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Fish diversity of Holy Kali Bein Rivulet- A tributary of the river beas in Punjab, India

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ABSTRACT

The present documentation is of the ichthyofaunal diversity of holy Kali Bein rivulet- A tributary of the river Beas in Punjab, India, along with the assessment of alteration in the physico-chemical quality parameters regarding water quality index. The physico-chemical parameters of Kali Bein viz. temperature, pH, conductivity, total dissolved solids (TDS), free carbon dioxide, dissolved oxygen (DO), biological oxygen demand (BOD), total alkalinity, chlorides, hardness, calcium, magnesium Phosphate, ammonia and nitrate were analyzed to determine water quality index. The Water Quality Index is at stations S-1 and S-2 in the category 'Good', station S-3, 'Very Poor' and station S-4, 'Poor'. A total number of 35 fish species were reported during the study period. Among all the highest numbers of fish species, 21 belonged to the order Cypriniformes, followed by the order Perciformes and Siluriformes 5 fish species each. The orders Beloniformes, Clupeiformes, Osteoglossiformes and Synbranchiformes were represented by single species each. Among families, Cyprinidae is represented by 21 fish species, followed by Bagridae 04 and Channidae 03. The IUCN status of 35 fish species, 23 were lower risk near threatened (LRnt), 9 were vulnerable and 3 were lower risk least concerned (LRlc).

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1. Introduction

Freshwater ecosystems are the richest and most divergent ecosystems on earth among all ecosystems (Revenga and Mock, 2000). These ecosystems constitute only 0.01% of the world's water, cover approximately 0.8% of the earth's surface and produce 3% of net primary productivity. More than 10% of animal species including 25% of all vertebrates and 40% of all fish species occurs in fresh water (Balian *et al*., 2008). Rivers are the one of the most dynamic ecosystems as well as lifeline of almost all civilizations in India (Athira and Jaya, 2020). The rivers and their tributaries are the main source of domestic, industrial and agricultural water supply and for inland water transport, hydroelectricity, inland fishing and formation of deltas (Balasubrahmanium, 2007). The rivers and their tributaries are under constant anthropogenic threats (Tripathi *et al*., 2014, Singh and Gaur, 2018; Solanki and Khera, 2018; Singh, 2020). River pollution has now reached a critical point due to agricultural runoff, unplanned urbanization and fast industrialization. Bhatnagar *et al*. (2016) reported significant changes in fish diversity due to urbanization, rapid pollution and different management practices of aquatic bodies in Haryana when compared with earlier fish diversity studies. The ichthyofaunal diversity of an aquatic ecosystem has a vital role in the food chain and the food web, directly or indirectly stabilizing the particular ecosystem (Polis and Strong, 1996). Study on ichthyofaunal diversity and conservation in Punjab is documented by a few workers (Johal and Tondon, 1979 & 1980; Dua and Chander, 1999; Brraich *et al*., 2003; Ladhar and Brraich, 2005; Brraich and Saini, 2015). Very little work is done in the area of ichthyofaunal diversity and water quality of Kali Bein in Punjab, India. Therefore, the present study is carried out of Kali Bein in districts Hoshiarpur and Kapurthala, Punjab, Kerala.

2. Materials and Methods

2.1 Topography of the study area:

Kali Bein is one of the majorrivulets that runabout 160 km into the meeting point of the rivers Beas and Satluj at HarikePattan in Punjab, Indiaand located at 32°26′33"N and 75°43′43"E.The Kali Bein rises from a spring in the village Dhanoaof tehsil Dasuyadistrict Hoshiarpur, Punjab. The main source of water for Kali Bein is the Mukerian hydel canal. The Punjabi word 'bein' derives from the Sanskrit 'veni', meaning a stream or a water body. The Kali Bein flows through the districts of Hoshiarpur and Kapurthala and several towns are on its banks. It plays a key role in recharging the water table and in flood management in its watershed. The Kanjli wetland,A Ramser site, is supported by the Kali Bein. The government of Punjab declared the rivulet Kali Bein as 'Holy Kali Bein' .

