fish followed by *S. esocinus* and *S. t. fario*. The other species present in the River viz *T. kashmirensis*, *G. reticulatum* and *C. diplochilus* contributed to the catch only occasionally. The month-wise data of the catch composition showed variations not only between the zones but also with the different months (seasons) of the year. Fish catch was higher during the winter and early spring months in the river. However, with approach of summer a decrease in catch composition was observed.

At Zone I, the total fish catch by number showed gradual increase from August upto January followed by a decreasing trend from February upto July. In the River on mean basis, the most dominant role was played by *Schizothorax plagiostomus* which on an average contributed about 55.67 ± 3.83% to the total catch by number and 87.83% by weight. The maximum contribution by number and weight of this species was observed during Mar (76.66 %) and April (96.93%) respectively. The minimum catch in the river by number and weight was recorded during June (31.16%) and December (60.71%) respectively. The maximum contribution of *Schizothorax plagiostomus* to total catch in Zone I was observed in the month of January (8680g) and least in the month of August (3670g). In Zone II, its highest contribution by weight was recorded in June (4920g) and lowest in November (1210g). In Zone III, the highest contribution by weight of this species was found in December (4240g) while the least in June (1790g).

The second most dominant fish was *S. esocinus* whose contribution to the total catch by number and weight on mean basis was 15.16% and 4.16% respectively. Its minimum and maximum contribution to total catch by number (7.50% and 24.07% respectively) and weight (1.78% and 6.80% respectively) was recorded during October and September and October and January respectively. In Zone I, Zone II and Zone III *S. esocinus* on average contributed 12.02%, 12.27% and 13.97% to the total catch by weight respectively. *Schizothorax labiatus* in the river was the third most dominant fish by number and weight and formed 9.65% and 4.16% respectively on mean basis. The minimum (3.75%) and maximum (13.50%) contribution of the fish to total catch by number was recorded during the months of March and December respectively. The minimum (1.21%) and maximum (10.32%) contribution of the fish to total catch by weight was recorded during the months of October and December respectively. In Zone I it contributed 3.51%, in Zone II 9.04% and in Zone III 14.25% to the total catch by weight. The maximum contribution of the fish at Zone I was in December (980g), in Zone II in June (810g) and in Zone III in December (960g). Its least contribution was recorded in Zone I in February (316g), in Zone II in September (105g) and in Zone III in October (185g).

After Schizothoracine fishes, the exotic fish *Salmo trutta fario* was the most dominant fish in the river and in upstream (Zone I) the fish was recorded almost throughout the year, in midstream (Zone II) it was recorded only for few months of the year and in downstream (Zone III) the fish was totally absent. Its mean contribution to total catch by number and weight in the river was 5.46% l and 2.78% respectively. The minimum and maximum contribution of the fish to total catch by number was recorded during February (2.08%) and November (11.21%) respectively while its minimum and maximum contribution to total catch by weight was recorded during April (1.17%) and December (6.45%) respectively. The mean contribution of other fishes like *G. reticulatum, T. kashmirensis* and *C. diplochilus* to total catch by number and weight was 1.07%, 5.05% and 1.81% respectively and 1.55%, 1.445% and 1.18% respectively.

Morphometric observations of fishes

A total of 136 specimens of *S. plagiostomus* Heckel were taken for the morphometric characteristics of this fish which ranged in total length from 96 mm to 520 mm and in total weight from 7 g to 948g. The total length was 1.20 ± 0.02 times the standard length, 7.04 ± 4.82 times the head length, 5.92 ± 0.24 times the body depth, 2.39 ± 0.17 times the pre-dorsal length, 5.41 ± 0.36 times the pre-pectoral length, 2.20 ± 0.20 times the pre-pelvic length and 1.5 ± 0.14 times the pre-anal length. All these parameters recorded significant positive relationship (r d" 0.87) with the total length. Head length was 3.42 ± 0.88 times the snout length and 6.26 ± 2.08 times the eye diameter and it was having a significant positive relationship (r d" 0.81) with both the parameters. The maximum growth as obtained by the regression analysis as value of "b" with respect to total length in the fish was found by the standard length (0.8538) fallowed by pre-anal length (0.6115), pre-pelvic length (0.4290), pre-dorsal length (0.4190), head length (0.177), maximum body depth (0.1683) and pre-pectoral length (0.1648) (Table 2). The length-weight relationship in the fish was represented by the equation; Log W = -4.9653 + 2.9467 Log L or $W = 0.000010831L^{2.9467}$.

