Pak. J. Agri. Sci., Vol. 53(4), 833-842; 2016
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/16.4849
http://www.pakjas.com.pk

DIVERSITY AND STATUS OF ICHTHYOFAUNA OF HILL TORRENTS OF SULEMAN MOUNTAIN RANGE, DERA GHAZI KHAN REGION, PAKISTAN

Sajjad Hussain[1,2,*], Muhammad Z. Hussain[3], Rehana Iqbal[1], Khalid Abbas[6], Javed A. Mahmood[5], Furhan Iqbal[1] and Muhammad Ali[4]

[1]Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan; [2]Government Postgraduate College, Dera Ghazi Khan, Pakistan; [3]Government Emerson College, Multan, Pakistan; [4]Government College University, Faisalabad; [5]Revenue Department, Government of Pakistan; [6]Department of Zoology, wildlife and fisheries, University of Agriculture, Faisalabad, 38040, Pakistan.
[*]Corresponding author's e-mail: sajjadh248@gmail.com

The current study investigated abundance, species richness and diversity of Ichthyofauna of hill torrents of Suleman Mountain, Range, Dera Ghazi Khan Region, Pakistan. Fish sampling was carried out from ten sites. The fishes were identified following standard taxonomic keys. Relative abundance (%) and diversity indices were calculated. One way analysis of variance (ANOVA) was used to compare the fish abundance and diversity at different sites. Twenty fish species belonging to five families were recorded. Cyprinidae was the richest family represented by sixteen fish species, demonstrating a significant dominance ($P<0.05$) in number of species over other families. *Tor macrolepis* was the most abundant species (20.87%). A significant difference ($P<0.001$) was observed for species abundance at various sites, with maximum abundance (21.11%) found at Hingloon. Similarly, a significant difference ($P<0.001$) was demonstrated for species richness between different sites, with maximum taxa number found at Barthi. The fish fauna was indigenous with three endemic species i.e. *Barilius pakistanicus*, *Labeo dyocheilus pakistanicus* and *Salmophasia punjabensis*. Diversity indices values did not indicate conclusive status about fish diversity of the region. Simpson diversity index indicate greater diversity, Shannon Weiner indicate moderate diversity and Margalef index indicate poor fish diversity of the region. The occurrence in wild of some high value commercial fishes indicates towards commercial fisheries potential of the area.
Keywords: Diversity indices, species richness, cyprinidae, hill torrents, endemism.

INTRODUCTION

Fishes are a valuable resource not only for other organisms of aquatic ecosystem but also for humans. Being an integral component of aquatic ecosystems, they have key role in energy flow, nutrient cycling and maintenance of community balance (Nelson, 2006; Kang *et al*., 2009). Freshwater fishes exhibit extraordinary taxonomic breadth, endemism and a wide range of geographic distribution (Leveque *et al*., 2005; Javed, 2015). The taxonomic diversity of freshwater fishes is revealed by the wide range of morphological, behavioral, and life history characteristics of the constituent species. Freshwater fishes dwell a wide range of habitats like streams, rivers, lakes, and wetlands bordered by terrestrial ecosystems. Thus, the dispersal of freshwater fishes is limited due to habitat isolation. This fact result in rich taxonomic and functional diversity of freshwater fishes (Berra, 2007). Therefore, freshwater fish is a major contributor to the rich biodiversity of freshwater ecosystems (Saunders *et al*., 2002). Freshwater ecosystems are important for maintenance and development of human culture.

This phenomenon has resulted in severe and complex impacts to freshwater biodiversity (Malmqvist and Rundle, 2002). In recent times, majority of the freshwater ecosystems have become highly threatened through anthropogenic activities and as a result their rich biological resources are rapidly diminishing (Dudgeon *et al*., 2006). Freshwater fishes are highly sensitive to the quantitative and qualitative changes in the aquatic ecosystem and thereby, constitute greatest proportion of the threatened species (Darwall *et al*., 2005; Moyle and Leidy, 1992). However, there exist several freshwater habitats where anthropogenic activities are at minimum level and their freshwater life could be least effected by modern day technology.

The Suleman Mountain Range, Dera Ghazi Khan Region, is a far off area of Pakistan with minimum human intervention. It is considered to be least effected by modern technology (Personal communication). Therefore, biodiversity of the region is expected to be conserved. However, there have been very little efforts to explore the biodiversity of this area. The current study aimed to assess the abundance, diversity, species richness and status of fish fauna of Suleman Mountain Range, Dera Ghazi Region, Pakistan. A more comprehensive and analytical approach, both qualitatively and quantitatively was adopted in present study compared to previous study (Ali *et al*., 2010) in this area.

MATERIALS AND METHODS

***Study area*:** The Suleman Mountain Range is situated in the middle Indus region. The Suleman Basin is the largest basin of main Indus Basin and consists of about 170,000 Km^2 (Malkani, 2010). Dera Ghazi Khan Region of the Suleman Mountain Range consists of Dera Ghazi Khan and Rajan Pur districts (28° 615009′ to 31° 188469′N and 69° 751382′to 70° 558877′E) (Fig. 1). The study area is situated in semi-arid subtropical continental monsoon region of Pakistan and consists of 13 catchments. Around sixty five percent of catchment areas consist of barren mountains without vegetative cover (Hanson, 1995).

The region is characterized by extremely dry climate both in summer and winter season. The water precipitation is in the form of occasional seasonal rains, during rainy season (July–September). The high intensity fleshy rains result in torrential flow (fast flowing water). These streams with high flow velocity are called "Hill Torrents" locally known as "Nallahs/Rodhkohi", a characteristic and unique feature of the area (Government of Pakistan, 1999). Throughout the region, there are frequently scattered pits and ponds associated with these streams. Most of the catchments drain to the River Indus.

***Fish sampling and analysis*:** Fish samples from standing water bodies of different localities of Suleman Mountain Range, Dera Ghazi Khan Region (Table 1; Fig. 1) were collected by using cast and drag nets (mesh size 2 cm^2); and scoop nets (mesh size 1 cm^2). Each catch was sorted by species and counted. The fishes for purpose of identification were preserved in ice and then brought to laboratory. The fishes were identified with the help of standard taxonomic keys (Mirza and Sharif, 1996; Talwar and Jhingran, 1991). The relative abundance (%) was calculated by using the formula; RA = n/N x 100, Where, n is number of individuals at one site and N indicates total number of individuals at all sites.