2.2 Methodology:

Surface water samples were collected monthly from March, 2017 to February, 2018 from Kali Bein rivulet, from all the selected four stations, in triplicate polythene bottle. Station 1 (S1), upstream of the rivulet near Dasuya, district Hoshiarpur, Station 2 (S2), a few kilometers downstream (Subhanpur) from station 1 where domestic sewage joins Kali Bein, Station 3 (S3), the area where city sewage has confluence with the rivulet near Kapurthala and Station 4 (S4), few kilometers downstream from station 3, which may indicate the revival zone of the river. The physiochemical characteristics of temperature,CO_2 and Alkalinity were analysed at the site itself as their values are liable to alter soon, where such as pH, Electrical conductivity, DO, BOD, Alkalinity, Total solids, Calcium, Magnesium Chloride, Phosphate, Ammonia and Nitrate were analysed in the Laboratory according to standard procedures (Garg *et al*., 2002,Trivedy& Goal 1984, APHA, 2012) on the following 3-4 days, during which sample was kept in cold storage.

Fishes were collected at regular intervals from upstream to downstream at four different stationswith the help of local fishermen using different types of nets. Fig. 1 depicts the map of Kali Bein, showing locations from where fishes were collected. Prior permission was taken from the fishery department, Punjab. At the site of the collection, photographs of fish were immediately taken with the help of a digital camera, aCanon DSLR . The fishes were identified based on morphometric characters with the help of standard keys and monographs (Day, 1889; Johal and Tandon, 1979, 1980; Talwar and Jhingran, 1991; Jayaram, 1999; Garg *et al*., 2002). The abundance status of fish species was recorded according to percentage occurrence of that species from different stations. The fish species was reported to be greater than 70% in quantity in a catch, which was represented by (+++) as abundance. If the occurrence of any species was between 40-70%,than represented by (++) as commonand less than 40% (+) rare. The conservation status of different fish species has been determined according to available literature as per IUCN criteria (IUCN 2020).

2.3 Statistical Analysis

The data for physico-chemical characteristics were subjected to ANOVA followed by Duncan's test (Duncan, 1955) to determine the significant differences among different stations. All data was expressed as mean±S.E of mean.

3. Results and Discussion

During the present study, based on the survey, 35 species of fishes belong to 7 orders, 10 families and 15 genera were observed from rivulet Kali bein. Fig. 2 depicts the photographs of 35 species (i to xxxv). Study on fish diversity and conservation status in Punjab is documented by a few workers (Johal and Tondon, 1979 & 1980; Brraich *et al*., 2003; Ladhar and Brraich, 2005; Dua and Parkash, 2009; Kumar and Khanna, 2014; Brraich and Saini 2015; Sharma, 2018), however, to the best of authors' belief no such study have been so far reported from Kali bein rivulet. Brraich and Ladhar (2005) documented 16 fish species from Kanjli wetland which is supported by the Kali Bein. Johal and Tondon (1980) have described 116 species

