



Documentation of fishes and physico-chemical characters of a stream Indrawati- a spring fed tributary of River Bhagirathi at Uttarkashi (Central Himalaya, Garhwal) India

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Abstract

Most of the riverine resources in Garhwal region are mountainous and perennial either snow fed or spring originated. All these mountainous streams provide a good natural habitat for survival of hill stream fishes. Present communication deals with documentation of Ichthyofauna along with physico-chemical properties of a similar perennial spring fed stream Indrawati- a left side tributary of river Bhagirathi. It comes down from the hills of Baragari and through Joshiyara debouches into the river Bhagirathi at Uttarkashi (elevation 1128 masl). Major part of stream water is mainly abstracted for the irrigation purpose in the side lying fields all along its length. There is heterogeneity in the stream bed characteristics which results into the existence of varied fish fauna. Study reports eleven fish species from the stream belonging to two orders, three families and six genera. Fishes belonging to cyprinidae family are found more commonly than the cobitidae and sisoridae family. Fishery of the stream is of subsistence nature and is under intense pressure of anthropogenic activities. Fishes captured are of generally small sized. The physico-chemical characteristics recorded during the study period in the different seasons are water temperature (9.0-16.0 °C), velocity (.50 m^s-1.46 m^s), TDS (49 mg^l - 65 mg^l), pH (8.0 - 8.3), DO (7.3 mg^l - 10.5 mg^l), Free CO₂ (0.10 mg^l - 0.30 mg^l) and turbidity (06-30 NTU).

Keywords: Hill stream, Ichthyofauna, physico-chemical characteristics, river Bhagirathi, stream habitat

Introduction

Indrawati stream is a spring fed perennial stream. It originates from the Baragari hills and merges into river Bhagirathi on its left bank at Uttarkashi (elevation 1128 masl). The stream is life line for people settled in small hamlet along the stream bank. Besides irrigation, stream water is used for drinking and other household purposes by the inhabitants. It provides critically important habitat for some of the important hill stream species of river Bhagirathi in Garhwal Himalaya. It provides habitat heterogeneity (pools, rapids, runs, falls and cascade) for the subsistence of some small sized cat fishes, lesser barils and few loaches. Fish fauna exhibits enormous diversity in their habitat, size, colour and shape. They are found in almost every type of water body (fresh, marine and brackish).

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Approximately 32,300 fish species are catalogued in fish base (<http://www.fishbase.org/>) from world over. Huge heterogeneity in the climatic condition and altitudinal variation favors very rich fish faunal diversity in India. A total of 2,500 fish species have been reported from Indian waters of which 930 species are the freshwater species (Jayaram, 2010). Indian uplands also have a rich ichthyofaunal diversity of 258 species (Sunder *et al.*, 1999). The Garhwal region of Central Himalaya which has pristine water resources with tremendous range of thermal regime supports 64 fish species from number of large and small river systems studied by Singh *et al.*, (1987). Though documentation of ichthyofauna of Garhwal (Central Himalaya) have been carried out by many workers (Badola and Pant, 1973; Badola, 1975; Sharma, 1984; Singh *et al.*, 1987; Lakra *et al.*, 1987; Dobriyal 1991; Khanna and Badola, 1991, Singh *et al.*, 1993; Agarwal *et al.*, 2005, 2011; Uniyal and Kumar, 2006; Bisht *et al.*, 2009), but comprehensive information on some of the important small streams is still lacking. The



Indrawati stream - a small but important tributary of Bhagirathi river system is one of them which didn't receive any attention. The present study is an attempt to fill up this lacuna and to catalogue the base line information of the fish species and water quality of Indrawati stream.

