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Ichthyofaunal Diversity In Kunah Stream: The Interplay Of Physicochemical Parameters And Habitat Configuration In Beas Riverine System, Himachal Pradesh, India

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Abstract: The present research article deals with the exploration of fish diversity and their distribution across various habitats within Kunah stream, located in Hamirpur (H.P). It also examines the impact of different physicochemical factors on the variety of fish species inhabiting the stream. A comprehensive analysis reveals the presence of 18 fish species spanning across six orders and eight families. These orders include Cypriniformes, Siluriformes, Synbranchiformes, Beloniformes, Anabantiformes, Cichliformes, while families comprise Cyprinidae, Danionidae, Nemachilidae, Mastacembelidae, Sisoridae, Belonidae, Channidae, Cichlidae. Furthermore, the study utilizes various diversity indices to assess the abundance of fish in distinct stream habitats, indicating that water pools exhibit the highest diversity (H′= 2.675), followed by riffles (H′= 2.243). Additionally, a UPGMA clustering dendrogram illustrates the distribution of common fish species across different stream habitats.

Keywords: beas river system • kunah, stream • ichthyofauna • diversity • ecology • habitat configuration

Introduction

Freshwater ecosystem occupies less than 0.1% of the Earth's surface but supports about 10% of total known biodiversity (Balian et al. 2008). Himalayas represent remarkable diversity and endemism (Mittermeier et al.1999; Myers et al. 2000). Himalayan aquatic biodiversity is declining at a very fast rate as compared to terrestrial biodiversity (Moyle & Williams 1990; Abramovitz 1995). A substantial part of Himalayas is still unexplored because of complex high-altitude terrains, which are inaccessible retards survey efforts, and the extant distribution of most freshwater species is still in speculative stage (Sharma et al. 2016). The hill streams are an essential and important part of mountainous ecosystem of the Himalayas. Heavy water velocity, cold water with more dissolved oxygen and typical indigenous fauna characterizes these streams.

The eco-physiography of the stream is determined by numerous factors, such as the elevation, catchment area, bedrock geology, vegetation cover and anthropocene (Abbas & Subramanian 1984; Ahmad et al.1998; Rajamani et al. 2009; Gizzi et al. 2020). Hillstreams have well defined habitats like runs, riffles, pools and rapids varying in their depth and current velocity (Hamilton & Bergersen 1984). These hill streams provide the feeding and breeding grounds for most of the hill stream fishes, which in turn have an impact on the reservoir fisheries. Hill streams are also valued for recreation, wildlife habitats, drainage habitation, industrial and agricultural uses. High species diversity was correlated with habitat volume and heterogeneity (Arunanchalam 2000). The contamination of water resources due to anthropogenic activities is high around the world mainly in developing nations, where freshwater ecosystems have been

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utterly debilitated (Franca et al. 2019; Keke et al. 2020; 2021). Fishes are an integral part of the food chain of an aquatic ecosystem and constitute about one-half of all vertebrates on the Earth, viz., 32,900 fish species out of 64,000 vertebrates (Froese & Pauly 2014). The ecology of fishes and in turn their diversity in hill streams of Himachal Pradesh is very closely related to landscape phenomena like inputs or accessibility of nutrients, sources or quality of water, geology, availability of food, water withdrawals, land use and interference of natural stream flow by impoundments. Earlier investigation on fish community and their distribution in Himachal Pradesh includes work of Hora (1927;1937); Menon (1951;1962;1987;1999); Sehgal (1974); Sharma & Tandon (1990); Uniyal (1995); Johal (1998;2002); Banyal (1998; 2003); Johal et al. (2002a); Johal et al. (2002b); Dhanze and Dhanze (2004) Mehta & Sharma (2008); Sharma (2010) and Sharma & Sidhu (2016).