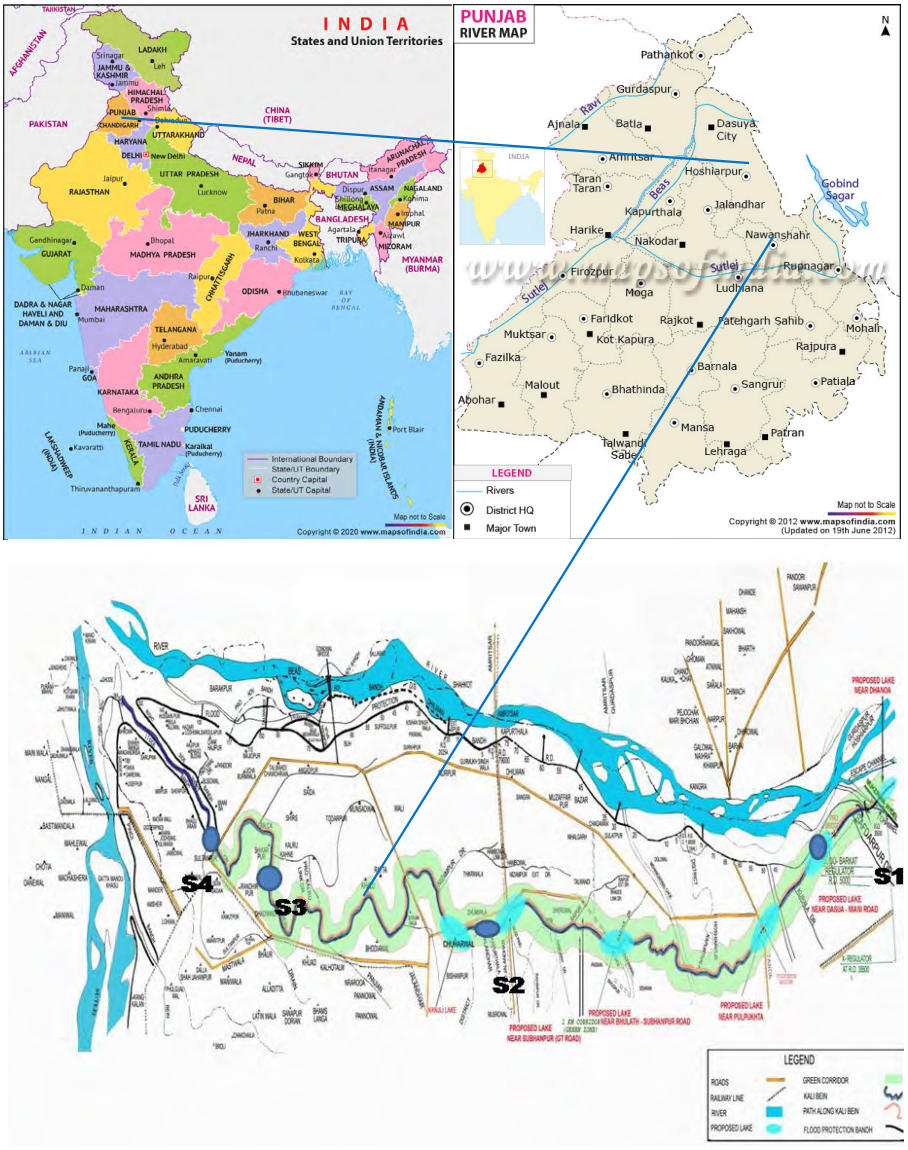

Fig. 1. Map of Kali Bein, Punjab, India showing different collection stations

from Punjab. Bhatnagar *et al*. (2016) investigated fish biodiversity of Haryana during 2011-2014 and recorded 59 species of fish fauna under 39 genera, 07 orders and 20 families. They reported a decrease in fish faunal diversity from 82 species in 2009 to 59 species in their research. They further stated that main reasons of decline in fish diversity are habitat destruction, changing land use pattern and pollution.

Order-wise and Family wise distribution of fish species is shown in fig. 3 and 4. In the present investigation Order Cypriniformes was found dominant with 21 species namely *Danio rerio, Carassius carassius, Labeo catla, Cirrhinus mrigala, Cirrhinus reba, Cyprinus carpio, Devario devario, Labeo bata, Labeo calbasu, Bangana dero, Labeo dyocheilus, Labeo gonius, Labeo rohita, Osteobrama cotia, Rasbora daniconius, Pethia ticto, Puntius chola, Pethia conchonius, Systomus sarana, Puntius sophre and Salmostoma bacaila.* The maximum number of fish species from the order Cypriniformes was also reported by Koparkar and Kamble (2014); Verma *et al*. (2015); Bhatnagar *et al*. (2016); Khekare and Sawane (2016); Singh *et al*. (2020) in their respective studies supporting the present results.

Order Perciformes includes *Channa marulius, Channa punctatus, Channa striata, Glossogobius giuris and Chanda nama* order Siluriformes includes *Mystus cavasius, Mystus tengra, Mystus vittatus, Sperata seenghala* and *Wallago attu* order Beloniformes includes single species namely *Xenantodon cancila* order Clupeiformes has *Gudusia chapra,* order Osteoglossiformes *includes Notopterous notopterous* and order Synbranchiformes also includes single species namely *Macrognathus aral.*

Among the total 35 fish species, twenty three were lower risk near threatened (LRnt), nine vulnerable (VU) and three lower risk least concerned (LRlc) under IUCN categories (Fig. 5). Brraich and Saini (2019) reported that out of the total 43 fish fauna of Ranjit Sagar Wetland and its three adjoining streams, 13 were under threatened categories of the Red List of IUCN. *Mystus cavasius, Notopterus notopterus, Chanda nama* and *Osteobrama cotia* fishes were reported in abundant quantity in the present studies and therefore these fishes do not need any specific attention regarding their conservation. *Cyprinus carpio* and *Pethia conchonius* need special attention because these fishes were vulnerable and rarely observed during the present study. *Cyprinus carpio* is the exotic species which was reported rarely. The reason behind the rare occurrence of this species may be due to less survival rate due to pollution. Bhatnagar et al. (2016) has also reported similar observation. *Danio rerio, Carassius carassius, Labeo calbasu, Rasbora daniconius, Pethia ticto, Pethia conchonius, Salmostoma bacaila, Channa marulius, Glossogobius giuris, Sperata seenghala* and *Macrognathus aral* fish species were also reported rarely during study period. *Xenantodon cancila*, *Gudusia chapra, Labeo catla, Cirrhinus mrigala, Cirrhinus reba, Devario devario, Labeo dyocheilus, Labeo bata, Labeo dero, Labeo gonius, Labeo rohita, Puntius chola, Systomus sarana, Puntius sophore, Channa punctatus* and *Channa striata* fish fauna were observed in moderate in numbers.