The Simpson diversity index (D) was calculated by using formula; $D = \sum ni\ (ni-1)/N\ (N-1)$ following Simpson (1949), Where, ni is number of individuals of ith species and N indicates total number of individual in division/phyla/group. The Shannon-Weiner index (H) was calculated by using formula; $H = -\sum ni/N \times Ln\ (ni/N)$ following Shannon and Weiner (1963), Where, ni = number of individuals of ith species, N = total number of individual in division/ phyla/group, Ln = natural logarithm. The Margalef index (d) was calculated by using formula; $d = (S-1)/ Ln\ N$ following

Margalef (1968), Where, S = number of species, Ln = natural logarithm, N = total number of individual in division/phyla/group. The Evenness index (E) was calculated by using formula; E = H/Ln S following Pielou (1966), Where, H = Shannon-Weiner index, Ln = natural logarithm, S = number of species. The Jaccard's index of similarity (J) was calculated by using formula; $J = j/[(x+y) - j]$ following Jaccard (1912), Where, j = Number of common species both to sample A and B, x = total number of species

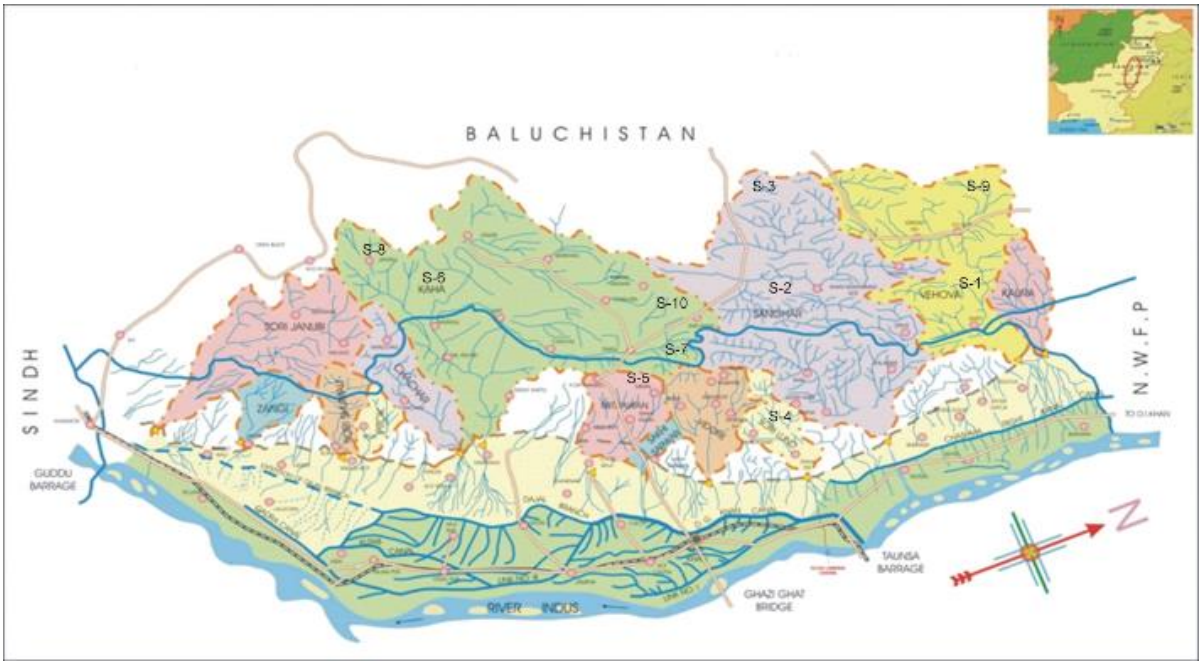

Figure 1. Location map of study sites (S-1 =Vehovwa; S-2 = Barthi; S-3 = Hingloon; S-4 = Zinda Peer; S-5 = Jaj; S-6 = Harand; S-7 = Siri; S-8 = Murunj; S-9 = Chitar Wata; S-10 = Rakhi Gaj) of Hill Torrents of Suleman Mountain Range, Dera Ghazi Khan Region, Pakistan.

Table 1. Names and location of sampling sites.

Site number	Site name	Hill torrent name	Altitude (Feet)	Geographic coordinates*
S-1	Vehowa	Gang	1200	31° 144637′N 70° 372431′E
S-2	Barthi	Sanghar	1050	30° 551303′N 70° 368479′E
S-3	Hingloon	Hingloon	3043	30° 469281′N 70° 067694′E
S-4	Zinda Peer	Sori Lund	1500	30° 408283′N 70° 481962′E
S-5	Jaj	Dalana	1583	30° 088246′N 70° 343917′E
S-6	Harand	Kaha	1250	29° 540411′N 70° 096233′E
S-7	Siri	Siri	2100	30° 012835′N 70° 134452′E
S-8	Morunj	Sori	2600	29° 263532′N 69° 411065′E
S-9	ChitarWata	Toe Sar	1800	31° 238996′N 70° 325663′E
S-10	RakhiGaj	Rakhi	2300	29° 956259′N 70° 106276′E