Area of Study

Kunah stream (Fig.1) is left bank tributary of Beas River which originates near Awah-devi and joins Beas River at Vilikleshwar, Hamirpur (H.P). This stream is located between 31º34'17" N latitude to 31º46'36" N latitude and 76º21'59" E longitude to 76º40'31" E longitude and is about 48 km long. Total catchment area of the stream is about 312.25 km^2. This stream is an integral part of the Beas riverine system. Moreover, almost negligible scientific knowledge is available regarding fish faunal diversity in Kunah stream. Hence, present study is designed.

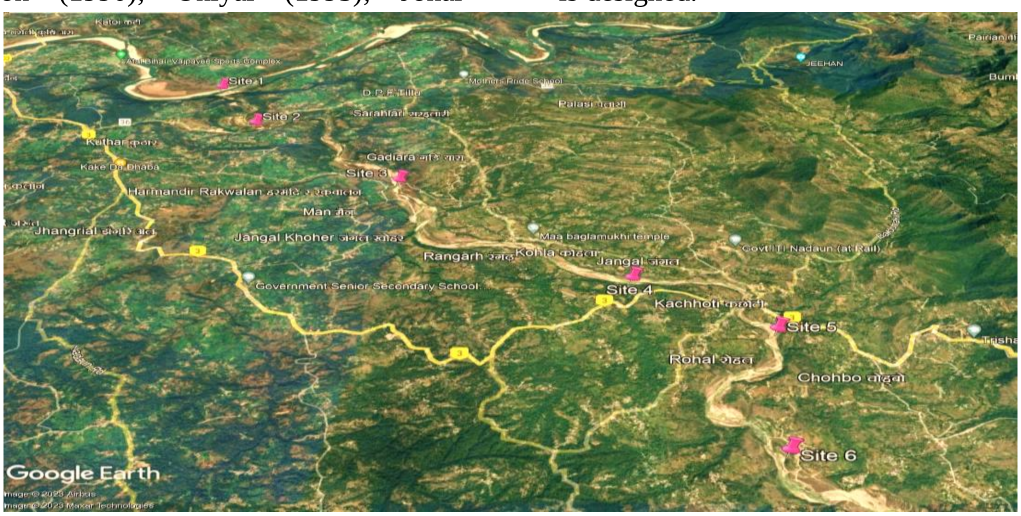

Fig 1. Map showing area of study. (*Source: Google Earth)*

Materials And Methods

The habitat types and substrate composition of the stream was classified as per Armantrout (1999). Various physico-chemical factors such as water temperature (°C), Dissolved Oxygen (mgl^{-1}), pH and Electrical Conductivity (µScm^{-1}) were measured using digital probes in the field. Alkalinity (mgl^{-1}), Total Hardness (mgl^{-1}), concentration of Phosphates and Nitrates (mgl^{-1}) were analyzed in the laboratory as per criteria given in APHA 1998. Fish sampling from the stream was done randomly at different sampling sites (Table.1) during 2022-23. Fish specimens were collected with the help of local licensed fisherman by using cast net and lines mainly, which are then preserved in 10% formalin/ 95% ethyl-alcohol. The collected specimens were then brought to the laboratory for further identification. Taxonomical identification of the collected specimens was done on the bases of morphometric and meristic characters by using published references of Talwar and Jhingran (1991); Jayaram (1999) and Fish and Paul (2023)

Table 1: Sampling sites

Name of locality	Latitude	Longitude
Site1 (Vilikleshwar)	31°46′18.57″N	76°22′29.89″E
Site 2 (Nadaun-Sujanpur Tihra bridge	31°45′54.26″N	76°22′56.66″E
Site 3 (Fatehpur)	31°45′7.03″N	76°24′5.69″E
Site 4 (near Muhun)	31°44′1.27″N	76°25′37.02″E
Site 5 (Rangas)	31°43′33.7″N	76°26′23.88″E
Site 6 (near Kunna Janni-jaggian)	31°42′38.27″N	76°26′23.83″E