Among the total fish species, 22.86% were herbivores, 51.42% omnivores and 25.72% carnivores (Fig. 6) advocating the dominance of omnivorous fishes.

The activities that have been causing decline in abundance of these species making them 'rare' are overfishing (more for commercial purposes than for living) and pollution of the aquatic systems, mainly due to discharge of domestic/ industrial effluents into the aquatic systems. Jhingran (1984) and Das and Barat (1990) have also stated similar reasons about declining fish biodiversity. Thus there is a need to discuss conservation issues in Indian river systems (Menon, 1989; Dubey, 1994; Anonymous, 1995; Kapoor and Sarkar, 2005).

The physico-chemical characteristics of water are major determinants of variety and abundance of fish available in all ecosystems (Kalla *et al*., 2004; Jana *et al*., 2006). During the investigation period, a decrease in DO and an increase in BOD, phosphate, ammonia and nitrate in the holy Kali Bein rivulet at station S-3 indicate that the addition of domestic sewage, industrial waste and agricultural run-off has altered the ecology of rivulet. Singh *et al*., (2020) also documented increases in the level of pollution from upstream to downstream of Kali Bein. Biochemical oxygen demand, phosphate and ammonia were more than the permissible limit for drinking water at station-3 and BOD, ammonia and free CO_2 for fish culture (Bhatnagar and Devi, 2013). The values of , Free CO_2, Electrical conductivity, Alkalinity, Biochemical oxygen demand (BOD), Alkalinity, Total solids, Calcium, Magnesium, and Chloride increased with maximum values at station S-3 as compared to other stations indicating higher pollution load at station S-3. pH of the rivulet remains alkaline throughout the study period. However. a decrease in phosphate, ammonia and nitrate values from stations S-3 to S-4 has been observed, indicating a revival of the rivulet (Chopra *et al.,* 2021). This analysis of water quality clearly reveals that these variations in the ecological conditions of the water due to industrial and domestic effluents are contributing towards decrease in fish abundance as well as variety.

Johal and Rawal (2005) reported that the trend of inclusion of fish species in one of the IUCN conservation categories can be reversed for that there is requirement of regular ichthyofaunal surveys, for determining conservation status of reported fish species, identification and protection of breeding and feeding grounds of fishes and finally declaration of ecologically undisturbed aquatic bodies. In situ conservation is one of the several prominent and suggestive measures for conservation of fish biodiversity.

4. Conclusion

The ichthyofaunal survey carried out from March, 2017 to February, 2018 revealed that 35 fish species belonging to 7 orders and 10 families were reported from Kali Bein rivulet. Analysis of data also exhibited that out of the total 35 species of fish species 23 species (65.71%) Low risk- near threatened (LRnt), 09 species (25.71%) were Vulnerable (VU) and 03 (8.57%) species were Low risk-

Table 1. Fish abundance and IUCN status of Kali Bein rivulet during March, 2017 to February, 2018