*www.latlong.net/c/?lat; https://www.google.com/maps/place

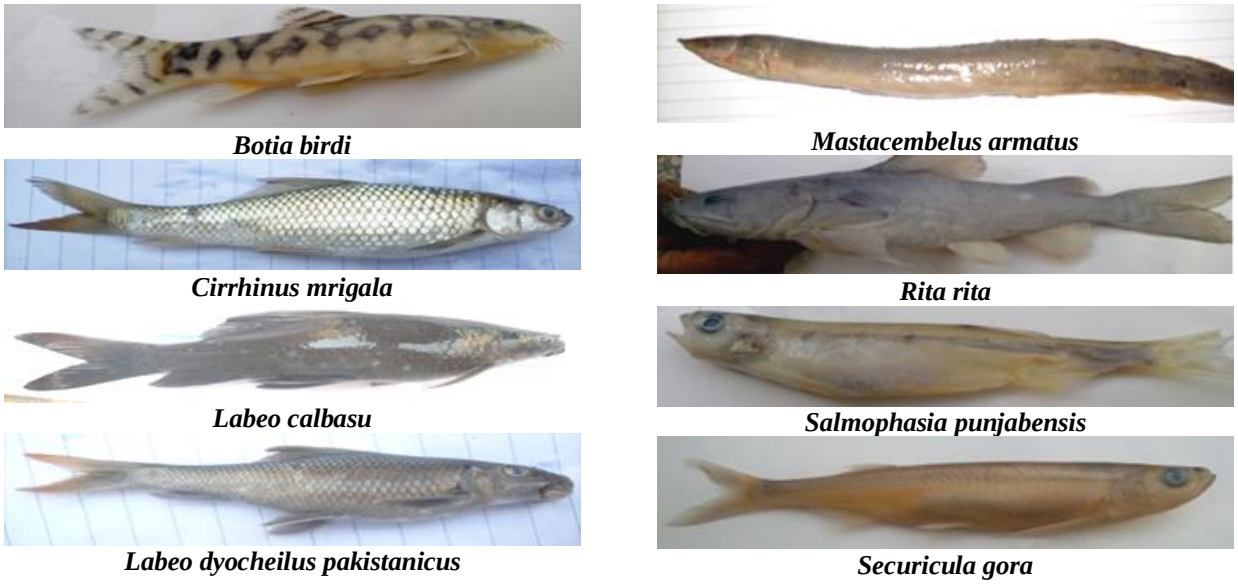

Figure 2. The figures of fish recorded in current study excluding the figures of identified fish from previous study (Ali *et al*., 2010).

in sample A, y = total number of species in sample B.

In present study, two more catchment areas i.e. Sori and Toe Sar were explored for fish biodiversity compared to previous study. Also for previous catchment areas, more number of water bodies was explored for fish diversity compared to previous study (Ali *et al*., 2010). However, for one catchment area i.e. Sanghar, new water bodies were explored for fish biodiversity instead of previous one.

***Statistical analyses*:** One way ANOVA, followed by posthoc LSD test was employed to compare the abundance, species richness and diversity of fish community at various sites. Cluster analysis was carried to assess similarity level of species composition at various sites. Dendrogram was constructed based on single linkage method. All statistical analyses were carried out using Minitab 16.

RESULTS

A total of 20 fish species belonging to 16 genera and 5 families were recorded from ten sampling sites of Suleman Mountain Range, Dera Ghazi Khan Region (Table 2). The family cyprinidae was the most dominant family comprising 80% (16/20) of the fish species. While other families i.e. cobitidae, bagridae, siluridae and mastacembelidae comprised 5% (1/20) each (Table 2).

One way ANOVA demonstrated a significant difference ($P < 0.05$; $df = 4$; $F = 8.20$) for occurrence of species number in different fish families in this region. Cyprinidae was significantly different from other fish families ($P<0.05$, post-hoc LSD test). Cyprinid constituted 96.80% of the total catch from all sites (Table 2). One way ANOVA demonstrated a significant difference ($P<0.05$; $df = 4$; $F = 3.44$) for the number of individuals of different fish families.

Table 2.Fish abundance and status of each species during study period.

Scientific name	Common name	n	RA (%)	Distributional	IUCN‡	Commercial*
Family Cyprinidae			**96.80**			
1.*Tor macrolepis*	Mahseer	340	20.87	Indigenous	NE	High
2.*Barilius vagra*	Chalwa	187	11.48	Indigenous	LC	–
3.*Barilius modustus*	Chalwa	68	4.17	Indigenous	NE	–
4.*Labeo diplostomus*	Paharirahu	277	17.00	Indigenous	LC	High
5.*Salmostoma bacaila*	ChotiChal	47	2.89	Indigenous	LC	–
6.*Garra gotyla*	Pathar chat	131	8.04	Indigenous	LC	–
7.*Securicula gora*	Bari Chal	13	0.80	Indigenous	LC	–
8.*Labeo dyocheiluspakistanicus*	Pakistani toraki	116	7.12	Indigenous	LC	High
9.*Crossochelus diplocheilus*	DograPathar Chat	70	4.30	Indigenous	NE	–
10.*Schizothorax plagiostomus*	Sawati	123	7.55	Indigenous	NE	High
11.*Cyprinion watsoni*	Sabzak	173	10.62	Indigenous	NE	–
12.*Labeo calbasu*	Kalbans	2	0.12	Indigenous	LC	–
13.*Puntius sophore*	Sophorepopara	3	0.18	Indigenous	LC	–
14.*Barilius pakistanicus*	Pakistani chalwa	19	1.17	Endemic	NE	–
15.*Salmophasia punjabensis*	Punjabi chal	4	0.25	Endemic	NE	–
16.*Cirrhinus mrigala*	Mori	4	0.25	Indigenous	LC	High
Family Cobitidae			**0.25**			
17.*Botia birdi*	Birdi loach	4	0.25	Indigenous	NE	–
Family Bagridae			**0.25**			
18.*Rita rita*	Khaga	4	0.25	Indigenous	LC	Very High
Family Siluridae			**2.45**			
19.*Ompok pabda*	Paharipafta	40	2.46	Indigenous	NT	–
Family Mastacembelidae			**0.25**			
20.*Mastacembalus armatus*	Bam	4	0.25	Indigenous	LC	High

n = number of organisms; ‡ = IUCN status described is worldwide; RA = relative abundance; NE = not evaluated; LC = least concerned; NT = near threatened. Fish family abundance in bold; *, ‡ = Rafique and Khan (2012).

Table 3.Fish abundance and diversity indices values at study sites.

Site	n	SR	RA (%)	D	H	d	E
S-1	290	7	17.80	0.21	1.68	1.09	0.30
S-2	220	8	13.50	0.23	1.66	1.30	0.31
S-3	344	7	21.11	0.23	1.64	1.03	0.28
S-4	92	4	5.64	0.29	1.29	0.66	0.29
S-5	134	4	8.22	0.26	1.36	0.61	0.28
S-6	127	7	7.79	0.31	1.37	1.24	0.28
S-7	44	3	2.70	0.34	1.06	0.53	0.28
S-8	213	7	13.07	0.22	1.63	1.12	0.30
S-9	136	5	8.34	0.33	1.27	0.81	0.26
S-10	29	2	1.78	0.53	0.64	0.30	0.19

n = number of individuals; RA = relative abundance; D = Simpson diversity index;
H = Shannon-Weiner index; d = Margalef index; E = evenness index; SR = Species richness

There was a significant difference for number of individuals of cyprinidae from family cobitidae, bagridae and mastacembelidae ($P<0.05$, post-hoc LSD test). However, no significant difference was found between cyprinidae and family siluridae ($P>0.05$, post-hoc LSD test).