Study area:

Study area is located in the upper and lower stretches of the Indrawati stream ($31^{\circ} 27' 34''$ N to $31^{\circ} 13' 22''$ N latitude and $77^{\circ} 58' 51''$ E to $78^{\circ} 53'$

$32''$ E longitude) (Fig.1). The upper stretch (1250 masl) is ~5 km upward from the Joshiyara, where the river is gorge like and rocky or full of large boulders (Fig 2). The stream has high gradient in this stretch. The lower stretch (1130 masl) is located at Joshiyara where the river has somewhat less gradient. The stream bed consisted of cobbles, pebbles and sand besides boulders. The river water is also abstracted in agricultural fields on both river banks in lower stretch. The total water discharge of stream fluctuates considerably, sometime in the



Fig. 1 Sampling sites (S-1 and S-2) in Indrawati stream- a tributary of river Bhagirathi



Fig. 2 Upper stretch of Indrawati Stream

summer season for a short duration, stream seems almost discontinuous at several places restricting water in the pools. The stream shows heterogeneity in the streambed characteristics in the lower and upper stretches. Deep pools are dominated in the lower stretches along with rapids and runs. While upper stretch is dominated by rapid, fall, runs and cascade type of habitat.

Material and Methods

Two sampling sites- one each in upper and lower stretches, were selected depending on the habitat variation and substratum types. For the documentation of ichthyofauna of Indrawati stream, experimental fishing was done in both upper and lower stretches of the stream. Collection was made from both the stretches during daytime (6:00-18:00 hrs) while 'baur' and 'gill net' were also fixed during late evening hours (17:00 -18:00 hrs) and recovered in early morning (5:00 -7:00 hrs). The fishes were collected with the help of local fishermen proficient in this occupation. The cast nets (dia. 2.0 m, mesh size 1.8 x 1.8 cm), gill nets locally called Jal (mesh size 1.2 x 1.2 cm, L x B = 12 m x 1.5 m) and another type of gillnet 'phans or baur' are primarily used for the collection of fish samples. The 'baur' is a type of indigenous nets, fabricated of several fine nylon loops knotted over a long nylon cord of 5-8 m length, rope is spread on the bottom of stream cross section with the help of large stones tied in few loops. Some other type of indigenous fishing method/ traps viz. goda, pot trap, hammering, hook and lines, diversion of river

channel, and hand picking are also used. Digital images of fresh specimen were taken prior to preservation. Subsequently the representative fish samples were preserved in 8% formaldehyde solution at the site of their collection. Small fish specimen (<150 mm in total length) were preserved directly without preservative injection or opening the visceral cavity. But the large specimen (>150 mm in total length) were preserved with preservative injection or slitting the abdomen. Afterwards fish samples were transferred to the laboratory with extensive care for further taxonomic studies. The identification of fish species was done in the laboratory on the basis of their morphometric and meristic characters. The standard keys outlined in literature (Day, 1878; Menon, 1974; Srivastava, 1980; Tilak, 1987; Talwar and Jhingran, 1991; Shrestha, 2008; Badola, 2009; Jayaram, 2010) and fish data base developed by NBFGR was also consulted for the identification of fishes. Physico-chemical characters of the stream viz. Temperature, Water velocity, DO, Free CO₂, TDS, pH and Turbidity were also determined seasonally (monsoon, summer and winter). These parameters were analyzed after following Trivedy and Goel, (1986) and APHA, (1998). The relative abundance (RA) of fish across different seasons was worked out by the following formula.

$$RA = \frac{\text{Number of samples of particular species} \times 100}{\text{Total number of samples}}$$

Results and discussion

Fish diversity and abundance:

The preparation of fish species inventory of Indrawati stream, from fishery viewpoint and ecological characteristics was done during the period 2010-12. A total of eleven fish species are collected from the whole stretch of stream during study period. All the species found in the stream are endemic, belonging to six genera, three families and two orders (Table 1). Among these three families, the species belonging to Cyprinidae family are found most common occupant in the stream. Cyprinidae family is represented by six species of three genera. The species of Cobitidae family are found rarely. It is represented by three species of a single genus. The family Sisoridae is also found rarely and has two species of two genera in the stream. Only *Schizothorax richardsoni*, is

found abundantly. While the species viz. *S. N. rupicola*, *N. multifasciatus*, *Glyptothorax plagiostomus*, *Barilius bendelisis* and *B. barna* are found commonly during the study period. While *Tor chillinoides*, *T. putitora*, *Noemacheilus beavani*, *N. pectinopterus* and *Pseudecheneis sulcatus* are found rarely in the stream.