S. No.	Name	Vernacular name	Order	Family	Habits	Abundance	IUCN status	Stations
1	*Xenantodon cancila* (Hamilton,1822)	Takla machi, Sua machi	Beloniformes	Belonidae	Omnivorous	++	LRnt	1,2,3,4
2	*Gudusia chapra* (Hamilton,1822)	Gudua, Chappera	Clupeiformes	Clupeidae	Omnivorous	++	LRlc	1,2
3	*Danio rerio* (Hamilton,1822)	--	Cypriniformes	Cyprinidae	Carnivorous	+	LRnt	1,2,3
4	*Carassius carassius* (Linnaeus, 1758)	Gold fish	Cypriniformes	Cyprinidae	Omnivorous	+	LRnt	3
5	*Labeo catla* (Hamilton,1822)	Katla	Cypriniformes	Cyprinidae	Omnivorous	++	VU	1,2,3
6	*Cirrhinus mrigala* (Hamilton,1822)	Mrigal	Cypriniformes	Cyprinidae	Omnivorous	++	LRnt	2,3
7	*Cirrhinus reba* (Hamilton,1822)	Mori, Sunni	Cypriniformes	Cyprinidae	Herbivorous	++	VU	2,3
8	*Cyprinus carpio* Linnaeus, 1758	Golden, Mirror carp	Cypriniformes	Cyprinidae	Omnivorous	+	VU	2,3
9	*Devario devario* (Hamilton,1822)	Makhni	Cypriniformes	Cyprinidae	Carnivorous	++	LRnt	1,2
10	*Labeo bata* (Hamilton,1822)	Bata	Cypriniformes	Cyprinidae	Herbivorous	++	LRnt	1,2,3
11	*Labeo calbasu* (Hamilton, 1822)	kalkoch, Kalahan	Cypriniformes	Cyprinidae	Herbivorous	+	LRnt	2
12	*Bangana dero* (Hamilton, 1822)	Giddah	Cypriniformes	Cyprinidae	Omnivorous	++	VU	2,3
13	*Labeo dyocheilus* (Mc Clelland, 1839)	Kunni, Torki	Cypriniformes	Cyprinidae	Herbivorous	++	VU	2,3,4
14	*Labeo gonius* (Hamilton,1822)	Sirheen, Sereehan	Cypriniformes	Cyprinidae	Herbivorous	++	LRnt	2,3,4
15	*Labeo rohita* (Hamilton,1822)	Rohu	Cypriniformes	Cyprinidae	Herbivorous	++	LRnt	1,2,3
16	*Osteobrama cotio* (Hamilton,1822)	Seesa machi	Cypriniformes	Cyprinidae	Omnivorous	+++	LRnt	1,2,3,4
17	*Rasbora daniconius* (Hamilton,1822)	Raankaalle, Chal	Cypriniformes	Cyprinidae	Herbivorous	+	LRnt	2
18	*Pethia ticto* (Hamilton,1822)	Ticker	Cypriniformes	Cyprinidae	Carnivorous	+	LRlc	1,2
19	*Puntius chola* (Hamilton,1822)	Puthi, Chidhu	Cypriniformes	Cyprinidae	Omnivorous	++	VU	1,2,3
20	*Pethia conchonius* (Hamilton,1822)	Ticker, Chidhu	Cypriniformes	Cyprinidae	Omnivorous	+	VU	2,3
21	*Systomus sarana* (Hamilton,1822)	Khami, Khangan	Cypriniformes	Cyprinidae	Omnivorous	++	VU	2,3
22	*Puntius sophore* (Hamilton,1822)	Ticker, Chidhu	Cypriniformes	Cyprinidae	Herbivorous	++	LRnt	1,2,3
23	*Salmostoma bacaila* (Hamilton,1822)	Chilwa, Parrand	Cypriniformes	Cyprinidae	Omnivorous	+	LRnt	1,2,3
24	*Notopterus notopterus* (Pallas, 1769)	Pari, Moh, But	Osteoglossiformes	Notopteridae	Carnivorous	+++	LRnt	1,2,3,4
25	*Channa marulius* (Hamilton,1822)	Sol, Dowlah	Perciformes	Channidae	Omnivorous	+	LRnt	3,4
26	*Channa punctata* (Bloch, 1794)	Dolla, Dallunga	Perciformes	Channidae	Omnivorous	++	LRnt	3,4
27	*Channa striata* (Bloch, 1793)	Dhoali, Soul	Perciformes	Channidae	Omnivorous	++	LRlc	3,4
28	*Glossogobius giuris* (Hamilton,1822)	Golbi	Perciformes	Gobiidae	Omnivorous	+	LRnt	3
29	*Chanda nama* Hamilton,1822	Seesa machi	Perciformes	Ambassidae	Carnivorous	+++	LRnt	1,2,3,4
30	*Mystus cavasius* (Hamilton,1822)	Kinger machi, Tingra	Siluriformes	Bagridae	Carnivorous	+++	LRnt	1,2,3,4
31	*Mystus tengra* (Hamilton,1822)	Tingara, Karal	Siluriformes	Bagridae	Carnivorous	++	LRnt	2,3,4
32	*Mystus vittatus* (Bloch, 1794)	Tingra, Kala Kander	Siluriformes	Bagridae	Carnivorous	++	VU	2,3
33	*Sperata seenghala* (Sykes, 1839)	Sanghala	Siluriformes	Bagridae	Omnivorous	+	LRnt	2,3
34	*Wallago attu* (Bloch and Schneider,1801)	Mullee	Siluriformes	Siluridae	Carnivorous	++	LRnt	1,2,3
35	*Macrognathus aral* (Bloch and Schneider,1801)	Bam	Synbranchiformes	Mastacembelidae	Omnivorous	+	LRnt	1