The fishes were categorized on the basis of relative abundance (%) i.e. abundant (>10%), moderate (2-10%) and rare (< 2%). One way ANOVA revealed a significant difference ($P<0.001$; df = 19; F = 8.314) between number of individuals of fish species. Several fish species were found abundantly (RA>10%). *Tor macrolepis* was the most abundant species (20.37%). Other abundant cyprinids species were *Labeo diplostomus*, *Barilius vagra* and *Cyprinion watsoni* (Table 2). Some members of cyprinids i.e. *Barilius modestus*, *Salmostoma bacaila*, *Gara gotyla*, *Labeo dyocheilus pakistanicus*, *Schizothorax plagiostomus*; and the silurid i.e. *Ompok pabda* showed moderate abundance (RA 2-10%). Rest of the species of family cyprinidae and other families were quite rare (RA<2%).

The highest number of individuals was found at Hingloon. Vehowa, Barthi and Murunj also showed high abundance. Zinda Peer, Jaj, Harand, Siri and Chitar Wata showed a significant difference ($P<0.001$; df = 9; F = 24.70) moderate abundance, while RakhiGaj has low abundance (<2%), (Table 3). One way ANOVA demonstrated that there between the abundance of fish individuals among study

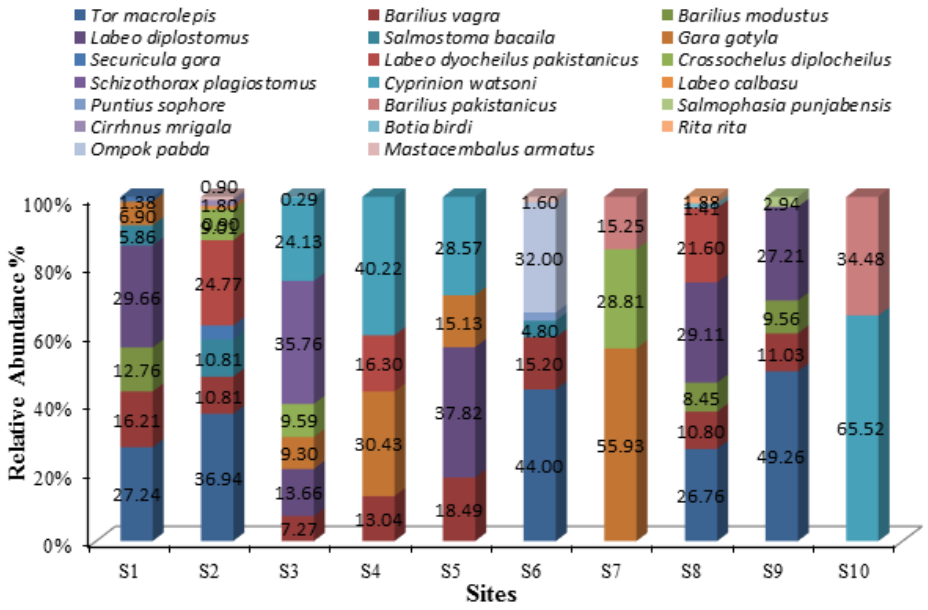

Figure 3. The relative abundance (%) of each fish species within each site during study period at Suleman Mountain Range, Dera Ghazi Khan Region, Pakistan.

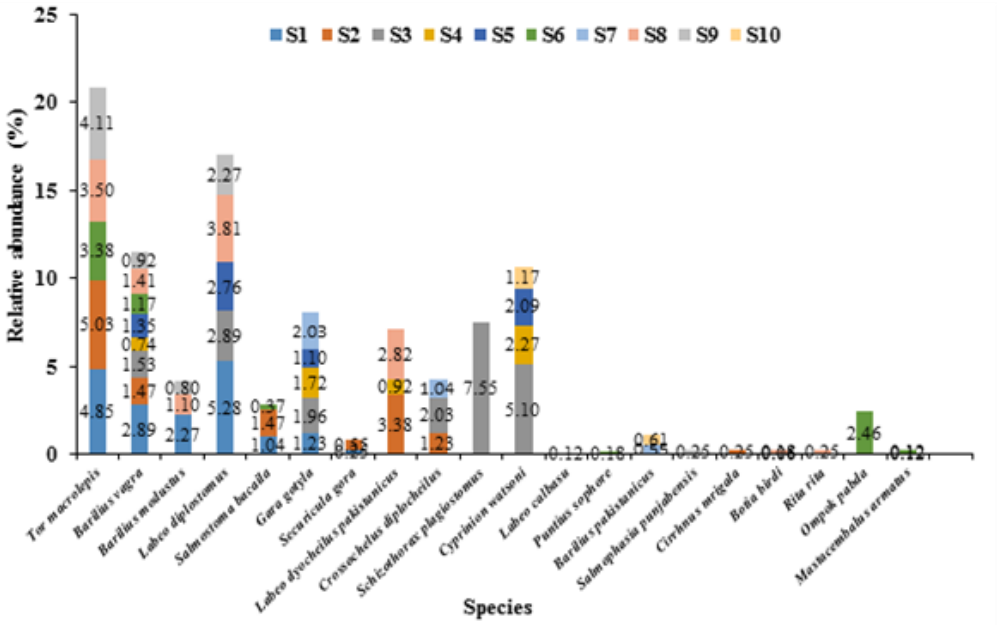

Figure 4.The relative abundance (%) of each fish species within all sites.

sites. Maximum number of species was found at Barthi and minimum number of species was found at Rakhi Gaj (Table 3). One way ANOVA for number of species for ten sites demonstrated that sites were significantly different ($P<0.05$, df = 9, F = 33.55).