70 specimens of *S. esocinus* Heckel having total length from 57mm to 420mm and weight from 1g to 644g were taken for various recording various biological parameters. The total length was 1.20 ± 0.05 times the standard length, 4.51 ± 0.29 times the head length, 6.28 ± 0.43 times the body depth, 2.37 ± 0.07 times the pre-dorsal length, 4.68 ± 0.22 times the pre-pectoral length, 2.25 ± 0.13 times the pre-pelvic length, 1.56 ± 0.09 times the pre-anal length. All these parameters recorded significant positive relationship (r d" 0.98) with the total length. Head length was 3.66 ± 0.43 times the snout length and 5.98 ± 1.57 times the eye diameter. The maximum growth with respect to total length in the fish was found by the standard length (0.9080) and least by the maximum body depth (0.1730). The length-weight relationship in the fish was represented by the equation Log W = -5.1635 + 3.0034 LogL or $W = 0.000006862L^{3.0034}$.

Schizothorax labiatus McClelland and Griffith ranged in length from 92mm – 255mm and in weight from 7g to 179g in the river. Statistical analysis of the data revealed that the total length was 1.20 ± 0.01 times the standard length, 5.19 ± 0.25 times the head length, 5.69 ± 0.24 times the body depth, 2.44 ± 0.05 times the pre-dorsal length, 5.35 ± 0.30 times the pre-pectoral length, 2.32 ± 0.05 times the pre-pelvic length, 1.62 ± 0.03 times the pre-anal length. All the parameters showed a significant positive relationship (r d" 0.98) with the total length. Head length was 3.57 ± 0.41 times the snout length and

Table 1: Percent catch composition of fishes (number and weight) during different months of the year

	S. plagiostomus		*S. esocinus*		*S. labiatus*		*S.t. faria*
	Number	Weight	Number	Weight	Number	Weight	Number
Apr	57.37* ± 10.85**	96.93* ± 28.08**	9.39 ± 9.11	2.31 ± 2.17	11.62 ± 10.09	3.11 ± 2.69	6.67 ± 11.55
May	59.60 ± 21.11	89.46 ± 32.08	16.21 ± 5.46	4.09 ± 1.16	11.78 ± 10.75	3.72 ± 3.59	0.00 ± 0.00
Jun	31.16 ± 28.92	74.78 ± 22.10	15.23 ± 18.86	4.62 ± 5.29	10.90 ± 9.82	4.63 ± 4.64	3.17 ± 5.50
Jul	45 ± 39.68	64.25 ± 29.79	8.61 ± 7.47	2.50 ± 2.67	8.61 ± 7.47	3.24 ± 3.01	4.44 ± 7.70
Aug	58.23 ± 7.23	79.50 ± 6.01	23.65 ± 4.94	3.68 ± 1.27	6.73 ± 5.92	1.25 ± 1.19	8.33 ± 14.43
Sep	56.84 ± 8.72	86.54 ± 6.11	24.07 ± 2.50	4.12 ± 0.91	8.83 ± 7.94	1.94 ± 2.39	7.69 ± 13.33
Oct	72.08 ± 14.59	87.21 ± 21.86	7.50 ± 6.61	1.78 ± 2.16	10.00 ± 13.23	1.21 ± 1.18	6.25 ± 10.83
Nov	55.55 ± 9.62	89.81 ± 25.81	14.95 ± 4.35	4.36 ± 3.96	7.20 ± 6.46	5.64 ± 6.55	11.21 ± 10.22
Dec	43.29 ± 3.25	60.71 ± 24.53	15.38 ± 2.50	5.23 ± 1.07	13.50 ± 2.81	10.32 ± 6.09	7.41 ± 8.49
Jan	50.67 ± 10.12	67.26 ± 23.40	13.35 ± 3.88	6.80 ± 2.34	11.38 ± 4.39	8.24 ± 5.21	8.33 ± 14.43
Feb	61.66 ± 12.58	85.14 ± 18.61	16.09 ± 3.76	5.79 ± 1.46	11.56 ± 6.23	5.52 ± 0.79	2.08 ± 3.61
Mar	76.66 ± 2.88	94.07 ± 19.99	17.5 ± 6.61	4.69 ± 1.76	3.75 ± 3.31	1.18 ± 1.10	0.00 ± 0.00
Av.	55.67 ± 3.83	87.83 ± 21.53	15.16 ± 2.59	4.16 ± 2.19	9.65 ± 4.77	4.16 ± 2.19	5.46 ± 8.41

Table 1: Cont.......