IUCN status:LRlc = Lower risk- least concern; LRnt = Lower risk- near threatened; VU = Vulnerable
Present status: +++ = Abundant, ++ = Common, + = Rare
Give all current names for fish. All author names as not in brackets. Refer FishBase
Check spelling (such software are there in modern days and such basic spelling errors should not happen in science manuscripts

Order: Beloniformes; Family- Belonidae

(i) *Xenantodon cancila*

Order: Clupeiformes; Family- Clupeidae

(ii) *Gudusia chapra*

Order: Cypriniformes; Family- Cyprinidae

(iii) *Danio rerio*

(iv) *Carassius carassius*

(v) *Labeo catla*

(vi) *Cirrhinus mrigala*

(vii) *Cirrhinus reba*

(viii) *Cyprinus carpio*

(ix) *Devario devario*

(x) *Labeo bata*

(xi) *Labeo calbasu*

(xii) *Bangana dero*

(xiii) *Labeo dyocheilus*

(xiv) *Labeo gonius*

(xv) *Labeo rohita*

(xvi) *Osteobrama cotio*

(xvii) *Rasbora daniconius*

(xviii) *Pethia ticto*

(xix) *Puntius chola*

(xx) *Pethia conchonius*

(xxi) *Systomus sarana*

(xxii) *Puntius sophore*

Order: Osteoglossiformes; Family- Notopteridae

(xxiii) *Salmostoma bacaila*

(xxiv) *Notopterus notopterus*

Order: Perciformes; Family- Channidae

(xxv) *Channa marulius*

(xxvi) *Channa punctata*

Family- Gobiidae

(xxvii) *Channa striata*

(xxviii) *Glossogobius giuris*

Family- Ambassidae

(xxix) *Chanda nama*

Order: Siluriformes; Family- Bagridae

(xxx) *Mystus cavasius*

(xxxi) *Mystus tengara*

(xxxii) *Mystus vittatus*

Family- Siluridae

(xxxiii) *Sperata seenghala*

(xxxiv) *Wallago attu*

Order: Synbranchiformes; Family- Mastacembelidae

(xxxv) *Macrognathus aral*

Fig. 2. Photograph of Fish species (i) to (xxxv)

Fig. 3. Order-wise representation of fish species of Kali Bein rivulet, Punjab

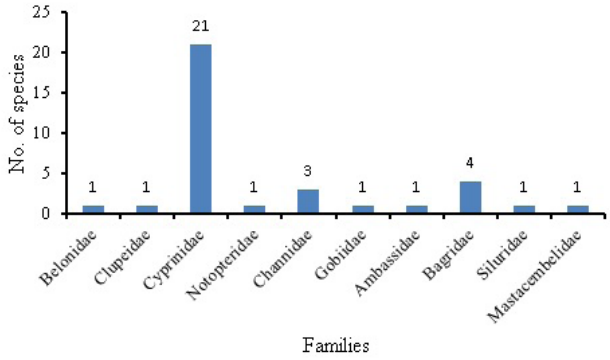

Fig. 4. Family wise representation of fish species of Kali Bein rivulet, Punjab

Table 2. Physicochemical parameters (Mean ± S.E of mean) of Kali Bein rivulet from March, 2017 to February, 2018