Table 1. Relative abundance of fish species of Indrawati stream in different seasons

Ichthyo species with order and family	Common name	Status	Relative abundance		
			Summer	Monsoon	Winter
Order Cypriniformes					
1. Family Cyprinidae					
<i>Barilius barna</i>	Fulra	c	9.70	12.36	11.85
<i>Barilius bendelisis</i>	Fulra	c	10.54	11.29	11.85
<i>Schizothorax plagiostomus</i>	Asela	c	12.65	13.44	14.81
<i>Schizothorax richardsonii</i>	Maseen	a	28.69	26.88	28.14
<i>Tor chillinoides</i>	Khasra	r	5.90	5.91	6.66
<i>Tor putitora</i>	Khasra	r	6.75	8.60	5.92
2. Family Cobitidae					
<i>Noemacheilus beavani</i>	Gadiyal	r	5.06	5.37	3.70
<i>Noemacheilus multifasciatus</i>	Gadiyal	r	4.21	4.30	2.96
<i>Noemacheilus rupicola</i>	Gadiyal	r	6.32	5.37	4.44
Order Siluriformes					
1. Family Sisoridae					
<i>Glyptothorax pectinopterus</i>	Kathrua	r	4.64	5.37	4.44
<i>Pseudecheneis sulcatus</i>	Kathrua	r	5.48	4.83	5.18
Total eleven species (3 orders, 3 families and 6 genera)					

The Indrawati stream is characterised by diverse flow, varying water depth, meandering nature and erratic hiding cover. All these varying habitat characters of the stream, provide critical habitats for some important IUCN, (2011) referred endangered (*Tor* and *Glyptothorax* spp.) and vulnerable (*Schizothorax* and *Pseudecheneis* spp.) hill stream fish taxa. It is also observed that the habitat of freshwater stream fishes is more dependent on physical features rather than on chemical features as in other aquatic habitats (Srivastava and Sarkar, 2000). Owing to these divergent ecological conditions various life stages of these fish species (adults, juveniles and spawners) are observed in the stream. In the upper stretch, the Indrawati stream is narrowed with high gradient and fast flowing water dominated by big boulders. The rapid, falls and cascade type of habitats are dominant in this stretch (Fig.2). Species having special adhesive apparatus on the ventral surface (*Glyptothorax* and *Pseudecheneis* spp.), adapted to these fast currents are reported from upper stretch of the stream. However, *Garra* sp.

having similar typical hill stream adaptation could not be reported from Indrawati stream which may be due to low total discharge in the stream. The species found in the upper stretch are seldom found in lower stretch. The lower stretch (Fig.3) of the stream is characterised by wide channel, less gradient with moderate currents. The habitat is characterised by deep and shallow pools followed by some rapids and riffles. The *Tor*, *Schizothorax*, *Barilius* and *Noemacheilus* spp. are found mostly in this lower section of the stream and very rare in the upper stretch. This lower stretch (near confluence with Bhagirathi river at Uttarkashi) is very important segment of the stream from the viewpoint that it provides critical habitat (breeding ground) for the brooders of *Tor*, *Schizothorax*, *Barilius* and *Noemacheilus* spp. and also the nursery ground for early stages of their life cycle. In this segment of the stream fingerlings and juveniles of all these species, are found abundantly. The juveniles of *Schizothorax* and *Tor* by attaining a size migrate into the river Bhagirathi. The shoals of lesser barils (*Barilius* spp.) and some loaches (*Noemacheilus*



species) were limited to shallow pools having rather high temperature. The individuals of *Barilius* could not be observed in the upper stretch. They continuously migrate between lower and middle stretches. Thus, these observations clearly reflect on the habitat specific distribution of hill stream fishes.