	S.t. faria	*G. reticulatum*		*T. kashmirensis*		*C. diplochilus*	
	Weight	Number	Weight	Number	Weight	Number	Weight
Apr	1.17 ± 2.02	3.33 ± 5.77	2.25 ± 3.90	11.61 ± 10.08	2.07 ± 3.24	0 ± 0	0.00 ± 0.00
May	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	12.40 ± 11.10	2.73 ± 4.39	0 ± 0	0.00 ± 0.00
Jun	3.82 ± 6.61	0 ± 0	0.00 ± 0.00	6.13 ± 6.92	1.13 ± 1.85	0 ± 0	0.00 ± 0.00
Jul	4.19 ± 7.25	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00
Aug	1.38 ± 2.39	0 ± 0	0.00 ± 0.00	3.03 ± 5.24	0.07 ± 0.12	0 ± 0	0.00 ± 0.00
Sep	1.74 ± 3.02	0 ± 0	0.00 ± 0.00	2.56 ± 4.43	1.27 ± 2.20	0 ± 0	0.00 ± 0.00
Oct	1.77 ± 3.07	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00
Nov	7.76 ± 9.29	9.69 ± 10.01	6.38 ± 7.99	1.39 ± 2.40	0.66 ± 1.15	0 ± 0	0.00 ± 0.00
Dec	6.45 ± 5.85	7.87 ± 6.85	7.09 ± 10.64	7.51 ± 8.65	3.86 ± 6.54	5.03 ± 8.71	6.33 ± 10.97
Jan	4.08 ± 7.07	1.19 ± 2.06	2.86 ± 4.96	7.15 ± 8.06	3.46 ± 5.79	6.06 ± 10.49	7.30 ± 12.65
Feb	0.98 ± 1.69	0 ± 0	0.00 ± 0.00	6.84 ± 5.93	2.02 ± 3.27	1.75 ± 3.03	0.55 ± 0.96
Mar	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	2.08 ± 3.60	0.06 ± 0.10	0 ± 0	0.00 ± 0.00
Av.	2.78 ± 3.20	1.07 ± 2.26	1.55 ± 2.29	5.05 ± 5.49	1.44 ± 2.39	1.81 ± 3.13	1.18 ± 2.05

*Mean ± **Std

Table 2: Correlation coefficient (r) and regression coefficients (a and b) of various morphometric parameters with TL and HL in three *Schizothorax* species

Independent variable	Dependent variable	*S. plagiostomus*			*S. esocinus*			*S. labiatus*		
		a	b	r	a	b	r	a	b	r
	Standard length	-4.2336	0.8538	0.9997	-12.766	0.908	0.9971	-4.3929	0.8601	0.9999
Total Length (TL)	Head length	-2.1446	0.177	0.874	-3.4109	0.2428	0.9962	4.1346	0.167	0.9892
	Max. body depth	0.4584	0.1683	0.9846	-2.4396	0.173	0.985	0.7469	0.1712	0.9856
	Pre-dorsal L	-0.367	0.419	0.9795	-4.2299	0.4453	0.9966	-1.4136	0.4187	0.9965
	Pre pectoral L	4.9095	0.1648	0.9857	-1.151	0.2215	0.9977	4.5973	0.1586	0.9846
	Pre pelvic L	5.9559	0.429	0.9794	-3.1491	0.4594	0.995	-1.8031	0.4415	0.9969
	Pre-anal L	13.897	0.6115	0.9711	-7.0631	0.6798	0.9922	-3.4357	0.6396	0.9974
Head Length (HL)	Snout length L	2.7728	0.2402	0.8631	0.5939-	0.2936	0.9366	-2.4686	0.3626	0.8821
	Eye diameter L	4.2998	0.0675	0.8189	-0.365	0.1748	0.8076	0.0605	0.2117	0.8157

4.71 ± 0.58 times the eye diameter. The maximum growth with respect to total length in the fish was found by the standard length (0.8601) and least by pre-pectoral length (0.1586). The relationship between the length and weight in the fish was expressed by the equation Log W = -5.25 + 3.0997LogL Or $W = 0.000005956L^{3.0997}$.

DISCUSSION

Depth and water velocity are regarded as the two major factors responsible for the distribution of fish species in the different habitats (Gorman and Karr, 1978; Moyle and Vondraceek, 1985; Arunachalam, 2000, Johal *et al.*, 2002 and Negi *et al.*, 2007). The river being massive flows there through gorge with high speed in upper reaches (Zone I) with more depth as compared to downstream (Zone II and III) where the speed as well as depth was low. Downstream the river water is diverted through enormous channels for irrigation, drinking and for other domestic and commercial uses and thus the water quantity, flow and depth get reduced. This substantial difference in river characters upstream and downstream were found responsible for the fish distribution and assemblages that is why upstream the number of the fishes (specimens and species) were less but the specimens were heavier and older. The trend was reverse downstream were only the smaller sized