PARAMETERS	SAMPLE SITES				Desirable values for fish culture*
	S-1	S-2	S-3	S-4	
Temperature (ºC)	23.38±1.2239^{C}	23.94±1.2784^{B}	24.80±1.1082^{A}	24.78±1.29^{A}	-
pH	8.016±0.07604^{A}	7.83±0.08503^{B}	7.66±0.0883^{C}	7.55±0.0650^{D}	7.0-9.5
Conductivity (microS/cm)	194.69±9.6229^{D}	213.89±10.1192^{C}	247.08±8.3977^{B}	251.44±4.8111^{A}	-
Total solids (mg l^{-1})	125.25±6.2251^{D}	136.64±6.3840^{C}	158.61±5.4734^{B}	160.83±3.1081^{A}	
Free CO_2 (mg l^{-1})	8.00±0.9534^{D}	11.49±1256^{C}	15.78±1.8210^{B}	19.11±2.1997^{A}	0-10
DO (mg l^{-1})	10.31±0.7321^{A}	9.12±0.7885^{B}	7.34±0.7738^{C}	6.59±0.7326^{D}	4-5
BOD (mg l^{-1})	1.05±0.1047^{D}	1.99±0.0820^{C}	3.21±0.2863^{B}	3.61±0.2761^{A}	>3
Total alkalinity (mg l^{-1})	41.99±0.7582^{B}	42.49±1.5395^{B}	51.83±1.4146^{A}	51.94±1.6082^{A}	50-200
Chlorides (mg l^{-1})	24.85±1.2103^{B}	28.44±2.4283^{A}	28.61±1.2318^{A}	28.88±1.7366^{A}	-
Hardness (mg l^{-1})	100.72±5.3658^{D}	102.39±4.5149^{C}	112.61±4.8618^{B}	115.39±4.0177^{A}	>20
Calcium (mg l^{-1})	32.47±1.7547^{D}	33.34±1.7567^{C}	36.19±1.8828^{B}	37.05±1.7700^{A}	4-160
Magnesium (mg l^{-1})	4.76±0.4551^{B}	4.82±0.4994^{B}	5.23±0.4811^{A}	5.43±0.6300^{A}	-
Phosphate (mg l^{-1})	0.067±0.0069^{D}	0.10±0.0044^{C}	0.59±0.0131^{A}	0.44±0.0133^{B}	0.03-2.0
Ammonia (mg l^{-1})	0.17±0.0069^{D}	0.19±0.0065^{C}	0.55±0.04716^{A}	0.30±.01277^{B}	0.0-0.2
Nitrate (mg l^{-1})	0.12±0.0066^{D}	0.20±0.00916^{C}	0.36±0.01004^{A}	0.27±0.01090^{B}	0.0-4.5

All values are Mean ± S. E. of mean.
Means with different letters in the same row are significantly (P<0.05) different.
(Duncan's Multiple Range test, Duncan, 1955)
*Bhatnagar and Devi (2013)

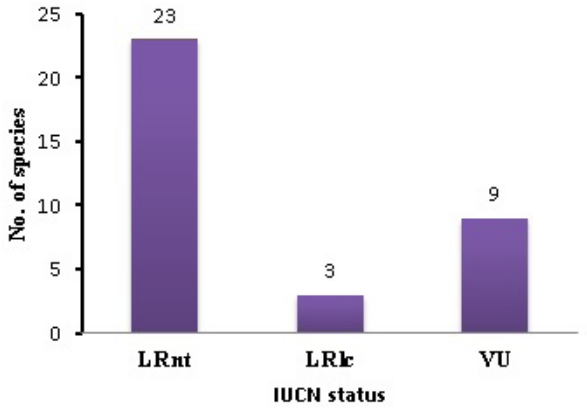

Fig. 5. IUCN status wise representation of fish species of Kali Bein rivulet, Punjab, following IUCN (2020)

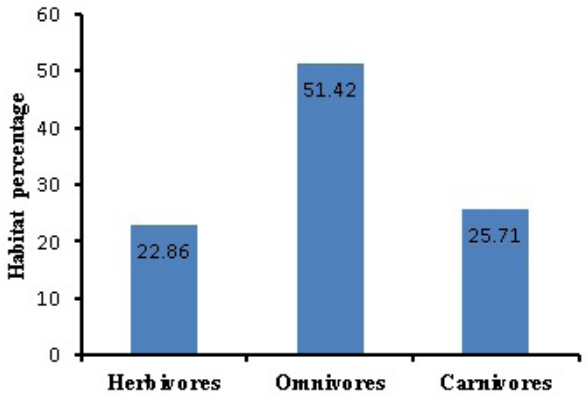

Fig. 6. Feeding status wise representation of fish species of Kali Bein rivulet, Punjab

least concern. It was further observed that variations in water quality characteristics due to influx of wastes (as at station S3) are the major cause affecting abundance and presence of a fish species. There is an urgent need to initiate management practices for the conservation of fish species in this area; regular ichthyo-faunal surveys and regulations to control the activities which cause stress to fish fauna are required.

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