Results And Discussion

Present studies have revealed that Kunah stream is a spring-fed perennial stream. The substrate of the stream is mainly dominated by boulders and cobbles with small amounts of sand and clay, which leads to the formation of different types of habitats in the stream. Riffles and side pools formed the dominant habitats in the stream followed by run, and rapids which were seen mostly during monsoon season. Macrohabitat analysis was done properly to assess suitability of stream for supporting fish-fauna. Since water temperature of the stream is generally determined by the volume of water, time of the day and with season. In the stream under report maximum temperature was recorded during May/ June and minimum was recorded during January/ February. It was found that riffles and shallow pools in the stream don't show thermal stratification (Dodge et al.1981; Simonson et al.1993), but deep pools are thermally stratified which supports more fish diversity. Water temperature and DO show an inverse relation (Hynes 1970). Hence lowest value of DO was recorded during summer months and highest during winter months. Stream was found alkaline during whole period of study, which determines the buffering capacity of the stream. pH value was less in monsoon months, this is probably due to dilution of stream water by surface-runoff and the photosynthetic communities are washed away by rainwater (Nautiyal 1984;1985). Conductivity and total dissolved solids are two interconnected parameters. Conductivity is due to ionized particles in stream water. Conductivity showed an overall increase up to the month of June, it then decreased in the month of July and August. Similar observations were recorded by Negi et al. (2006) in Pong dam reservoir. Total hardness (Ca^{2+} & Mg^{2+}) was maximum during the month of July and August due to addition of allochthonous material by surface runoff. Nitrate (oxidized form of nitrogen) is a crucial factor which dictates the growth of phytoplankton (Saha et al.1971). Nitrates were found to be maximum during the month of September and October. Phosphate concentration limits plant production and is added to the stream mainly by surface runoff. Phosphate concentration was found to be maximum and minimum during November and August months respectively. In lowland streams of H.P, different researchers (Banyal 1998, 2003; Johal et al. 2001; Johal & Rawal 2005) made similar inferences. Based on present investigations a positive correlation was recorded between pH, DO, EC, total hardness, nitrates, phosphates, and fish species richness as shown by correlation coefficient and regression equation. Furthermore, negative correlation was reported between temperature, alkalinity, and fish species richness (Table. 2)

Table 2. Species richness Vs Abiotic factors

Parameter	Observed Range (range difference)	Mean	Standard Deviation	Correlation coefficient
Water Temperature (°C)	17.5 – 32.4 (14.9)	26.4	4.998694	-0.11895
pH	7.9 – 10.1 (2.2)	8.5	1.318843	0.221952
DO (Dissolved Oxygen) (mgl^{-1})	6.1 – 9.2 (3.1)	7.8	0.634	0.183332
EC (Electrical Conductivity) (μScm^{-1})	239 – 350 (111)	293.4	36.09518	0.164915
Alkalinity (mgl^{-1})	152 – 285 (133)	190.5	35.99522	-0.16643
Total Hardness (mgl^{-1})	130 – 220 (90)	161.7	25.29106	0.051797
Nitrates (mgl^{-1})	0.010 – 0.117 (0.007)	0.06	0.031209	0.070374
Phosphates (mgl^{-1})	0.030 – 0.220 (0.19)	0.07	0.046704	0.071746

Fish diversity from Kunah stream was recorded from six sampling sites. A total of 18 fish species (Fig.4) belonging to 6 orders and 8 families were recorded (enlisted in Table.3). Cypriniformes is the dominant order (11 species) followed by Synbranchiformes and Anabantiformes having 2 species each which are then followed by Siluriformes, Beloniformes, Cichliformes represented by one species each. The greatest diversity of Cypriniformes and Siluriformes in the freshwater habitats were also reported by Nelson (1994) and Shrestha (1999). Minnows, loaches, and commercially insignificant fishes were found to be abundant in the stream. Commercially important fishes such as *Tor putitora* and *Cyprinus carpio* were also found in the stream. Additionally, this stream also provides breeding ground to one commercially important endangered fish (*Tor putitora*), revealed by presence of fingerlings of the fish in the diverse aquatic habitats.