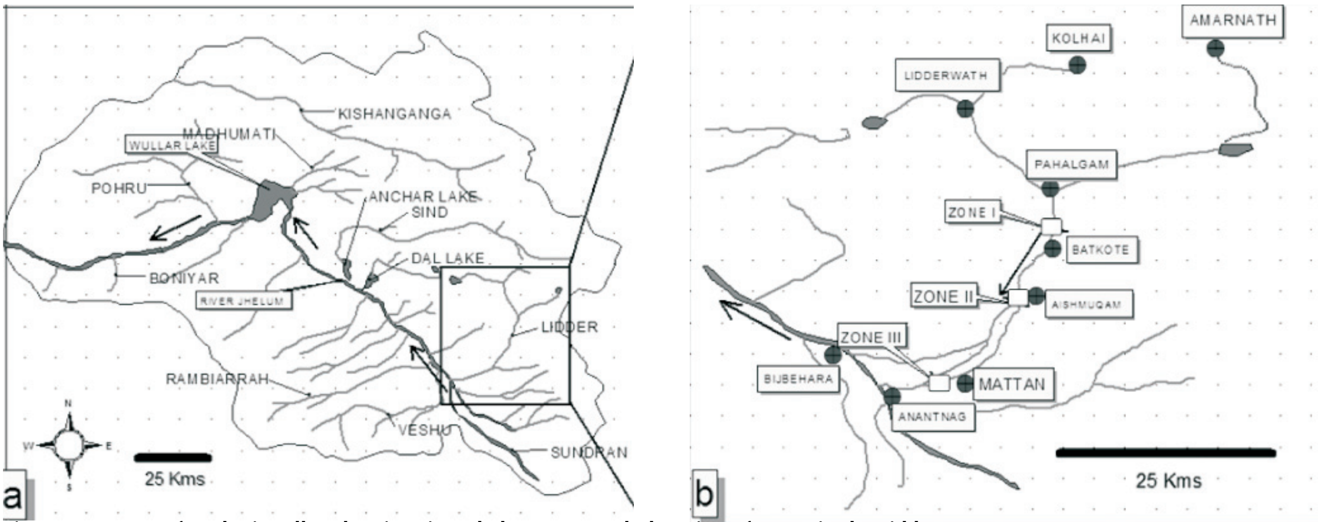

Figure 1(a): Map of Kashmir valley showing river Jhelum system, (b) location of zones in the Lidder stream

fishes and more species were present. The smaller fishes upstream are unable to withstand the high current velocity. This is supported by the works of Harvey and Stewart (1991) and Bain *et al*. (1988) who reported that small fishes remain restricted to shallow stream margins as compared to mid stream reaches were the current is fast or too deep or both and this is also substantiated by Horowitz (1978) who reported that most of the fishes in the small lotic systems are habitat generalists. The dominance of *S. plagiostomus* throughout the river seems to be related to its love for fast flowing water in torrentials (Yousuf, 1996) and this fish was present both in low and high depth and velocity. Although *S. esocinus* ranked 2^{nd} and *S. labiatus* ranked 3^{rd}, the two species were recorded at Zone I only during the winter months when the current was low, whereas, downstream they were present throughout the year. The presence of homogenous type of mixing of fishes during winter (December) in the river when the depth and water current substantially decreases has led to almost high Shannon Diversity index during this period. However, during spring and summer season (April – July) due to start of melting of glaciers and snow in the upper reaches, the depth and water current in the river increases which has lead to heterogeneity of fish distribution and decrease in Shannon Diversity Index. Comparatively in downstream (Zone III), the presence of Cobitids and Cyprinids throughout the year has lead to high Shannon Diversity Index. This is in accordance with the hypothesis of Horowitz (1978) who reported that species diversity increases with stream order (downstream) and which has subsequently been proven true in the case of many tropical rivers including those from the northern part of Western Ghats by Bhat (2003).

Salmo trutta fario contributed to the catch in most of the months of the year in the upstream. This is related to the cleanness of the water upstream where the high dissolved oxygen, low nutrients and high density of benthic insects were recorded throughout the year. The trout being carnivorous (Allan, 1981., Forrester *et al*., 1994., Elliott, 1997, 2000., Amundsen *et al*., 1999) in habit and feeds on the benthic fauna which flourished well in upper reaches (Zone I and II) and that is the reason that the trout was restricted to these zones only. Arunachalam (2000) reported that non cyprinids such as Balitorids occur mostly in pool edges and shallow waters, similar results were observed during the present investigations having the diverse group of small fish species such as *T. kashmirensis* and *Crossocheilus diplochilus* restricted primarily to downstream with shallow depth and slow water current velocity. At Zone II (midstream) the good catch composition during April to July (spring and early summer) can be attributed to the upward migration of fishes for spawning and breeding (Jyoti and Malhotra, 1975; Sunder *et al.,* 1984; Yousuf, 1996, Yousuf and Firdous, 1997; Bhat *et al*., 2010) and seems to effect greatly to the catch statistics in the main river.