Variable number of fish species was revealed from each site (Table 3, Fig. 3). *Labeo diplostmus* showed maximum relative abundance at Vehowa, Jaj and Murunj; *Tor macrolepis* at Barthi, Harand and Chitar Wata; *Cyprinion watsoni* at Zinda Peer and Rakhi Gaj; *Schizothorax plagiostomus* at Hingloon and *Gara gotyla* at Siri. Relative abundance (%) of each fish species within all sites also varied (Fig. 4). Of the important fishes, *Tor macrolepis* showed highest abundance (%) at Barthi, *Barilius vagra* at Vehowa, *Labeo diplostomus at* Vehowa, *Cyprinion watsoni* at Hingloon and *Schizothorax plagiostomus* at Hingloon.

Table 4.Similarity index values (Jaccard's index) between sites.

Sites	S-1 & S-2	S-1 & S-3	S-1 & S-4	S-1 & S-5	S-1 & S-6	S-1 & S-7	S-1 & S-8	S-1 & S-9	S-1 & S-10
Similarity	0.15	0.27	0.15	0.37	0.27	0.11	0.4	0.5	0
Sites	S-2 & S-3	S-2 & S-4	S-2 & S-5	S-2 & S-6	S-2 & S-7	S-2 & S-8	S-2 & S-9	S-2 & S-10	S-3 & S-4
Similarity	0.15	0.2	0.09	0.36	0.1	0.25	0.18	0	0.37
Sites	S-3 & S-5	S-3 & S-6	S-3 & S-7	S-3 & S-8	S-3 & S-9	S-3 & S-10	S-4 & S-5	S-4 & S-6	S-4 & S-7
Similarity	0.57	0.07	0.25	0.27	0.2	0.12	0.6	0.1	0.16
Sites	S-4 & S-8	S-4 & S-9	S-4 & S-10	S-5 & S-6	S-5 & S-7	S-5 & S-8	S-5 & S-9	S-5 & S-10	S- 6 & S-7
Similarity	0.22	0.12	0.2	0.1	0.16	0.22	0.28	0.2	0
Sites	S-6 & S-8	S-6 & S-9	S-6 & S-10	S-7 & S-8	S-7 & S-9	S-7 & S-10	S-8 & S-9	S-8 & S-10	S-9 & S-10
Similarity	0.16	0.2	0	0	0	0.25	0.5	0	0

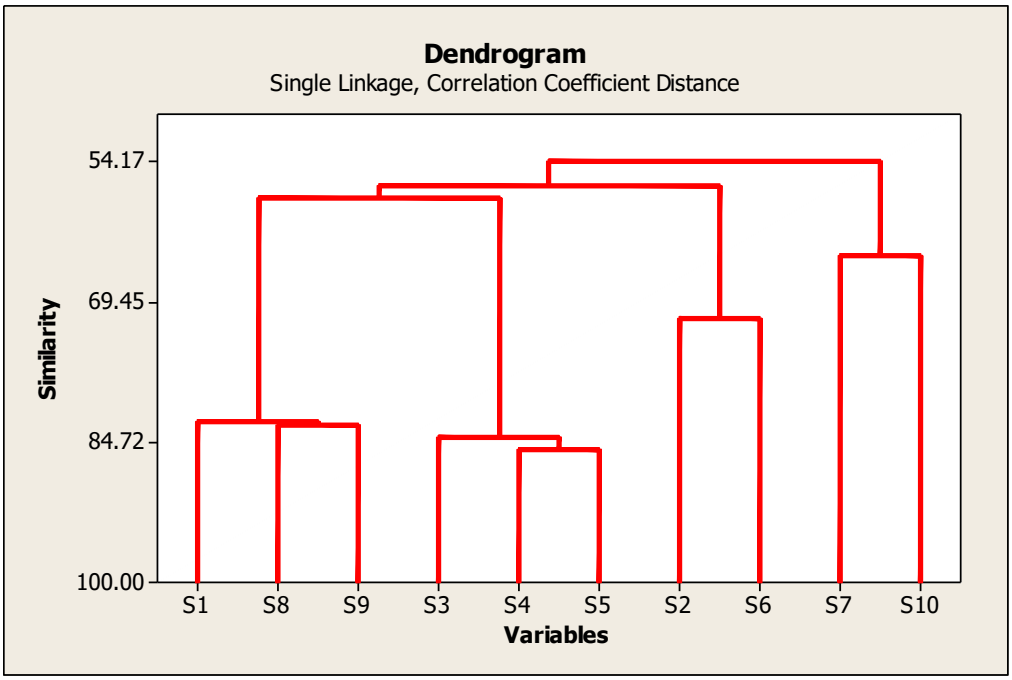

Figure 5. Dendrogram showing similarity in species composition across ten sampling sites based on Jaccard's similarity index.

The values of various diversity indices showed narrow variations (Table 3). Simpson diversity index (D) ranged from 0.21-0.53; Shannon-Weaner index (H) from 0.64-1.68; Margalef index (d) from 0.30-1.30 and evenness index (E) from 0.19-0.31. Calculations of the Jaccard's index of similarity (j) for comparison of species composition among the sites showed highest value (0.6) between Zinda Peer and Jaj (Table 4). There existed no similarity between several pairs of data sets i.e. Harand and Siri, Siri and Murunj; and Siri and Chitar Wata. Rakhi Gaj demonstrated no similarity index with several other sites i.e. Vehowa, Barthi, Harand, Murunj and Chitar Wata. The dendrogram using Jaccard's index of similarity (based on single linkage method) demonstrated Zinda Peer and Jaj to show maximum similarity level, while Vehowa and Siri showed minimum similarity level in species composition (Fig. 5).

DISCUSSION

In present study, 20 fish species of sub-class Actinopterygii encompassing 3 orders (cypriniformes, siluriformes and synbrancheiformes), 5 families (cyprinidae, siluridae, cobitidae, bagridae and mastacembalidae) and 16 genera were identified. Whereas, 15 species were identified in previous study (Ali *et al.*, 2010) of this area. Eight additional fish species were recorded from this area compared to previous study. Therefore, total number of fish species identified at Suleman Mountain Range, Dera Ghazi Khan Region reaches up to 23. Three species namely *Glyptothorax cavia*, *Mystus cavacius* and *Schistura sp* were recorded in previous study (Ali *et al.*, 2010) only, and not in this study.
Several species including *Salmophasia punjabensis*, *Securicula gora*, *Labeo dyocheilus pakistanicus*, *Labeo*

calbau, *Cirrhinus mrigala*, *Botia birdi*, *Rita rita* and *Mastacembelus armatus* were recorded in present study in addition to previous study (Ali *et al*., 2010). Thus, the total number of identified species reaches up to twenty three (23) at Suleman Mountain Range, Dera Ghazi Khan Region, Pakistan.