Table 3. Ichthyofauna of Kunah stream, Hamirpur (H.P)

Fish Species	Species Code	Family	Order	IUCN Status	Habitat Preference
Cyprinus carpio (Linneaus, 1758)	CC	Cyprinidae	*Cypriniformes*	VU	Deep Pools
Tor putitora (Hamilton, 1822)	TP	Cyprinidae	*Cypriniformes*	EN	Riffles/Pools
Pethia ticto (Hamilton, 1822)	PT	Cyprinidae	*Cypriniformes*	LC	Shallow Pools
Garra gotyla (Gray, 1830)	GG	Cyprinidae	*Cypriniformes*	LC	Pools/Riffles
Tariqilabeo diplocheilu Heckel, 1838)	CLD	Cyprinidae	*Cypriniformes*	LC	Deep Pools
Opsarius bendelisis (Hamilton, 1807)	OB	Danionidae	*Cypriniformes*	LC	Riffles
Barilius vagra (Hamilton, 1822)	BV	Danionidae	*Cypriniformes*	LC	Riffles

Barilius barila (Hamilton, 1822)	BB	Danionidae	*Cypriniformes*	LC	Riffles
Salmostoma bacaila (Hamilton, 1822)	SB	Danionidae	*Cypriniformes*	LC	Pools/Riffles
Acanthocobitis botia (Hamilton, 1822)	AB	Nemacheilidae	*Cypriniformes*	LC	Riffles
Schistura horai (Menon, 1952)	AH	Nemacheilidae	*Cypriniformes*	NE	Riffles
Xenontodon cancila (Hamilton, 1822)	XC	Belonidae	*Beloniformes*	LC	Runs
Glyptothorax indicus (Talwar, 1991)	GI	Sisoridae	*Siluriformes*	LC	Rapid
Mastacembelus armatus (Lacepede, 1800)	MA	Mastacembelidae	*Synbranchiformes*	LC	Riffles
Macrognathus pancalus (Hamilton, 1822)	MP	Mastacembelidae	*Synbranchiformes*	LC	Riffles
Channa punctata (Bloch, 1793)	CP	Channidae	*Anabantiformes*	LC	Deep and Shallow pools
Channa gachua (Hamilton, 1822)	CG	Channidae	*Anabantiformes*	LC	Pools and Riffles
Oreochromis niloticus (Linneaus, 1758)	ON	Cichlidae	*Cichliformes*	LC	Pools

(VU: Vulnerable, EN: Endangered, LC: Least Concern, NE: Not Evaluated)

Maximum fish diversity was recorded in the pools (H′= 2.675), followed by riffles (H′= 2.243) and runs (H′= 1.609) (Table.4), due to the fact that deep water allows vertical stratification and environmental stability to the fish habitat. Also, stream discharge directly influences habitat stability and composition, so maximum diversity was recorded during the periods of low water level in the stream i.e. from November up to the onset of the monsoon. Similar observations were also made by Banyal (2003); Johal et al. (2002a); Johal et al. (2002b); Negi et al. (2010) in most of western Himalayan lowland streams.

Table 4. Diversity of Ichthyofauna in different habitats of the stream

Index	**Pools**	**Riffles**	**Run**
Simpson Diversity Index	0.9237	0.8771	0.8
Shannon and Wiener diversity Index	2.675	2.243	1.609
Evenness Index	0.907	0.8565	1
Marglef Diversity Index	3.988	3.189	2.485
Menhinick Diversity Index	2.44	2.294	2.236