Fig. 3 Lower stretch of stream near its confluence with Bhagirathi river

Total water discharge of Indrawati stream is comparatively low. Thus due to less total discharge the stream has small sized fishes and less ichthyofaunal diversity as compared to the other tributaries of river Bhagirathi (viz. Assiganga and Bhilangana) having more discharge with greater fish diversity (Agarwal *et al.* 2011). The continuous fluctuating discharge in different seasons also affects the diversity and distribution of fish species. The significant correlation between stream volume and fish species abundance has been reported by Johnson and Arunachalam, (2010). Sehgal, (1999) observed that the fluctuating discharge of water and drying out of streams, leaving only isolated pools or no water at all is also important matter for the fish distribution and their diversity. During present study it is also observed that in the summer season the stream seems discontinuous at several places on its banks, leaving water in side-pools. In this period these side pools provide shelter to the fishes for their subsistence. The stream restores itself depending on precipitation. This reduction of torrential streams to semi-stagnant pools at some places also exposes the fish to terrestrial predator affecting the fish population (Agarwal and Singh, 2009). Stream substratum type is very important for

providing feeding and breeding niche to most of the fish species. It largely influences the distribution of fish fauna (Agarwal *et al.*, 2011). The substratum of Indrawati stream is comprised of bedrock, boulders, cobbles and gravels. This substratum type provides all the ecological requirements to the existing fish taxa of the stream. The stony substratum provide suitable habitat to *Schizothorax* sp. for feeding on periphyton by scraping the stones. The large boulders in the stream while serve as hiding cover to the *Barilius* and *Noemacheilus* spp. they also support *Glyptothorax* and *Pseudecheneis* spp. to adhere by their adhesive apparatus to withstand in fast water current. The stony substratum with boulders, cobbles and gravels is primary requisite for the young stages of most of the hill stream fishes.

Threats to fish resources of Indrawati stream

The fish fauna of Indrawati stream is under serious threat due to various anthropogenic hazards (abstraction of stream water, mining of sand and gravel, use of agricultural pesticides and destructive fishing practices). The abstraction of water for irrigation purpose in nearby fields results into the considerable reduction of water in dry months. This affects the stream habitats deleteriously. The fish fauna is impecunious during this period and the fishes are noticed restricted to the deep pools which serve as natural abode for their existence. Further, chemical fertilizers and pesticides are frequently used by the farmers. These chemical fertilizers and pesticides leach into the stream and contaminate the water thus affecting the physico-chemical properties of the water. This leads to deleterious effect on early life history stages of many fish species inhabiting the stream. Another factor which influences the fish fauna in Indrawati stream is removal of sand, gravel and boulder from the stream for various constructions activities. The stones and the boulders often provide suitable habitat as fish hiding covers, breeding and feeding grounds. The removal of this material completely destructs the habitat and substratum type and hiding covers used by the resident species. Thus, the fish fauna is being affected seriously. The use of unscientific or destructive fishing methods by the denizens is causing threat to the fish wealth of the stream. People living on the banks of the stream used chemical (bleaching powder), some

ichthyotoxic plants (*Xanthoxylum*, *Euphorbia*, *Sapiump*, *Randia*, *Agave*, *Polygonum*) extracts and some time electric current. These methods indiscriminately kill all the fishes including their early life stages thus causes serious damage to fishery.

Table 2: Physico-chemical characters of Indrawati stream at sampling site S-1 and S-2

Physio-chemical parameters	Seasons					
	Summer		Monsoon		Winter	
	S-1	S-2	S-1	S-2	S-1	S-2
	Mean \pm SD	Mean \pm SD				
Temperature ($^{\circ}$ C)	15.3 \pm 1.54	14.2 \pm 1.65	16.0 \pm 1.33	15.8 \pm 2.16	10.0 \pm 1.81	9.0 \pm 2.64
Velocity (m^{-sec})	0.5 \pm 0.15	0.7 \pm 0.1	1.4 \pm 0.132	1.46 \pm 0.40	0.9 \pm 0.1	1.0 \pm 0.2
pH	8.3 \pm 0.44	8.3 \pm 0.34	8.2 \pm 0.36	8.0 \pm 0.43	8.0 \pm 0.68	8.0 \pm 0.36
D.O. (mg^{-l})	7.75 \pm 0.58	8.0 \pm 0.5	7.3 \pm 0.7	8.3 \pm 1.08	10.0 \pm 1.32	10.5 \pm 0.75
Free CO ₂ (mg^{-l})	0.15 \pm 0.026	0.10 \pm 0.026	0.30 \pm 0.161	0.18 \pm 0.026	0.12 \pm 0.028	0.1 \pm 0.02
TDS (mg^{-l})	49 \pm 5.29	53 \pm 10.81	56 \pm 5.29	65 \pm 12.12	52 \pm 2.65	52 \pm 6.0
Turbidity (N.T.U)	19 \pm 3.46	09 \pm 2.0	30 \pm 4.58	14 \pm 3.0	14 \pm 2.0	06 \pm 2.0