The twenty recorded fish species in present study have also been frequently reported from other major mountainous, sub-mountainous and plain areas of Pakistan (Yousafzai *et al*., 2013; Akhtar *et al*., 2014; Hasan *et al*., 2014). However, the number and type of fish species shared with several studies (Kakarabdullahzai and Kakarsulemankhel, 2004; Khan *et al*., 2008 and Ullah *et al*., 2014) from other regions of Pakistan is variable. Fewer fish species were found to be common with fish fauna recorded from adjacent areas of Suleman Mountain Range, Dera Ghazi Khan Region, Pakistan. Five species i.e. *Labeo calbasu*, *Labeo dyocheilus pakistanicus*, *Mastacembelus armatus*, *Cirrhinus mrigala* and *Puntius sophore* were common with fish fauna from Baran Dam, District Bannu, major part of which is included in Suleman Mountain Range (Ullah*et al*., 2014). Five species i.e. *Cyprinion watsoni*, *Labeo dyocheilus pakistanicus*,*Cirrhinus mrigala*, *Barilius pakistanicus* and *Mastacembelus armatus* were common with fish fauna from River Zhob, a mountainous region of Baloachistan, adjacent to Suleman Mountain Range (Kakarabdullahzai and Kakarsulemankhel, 2004). Four species i.e. *Cirrhinus mrigala*, *Rita rita*, *Labeo calbasu*, and *Mastacembelus armatus* were shared with fish fauna of Taunsa Barrage at River Indus (Khan *et al*., 2008), near drainage place of Nallah Sanghar (Hill torrent of Suleman Mountain Range, Dera Ghazi Khan Region). From the above mentioned account, it is evident that this region may have fewer land connections with adjacent areas. Therefore only few species are shared. In other words, this could imply the physical separation/isolation of water bodies of this sub-mountainous region not only from adjacent areas but also within the region.

The cyprinidae has been observed as the most abundant fish family from this region in present study while other four fish families have low abundance (Table 2). The several studies have reported cyprinids abundance from various bodies at different localities of Pakistan (Iqbal *et al*., 2013; Akhtar *et al*., 2014; Ishaq *et al*., 2014; Ullah *et al*., 2014). Cyprinid dominance has been observed in small sized lakes with high total phosphate where species number ranged from three to twelve (Olin *et al.,* 2000) and in eutrophic lakes (Tammi *et al.,* 1999). Similarly, the cyprinid dominance has been strongly linked with productivity and eutrophic status of lakes (Persson *et al.,* 1991; Jeppensen *et al.,* 2000). Cyprinid dominance at study sites suggests eutrophic nature of these water bodies. However, phosphates, nitrates and other nutrient concentration parameters need to be investigated for confirmation.

To better describe the fish diversity of this area, several biodiversity indices were considered in this study. If all the species making up a community structure contribute equal abundance then diversity is maximum. However, diversity also depends on the varieties of habitats. Large number of species tends to be found in more varied habitat compared to less variable habitat. More species diversity is found in older habitat compared to younger one. Among other factors resulting in higher biodiversity are warmer temperatures, availability and stability of food. The latitudes and longitudes also affect biodiversity (Mulder *et al.,* 2004; Varrin *et al*., 2007; Wittebolle *et al*., 2009).

Simpson's (D) and Shannon-Weiner's index (d) describe both species richness and evenness of the species distribution of an area. Simpson Index calculates about the probability whether two individual fish drawn from a large community will belong to the different species. The value of this index ranges between 0 and 1, the greater the value, the greater the sample diversity (Vyas and Vishwakarma, 2013). Simpson diversity index values ranged from 0.96 to 1.00 at ten sampling sites with an overall value of 0.86 for whole region, indicating greater diversity.

The most commonly used index to compare diversity among various habitats is Shannon's Index of diversity (Clarke and Warwick, 2001). It is a measure of heterogeneity taking into account both the species number and their evenness (Hollenbeck and Ripple, 2007). Shannon's Index of diversity is considered sensitive to the presence of rare species in a sample compared to other indices like Simpson's index (Krebs, 1989). The values of Shannon-Weiner Diversity Index usually range between 1.5 and 3.5. The higher values indicate greater diversity (Kent and Coker, 1992).In our study, Shannon-Weiner Diversity Index value ranged from 0.64-1.68 for ten fish sampling sites with an overall value of 2.11 for the region. These values imply moderate diversity of the region.

Another index, the Margalef index that is also a measure of species richness was also calculated. It is highly sensitive to sample size and also accounts for sampling effects (Magurran, 2004). In this study, its values ranged from 0.30 to 1.30 at ten fish sampling sites with an overall value of 2.56. This indicates poor diversity of the region. Evenness indices (E) are used to standardize abundance (Smith and Wilson, 1996). Evenness indices range from near 0 to close to 1. If most of the individuals belong to a few species then values are near 0, and when species are nearly equally abundant then values are close to 1 (Smith and Wilson, 1996). In our study, evenness index ranged from 0.19-0.31 for ten fish sampling sites with overall value of 0.70. These imply that most of the individuals belong to a few species at most sites.

The variation in species composition among different localities was calculated using Jaccards index (j) of similarity. It identifies species composition of any of the two

or more sites and the shared species between them (Novotny and Weiblen, 2005). The highest similarity level observed between Zinda Peer and Jaj (Fig. 5) is probably due to interconnection of water ways in these two adjacent areas. Similarly, the water paths of hill torrents of Hingloon area also drain to Jaj, thereby, exhibiting higher similarity in species composition. In addition, Vehowa and Chitar Wata, two adjacent areas also exhibited higher similarity.