Based on cluster analysis (Fig.3) the fish-faunal assemblage was classified in different habitats of the stream (viz., pool, riffle, run). Cluster A represents single species (*Oreochromis niloticus*) which is found in very low number in pools, only 1 individual was recorded. Cluster B represents the species which were present in all three habitats. Cluster C and E represent the species present in pools and riffles but in cluster E there was abundance of species in pool whereas cluster D shows species present in pools. Cluster F represents the species present in riffles only. Overall, the diversity of fish-fauna was noticed maximum downstream due to increased nutrient availability (Vannote et al.1980), more water depth and dominance of pool habitat. Different fish species utilize a variety of physical objects during their life cycle to fulfill their ecological requirements (Schlosser 1982). According to Edds (1993) fish assemblage model pertaining to Himalayan region, Cyprinids (*Barilius bendelisis, B. vagra*) are common in pools, runs and riffles, *Nemacheilus* sp. in riffles and *Glyptothorax* sp. in low hill riffles. Arunanchalam et. al. (1997) and Negi et. al. (2010) reported *Mastacembelus armatus* to be confined to the deep pool areas avoiding fast current. Similar pattern was observed related to fish species described above except *Acanthocobitis botia* and *Schisturia horai* which were found mainly in pool, riffles, run and pools respectively.

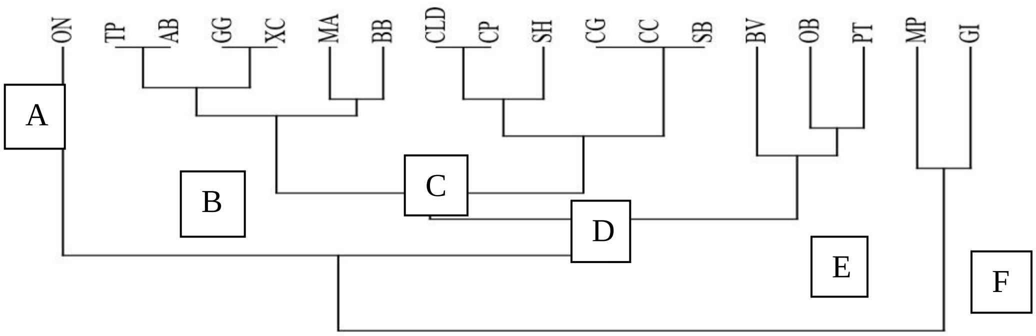

Figure 3. UPGMA clustering of common fish species using Bray-Curtis similarity measure based on their abundance in six different sites. (Species code given in Table: 2)

Based on aforesaid investigations, it is concluded that the water temperature, water depth along with water current, water volume and water quality play an important role in governing distribution of fishes. Besides, availability of nutrients plays crucial role in governing distribution of fishes in different habitats of the stream under report. Furthermore, analysis of different physicochemical factors and presence of fair fish diversity in different habitats of the stream revealed that the stream is quite productive and healthy. The presence of adult and juvenile specimens of fishes *Xenentodon cancila*, *Glyptothorax indicus* and *Tor putitora*, (endangered fish as per IUCN) has highlighted the importance of this stream as a breeding ground for said fishes which ultimately provides fish spawn to the Beas River.

Fig. 4. Ichthyofauna of Kunah stream, Hamirpur (H.P)

But removal of bed material, addition of effluents, various types of household pollutants and illegal fishing are noticed to be the potential threats in and around the watershed of Kunah stream which can disturb the ecology and composition of ichthyofauna in the stream. Moreover, the presence of trash fish viz. *Oreochromis niloticus* (Linneaus, 1758) is also a matter of concern for native fishes of the stream due to its furious feeding habits and high reproductive rate. Vicente and Fonseca-Alves, 2013 reviewed the impact of introduced *Oreochromis niloticus* on biodiversity of varied aquatic resources all over the world. In India, potential negative impacts of *Oreochromis niloticus* on local fish fauna and other aquatic organisms was given by Mayank et al. (2011; 2021), Kour et al. (2014), Singh et al. (2014), Dwivedi et al. (2016), Johnson et al. (2020;2022). Hence, proper management plan should be prepared and implemented by the fishery managers and administrators to conserve the ichthyofaunal diversity in the stream.

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