Sampling site S-1 (lower stretch 1130 masl), Sampling site S-2 (Upper stretch 1250 masl)

Physico-chemical profile of the stream

Physico-chemical parameters of Indrawati stream analyzed during summer (S) monsoon (M) and winter (W) has shown characteristic seasonal variation in both the sites (Table 2). The temperature of stream is found low throughout all seasons (annual range 9.0 \pm 2.64 to 16.0 \pm 1.33 $^{\circ}$ C). Lower reaches of the stream (S-1) has recorded slightly higher temperature from the upper stretch (S-2) in all the seasons. It might be due to higher elevation and dense vegetation in the riparian zone of S-2. The low temperature range round the year is highly conducive for cold water fish species. Velocity of the stream water shows large variation in sampling sites. In summer months it is low. Average high water velocity (m^{-s}) is found at S-2 (0.7 \pm 0.1 S, 1.46 \pm 0.40 M, 1.0 \pm 0.2 W) than S-1 (0.5 \pm 0.15 S, 1.4 \pm 0.132 M, 0.9 \pm 0.1W) because of high gradient of stream in upper stretch. Sometimes in summer season due to absence of precipitation, the stream seems discontinuous. Water was found alkaline in all the seasons at both the sites. No significant difference is recorded in pH value from both the sites. Dissolved oxygen (mg^{-l}) at both sites showed significant variation in summer and monsoon season. However DO of stream water from upper stretch (S-2) is recorded comparatively high (8.0 \pm 0.5, 8.3 \pm 1.08, 10.5 \pm 0.75 mg^{-l}) than the lower stretch (S-1) (7.75 \pm 0.58, 7.3 \pm 0.7, 10.0 \pm 1.32

mg^{-l}) in summer, monsoon and winter months respectively. High oxygen contents at S-2 are due to presence of frequent water falls in upper reaches causing mixing of air in the stream water. Free CO₂ (mg^{-l}) was found low in all the seasons at both the sites. Total dissolved solids (mg^{-l}) in the stream recorded slightly higher value (53 \pm 10.81, 65 \pm 12.12) at S-2 than S-1 (49 \pm 5.29, 56 \pm 5.29) in summer and monsoon seasons respectively. However in winter same TDS value (52 mg^{-l}) is recorded at both sites. Stream water is recorded less turbid throughout the year. S-1 portrayed comparatively high turbidity value (N.T.U) (19 \pm 3.46 S, 30 \pm 4.58 M, 14 \pm 2.0 W) in comparison to S-2 (09 \pm 2.0 S, 14 \pm 3.0 M, 06 \pm 2.0 W). These observations on the physico-chemical characteristics very well co-relate the occurrence and distribution of fish species in the Indrawati stream. The high velocity, large gradient with clear oxygenated water dominated by rocky- stony substratum in upper stretch of the stream favoured the survival and existence of *Glyptothorax* and *Pseudecheneis* spp. The occurrence of these species in lower stretch is accidental and reported only in monsoon months when heavy rain disturbed the substratum and these fishes wash away from stones due to turning down by the force of water with heavy silt. Bisht *et al.* (2009) has reported that seasonal distribution and relative abundance of fish

fauna is directly related to change in physico-chemical properties, channel course, water discharge and pattern and geometry of tributaries. Present observation also reveals that fish diversity decreases with increase in gradient of stream. However substratum is also an important factor which influences the density and diversity of fish fauna in Indrawati stream. Similar observation has been made by Singh and Kumar, (2000) while working on the Ichthyofauna and ecology of hill-streams of Garhwal Himalaya.

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