The freshwater fish fauna of Pakistan is considered to have a high proportion of endemism. Three fish species endemic to Pakistan i.e. *Salmophasia punjabensis* (Day, 1872), *Barilius pakistanicus* (Mirza and Sadiq, 1978) and *Labeo dyocheilus pakistanicus* (Mirza and Awan, 1976), were also recorded from this region. All other species are considered indigenous inhabiting the adjacent countries/regions. The distributions of endemic fish species is localized due to dispersal limitation and therefore restricted to localized areas (Rosenfeld, 2002). The IUCN conservation status of most of the endemic fish species tends to be critically endangered or threatened with extinction due to narrow range of distribution, decline of population and fewer chances of reproductive success (IUCN, 2014). The IUCN status of the two endemic species i.e. *Salmophasia punjabensis* and *Barilius pakistamicus* has not been evaluated yet. *Labeo dyocheilus pakistanicus* has also been described as least concern (Rafiq and Khan, 2012).

The commercial fisheries have a significant socio-economic contribution in the life of peoples of Pakistan for a frequent part of country. Up till now, 31 fish species with high commercial value has been recorded from fresh water bodies of Pakistan (Rafique and Khan, 2012) which is fairly a high number. One of the commercially important fish species of the mountainous/sub-mountainous region i.e. *Tor macrolepis* is the most abundant and also the frequent species, being recorded from five sites of this region. Previously, the population of *Tor putitora,* a closely related species was considered to be declining (Rafiq and Khan, 2012). However, the population was restored after several measures particularly farming (Chatta *et al*., 2015a,b). The frequent occurrence and abundance of *Tor macrolepis* from various sites of this region indicate a considerable conservation of population of this species. *Tor macrolepis* has been reported to be rare from other regions (Iqbal *et al*., 2013; Ishaq *et al*., 2014). The abundance in wild of this species from this region indicates the potential of this region to contribute in sustaining the natural fish population of this species in Pakistan (Chatta *et al*., 2015a,b).

Schizothorax plagiostomus, a cold water fish of high altitudes have been recorded with moderate abundance. This species has high commercial importance and has also been described from Northern hilly areas of Pakistan (Rafiq and Khan, 2012; Yousafzai *et al*., 2013). It was described from this region, for the first time, in our previous study (Ali *et al*., 2010). And now in current study, but only from a specific study site i.e. Hingloon. The occurrence of 23 fish species including frequent presence of two very rare species i.e. Mahasheer (*Tor macrolepis*) and Snow carp (*Shizothorax plagiostomus*) is an indicator of the richness of the biodiversity of this area.

Among other edible and commercially important fish species *Labeo diplostomus* and *Labeo dyocheilus pakistanicus* were recorded with moderate abundance in this area. It may be assumed that the population of these species is conserved in this area and this area has potential for cultivation of these species. While several other commercially important fish species i.e. *Cirrhinus mrigala*, *Labeo calbasu*, *Rita rita* and *Mastacembelus armatus* were found to be rare in this region.

In conclusion, the three diversity indices values i.e. Simpson diversity index, Shannon-Weiner index and Margalef index indicate greater, moderate and poor diversity of fish respectively in Suleman Mountain Range, Dera Ghazi Khan Region, Pakistan. The values obtained from various diversity indices indicated inconclusive status of fish diversity of the region. Simpson diversity index which demonstrate species richness and evenness indicated greater diversity of the region. While Shannon-Weiner index which also considers presence of rare species along the species number and evenness indicated moderate diversity of this area. The Margalef index which is sensitive to sample size in addition to measure of species richness indicated poor diversity of the region. The presence of endemic and vulnerable species indicates richness and conservation of species diversity. While, occurrence of several important edible fish species indicate commercial fisheries potential of the area.

REFERENCES

Akhtar, N., S. Khan and K. Saeed. 2014. Exploring the Fish Fauna of River Swat, Khyber Pakhtunkhwa, Pakistan. World J. Fish Mar. Sci. 6:190-194.

Ali, M., S. Hussain, J.A. Mahmood, R. Iqbal and A. Farooq. 2010. Fish diversity of freshwater bodies of Suleman Mountain range, Dera Ghazi Khan Region, Pakistan. Pak. J. Zool. 42:285-289.

Berra, T.M. 2007. Fresh water Fish Distribution.University of Chicago Press.

Chatta, A.M., A.M. Khan, M.N. Khan and M. Ayub. 2015a. A study on growth performance and survival of Indus golden Mahseer (*Tor macrolepis*) with Indian major carps in semi-intensive polyculture. J. Anim. Plant Sci. 25:561-566.

Chatta, A.M., Z. Ahmad, S. Hayat, S.A. Naqvi and A.M. Khan. 2015b. Studies on survival of endangered Indus golden Mahseer (*Tor macrolepis*) and its impact on growth of other carps. J. Anim. Plant Sci. 25:542-549.

Clarke, K.R. and R.M. Warwick. 2001. Changes in marine communities: an approach to statistical analysis and interpretation, 2nd Ed. PRIMER-E Ltd., UK. p. 172.

Darwall, W.R.T. and J.C. Vie. 2005. Identifying important sites for conservation of freshwater biodiversity: extending the species based approach. Fish Manage. Ecology 12:287-293.

Dudgeon, D., A.H. Arthington and M.O. Gessner. 2006. Freshwater biodiversity: Importance, threats, status and conservation challenges. Biol. Rev. Cambridge Philosophical Soc. 81:163-182.

Government of Pakistan. 1999. District census report of D.G. Khan, 1998. Population Census Organization Statistical Division, Govt. of Pakistan, Islamabad.Population Census Organization Printing Press, Islamabad, Pakistan.pp.1-166.

Hanson, G., M.A. Hashmi and V.B.B. Viak. 1995. Conservation and development of land and water resources of upper Kaha hill torrent catchment. Report No. NES. 4804.

Hasan, Z., W. Khan, M.A. Khan, L.U. Rehman, J. Khan and Sanaullah. 2014. Comparative abundance of fish fauna of different streams of Bajaur Agency, Khyber Pakhtunkhwa, Pakistan. Biologia 60:159-163.

Hollenbeck, J.P. and W.J. Ripple. 2007. Aspen and conifer heterogeneity effects on bird diversity in the Northern Yellowstone ecosystem. West.North. Am. Naturalist 67:92-101.

Iqbal, Z., K. Pervaiz and M.N. Javed. 2013. Population dynamics of *Tor macrolepis*(Teleostei: Cyprinidae) and other fishes of Attock region, Pakistan. Can. J. Pure Appl. Sci.1:2195-2201.