The morphometric measurements have been extensively used in identification of fish (Kullander *et al*., 1999 and Yousuf *et al*., 2003). The maximum caudal fin length was observed in *S. plagiostomus*, where it formed 16.2 % of the total length, followed by *S. esocinus* (14.85 %) and *S. labiatus* (15.88 %). *S. esocinus* showed the longest head region among the three species, being 0.24% of the total length. Because of the longer head in *S. esocinus* the pre-dorsal, pre-pectoral, pre-pelvic and pre-anal regions recorded the highest ratio with reference to the total length in this species. However, the ratio between snout length and the eye diameter recorded highest values in *S. labiatus*. The maximum body depth was observed in *S. labiatus* followed by *S. plagiostomus* and the lowest in *S. esocinus*. The high peduncle depth was found in *S. labiatus* followed by *S. plagiostomus* and the lowest in *S. esocinus*. The variations in various morphometric parameters of the three species were statistically significant and thus can be regarded as different species (Yousuf, 1996; Kullandar *et al*., 1999 and Yousuf *et al*., 2001).

According to Allen (1938) the value of "n" in length-weight relationship remains constant at 3 in an ideal fish living in an ideal condition. However, as a fish passes through several stages, the simple cube law does not hold well throughout its life span and equilibrium constant shows certain variations (Martin, 1949) in the growth pattern of fish. As the growth of a fish is very important for more specific fishery management and is influenced by many environmental factors like pH, temperature, salinity, dissolved oxygen, ammonia, heavy metal

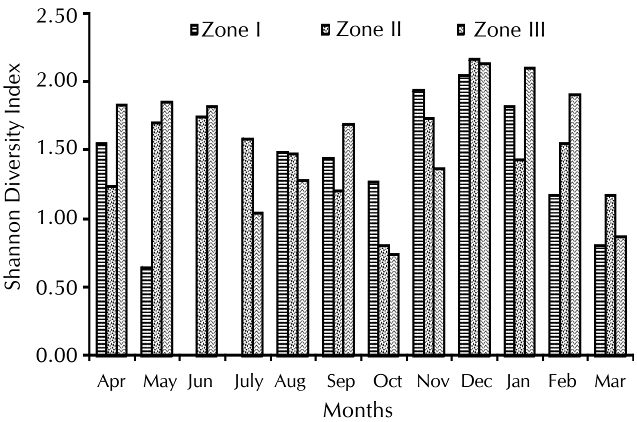

Figure 2: Shannon diversity index of fishes in different zones in Lidder river

concentration etc. Yousuf and Firdous (1992) and Yousuf *et al*. (2001) suggested the environmental factors to a great extent responsible for the deviation from the ideal state and Antony (1967) has reported the value of "n" deviating from 2.0 to 5.4. The value of "n" being near to 3 in *S. esocinus* and *S. labiatus* and a little deviated from '3' in *S. plagiostomus* during the present study can be attributed to the fact that the *S. esocinus* and *S. labiatus* species were recorded only from the lower reaches of the Lidder where the water current was less and the food was present in abundance as compared to the upper reaches where the current is too fast and the *S. plagiostomus* was the most dominant fish there and had to face the stress of huge volume of the fast water which definitely has a bearing on the growth pattern of the fish (Bhat, 2003).

All the Schizothoracine fishes recorded in the Lidder during the present study are typical inhabitants of running habitats in their distributional range and generally prefer clean waters (Yousuf, 1996; Yousuf *et. al.,* 2003). The Lidder water as has been reported to be having relatively low pollution load by Bhat (2003) and as such the environmental stress on the three species seems to be of the very low order. This has led to the almost ideal growth pattern in these fishes in the river. The upper reaches of the unified Lidder, where trout was recorded can be regarded as trout zone while downstream, due to presence of species like *Triplophysa kashmirensis, Crossocheilus diplochilus, S. labiatus* and *S. esocinus,* can be regarded as carp zone. The presence of smaller sized fish (fry and fingerlings) in the downstream and midstream seems to be related with the feeding and breeding grounds of *Schizothoracines*. In order to manage the fisheries, especially *Schizothoracine* fishes, in the river, immediate steps need to be taken to control the entry of sewage, agriculture wastes and domestic effluents into it.

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