Ishaq, M., S. Khan, J. Khan, N. Akhtar and K. Saeed. 2014. Study on ichthyofaunal biodiversity of river Swat. World J. Fish Marine Sci. 6:313-318.

IUCN. 2014. The IUCN red list of threatened species. Version 2014.

Jaccard, P. 1912. The distribution of flora in alpine zone.New Phytol.11:37-50.

Javed, M. 2015. Growth and metals depuration in Zn+Pb+Ni mixture stressed fish grown under composite pond culture conditions. Int. J. Agric. Biol. 17:631–636.

Jeppesen, E., J.P. Jensen, M. Sondegaard, T. Lauridsen and F. Landkidehus. 2000. Trophic structure, species richness and biodiversity in Danish lakes; Changes along a phosphorus gradient. Freshwater Biol. 45:201-218.

Kakarabdullahzai, A.S. and J.K. Kakarsulemankhel. 2004. Additions to the fish fauna of river Zhob, Balochistan, Pak. J. Biol. Sci. 4:293-297.

Kang, B., D. He, L. Perrett, H. Wang, W. Hu, W. Deng and Y. Wu. 2009. Fish and fisheries in the Upper Mekong: Current assessment of the fish community, threats and conservation. Rev. Fish Biol. Fisheries 19:465-480.

Kent, M. and P. Coker. 1992. Vegetation description and analysis a practical approach. John Wiley and Sons, New York.

Khan, A.M., H.A. Shakir, M.N. Khan, M. Abid and M.R. Mirza. 2008. Ichthyofaunal survey of some freshwater reservoirs in Punjab.J. Anim. Plant Sci. 18:151-154.

Krebs, C.J. 1989. Ecological Methodology.Harper- Collins Publishers, New York.p. 654.

Leveque, C., E.V. Balian and K. Martens.2005. An assessment of animal species diversity in continental waters. Hydrobiol.542:32-67.

Magurran, A.E. 2004. Measuring Biological Diversity. Blackwell, Malden.

Malkani, M.S. 2010. Stratigraphy and mineral potential of Sulaiman (Middle Indus) basin, Pakistan.Sindh Univ. Res. J. 42:39-66.

Malmqvist, B. and S. Rundle. 2002. Threats to running water ecosystems of the world. Environ. Conserv.29:134-153.

Margalef, R. 1968. Perspective in Ecological Theory.Uni. of Chicago Press.p.112.

Mirza, M.R. and H.M. Sharif. 1996. A Key to theFishes of Punjab, 1st Ed. IlmiKitabKhana, Lahore, Pakistan.

Moyle, P.B. and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems; evidence from fish faunas. In: P.L. Fielder and S.K. Jain (eds.), Conservation Biology: The theory and practice of nature conservation. Chapman and Hall, UK.pp.129-161.

Mulder, C.P.H., E. Bazeley-white, P.G. Dimitrakopoulos, A. Hector, M. Scherer-lorenzen and B. Schmid. 2004. Species evenness and productivity in experimental plant communities. Oikos 107:50-63.

Nelson, J.S. 2006.Fishes of the World, 4th Ed. John Wiley and Sons, Inc., New York.p.601.

Novotny, V. and G.D. Weiblen. 2005. From Communities to Continents: Beta diversity of herbivorous insects. AnnalesZoologiciFennici. 42:463-475.

Olin, M., M. Rask, Ruuhiharvit, M. Kurrilahti, P. Ala-Opas and O. Ylonens. 2002. Fish community structure in mesotrophic and eutrophic lakes of southern Finland, the relative abundances of percids and cyprinids along a trophic gradient. J. Fish. Biol. 60:593-612.

Persson, L., S. Diehl, S., L. Johanson, G. Andersson and S.F. Hamrin. 1991. Shifts in fish communities along the productivity gradient of temperate lakes patterns and importance of size-structured interactions. J. Fish. Biol. 38:281-293.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections.J. Theor. Biol. 13:131-144.

Rafique, M. and N.U.H. Khan. 2012. Distribution and status of significant freshwater fishes of Pakistan. Zool. Surv. Pak. 21:90-95.

Saunders, D.L., J.J. Meeuwig and C.J. Vincent. 2002. Freshwater Protected Areas: Strategies for conservation. Conservation Biol. 16:30-41.

Shannon, C.E. and W. Wiener .1963.The mathematical theory of communication.University Illinois Press, Urbana; pp.360.

Simpson, E.H. 1949. Measurment of diversity. Nature 163:688. doi:10.1038/163688a0.

Smith, B. and J.B. Wilson. 1996. A consumer's guide to evenness indices. Oikos 76:70-82.

Talwar, P.K. and A.G. Jhingran. 1991. Inland fishes of India and adjacent countries, Vol. I and II.Oxford and IBH publishing Co. Pvt. Ltd., New Delhi, Bombay.

Tammi, J., A. Lappalainen, J. Mannio, M. Rask and J. Vuorenmaa. 1999. Effects of the eutrophication on fish and fisheries in Finnish lakes, a survey based on random sampling. Fish. Manage. Ecol. 6:173-186.

Ullah, A., H. Ullah, A. Rehman, Z. Masood, F.U. Rehman, H.U. Rehman, Z. Hassan, S. Ayaz and A. Ullah. 2014. The diversity of fish fauna in Baran Dam of district Bannu, (KPK), Pakistan. Int. J. Adv. Res. 2:136-145.

Varrin, R., J. Bowman and P.A. Gray. 2007. The known and potential impacts of climate change on biodiversity in Ontario's terrestrial ecosystems: Case studies and recommendations for adaptation; Climate Change Research Report CCRR-09, Applied Research and Development Branch, Ontario Ministry of Natural Resources, Sault Ste. Marie, Ontario. p.48.

Vyas, V. and K.S. Vishwakarma. 2013. Species diversity and assemblage of fish fauna of Sip River: A tributary of Narmada River. J. Res. Biol.3:1003-1008.

Wittebolle, L., M. Marzorati, L. Clement, A. Balloi and D. Daffonchio. 2009. Initial community evenness favors functionality under selective stress. Nature 458:623-626.

Yousafzai, A.M., W. Khan and Z. Hasan. 2013. Fresh records on water quality and ichthyodiversity of river Swat at Charsadda, Khyber Pakhtunkhwa. Pak. J. Zool. 45:1727-1734