VOLUME 8 ISSUE 1 2022

ISSN 2454-3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, No. 1, 39-45 (2022)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Impact of Heavy Rain and Flood on Ichthyofaunal Diversity and Distribution Pattern in River Network of Kumaon Region of Uttarakhand State, India

Joshi Mamta[1*], Pandey N. N.[2] and Bisht H. C. S.[1]

[1]Zoology Department, D.S.B Campus, Kumaun University, Nainital 263002, Uttarakhand, India
[2]ICAR-Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand, India

**Corresponding Author*

Received: 11th December, 2021; **Accepted:** 1st January, 2022; **Published online:** 7th January, 2022

https://doi.org/10.33745/ijzi.2022.v08i01.005

Abstract: In the present study an attempt has been made to assess the ichthyofaunal diversity in the rivers and streams of Kumaon region of Uttarakhand state with main focus on impact of natural calamity such as heavy rain and flood. The estimated total length of major river network in Kumaon region is 1626.2 km including streams, tributaries and rivulets, which support occurrence of 31 fish species. The data of Catch Per Unit Effort (CPUE) indicated decrease in main river courses, but richness in their tributaries after flood. In main river courses, the CPUE was decreased as 0.03 kg/h to 0.32 kg/h from 0.12 kg/h to 1.28 kg/h due to heavy rain and flood condition during the month of September, 2021, while it was increased in side tributaries of these rivers as 1.84 kg/h to 3.12 kg/h from 1.14 kg/h to 2.30 kg/h after the flood. Tributaries are shelters and protected areas to the local migratory fish species during natural calamity and high turbidity in the main river course. These resources are important for ichthyofaunal diversity and sustainability of aquatic ecosystem.

Keywords: Natural calamity, Tributaries, Ichthyofaunal diversity, Catch per unit effort, Migratory fish

Citation: Joshi Mamta, Pandey N. N. and Bisht H. C. S.: Impact of heavy rain and flood on ichthyofaunal diversity and distribution pattern in river network of Kumaon eegion of Uttarakhand State, India. Intern. J. Zool. Invest. 8 (1): 39-45, 2022.
https://doi.org/10.33745/ijzi.2022.v08i01.005

Introduction

Uttarakhand is 27th state of the Republic of India and it is located in northern part between latitude 28°40'-31°29'N and longitude77°35'-81°5'E covering an area of 53,566 km^2. The state has unique ecosystem and bestowed with vast and varied water resources in the form of rivers, rivulets, streams, streamlets and lakes. The diverse aquatic habitats of the hill region harbour rich piscine diversity. Biodiversity is essential for stabilization of ecosystems, protection of overall environmental quality and for understanding intrinsic worth of all species on the earth (Ehrlich and Wilson, 1991). Himalayan ecosystem is unique in its biodiversity and it is the origin point of two mightiest river systems in Uttarakhand i.e. Ganga river system from Gangotri glacier and Yamuna river from Yamunotri glacier having so many rivers like Alaknanda, Bhagirathi, W-Ramganga, Kosi, Yamuna, Saryu, Mandakini and Sharda along with many small streams and

tributaries. Fish is an indicator of habitat suitability and health of any aquatic system (Gorman and Karr, 1978), however, thermal regime is an important limiting factor affecting distribution pattern and abundance of fish. Various abiotic and biotic factors are the key factors for determining the fish diversity, community structure and species assemblages in the stream and rivers (Minns, 1980). Suitable spawning ground, shelters and feeding ground play important role in the life cycle of fish and consequently in the sustainability of fish population. Scanty information is available on the aquatic faunal diversity and density for the study area as majority of the earlier studies were focused on the main river course and its major tributaries. In the Himalayan streams, the distribution of fish depends upon the flow rate, type of substratum, water temperature, food availability and the hydrographical features of the basin (Sehgal, 1988). Sunder *et al.* (1999) enlisted total of 218 fish species for the entire Himalayan region. Himalayan fish fauna was classified under subsistence and commercially important fish groups i.e. carps (*Labeo* and *Tor* spp.), lesser barils (*Barilius* spp.), schizothoracines (*Schizothorax* and *Schizothoraichthys* spp.), garrids (*Garra* spp.) and sisorids (*Glyptothorax* and *Glyptosternum* spp.) (Vass, 2005). Coldwater species inhabiting in the Himalayan rivers belong principally to 5 different families, Salmonidae, Cyprinidae, Cobitidae, Sisoridae and Mastacembelidae; out of which fishes comprising major commercial fishery belong to Cyprinidae represented by 3 sub-families, (i) Cyprininae- Mahseers and minor carps, (ii) Rasborinae-Indian trout, and (iii) Schizothoracinae-Snow trout (Moza, 2002). Owing to complex microclimatic conditions coupled with thermal variables, the capture fishery in the state is still at very low pace.

In the present study an attempt has been made to assess the ichthyofaunal diversity in the rivers and streams of Kumaon region of Uttarakhand state with main focus on impact of natural calamity such as heavy rain and flood.

Materials and Methods

The ichthyofaunal diversity of the major rivers and their tributaries in Kumaon region was worked out by field survey, however, available literature was also used for the major rivers and streams such as Kosi river, Ramganga river and Kali river (Table 1). Sampling for fish fauna was carried out using cast net and drag net in the sample sites to represent wide range of habitat conditions with the study area. The density of species wise fish fauna were recorded wherever fish occurred. The biomass of the fish species was calculated based on the total fish catch. A minimum of 15 netting was made for the period of 2 h in the sampling area to collect the available fish specimen. The percentage catch composition was calculated based on the total weight.

$$\% \text{ Biomass} = \frac{\text{Total weight of fish species (g)}}{\text{Total fish catch (g)}} \times 100$$

Catch per unit effort (CPUE) is the number or weight of fish taken during defined period of effort. The CPUE was calculated as:

$$\text{CPUE} = \frac{\text{Total weight of the fish (kg)}}{\text{Time (h)}}$$

Fish including their spawns, fry and fingerlings caught from the tributaries were identified up to genera/species level with the help of keys given by Jayaram (1999), Menon (1987) and Talwar and Jhingran (1997).

Samples of periphyton were collected by scraping of 3 cm^2 area of the boulders and preserved in 1 ml of Lugol's solution. The keys of Ward and Whipple (1959) and Trivedy and Goel (1984) were used for identifying the algae. Horizontal and vertical hauling was carried out by 0.25 mm pore size plankton net to assess the species richness of phytoplankton and zooplanktons. Quantitative and density estimation of plankton were made using plankton net and preserved in Lugol's solution for identification using keys given by Pennak (1989); Fitter and Manuel (1986) and Edmondson (1992). Enumeration of plankton samples were done

Table 1: Rivers, streams and their tributaries of the Kumaon region in Uttarakhand state

Rivers	Tributaries
W-Ramganga River (588.5 km)	Ram Ganga River , Bhelichin Nala, Bagri Gad, Bhojpatri Gad, Mehar gad, Jhiniya Ga, Lathiya Gad, Dokanna Nala, Kalapani Gad, Hari Gad, Sauron Gad & Tanar Ki Gad.
Kosi River (591 km)	Lamgada Gad, Ban Gad, Dhaula Gad , Nariye Gad, Kali Gad, Ghatt Gad, Swal Nadi, Sakuni Gad, Ghat Gad, Kaluwa Gad, Taklari Gad, Gaunchhil Gadhera, Baurar Gadhera & Khalgari Gad.
Saryu River (619.1 km)	Gomati River, Khir Ganga, Revti Ganga,Gason Gad, Lahor Nadi, Galipatal Gad, Belang Gad, Chhira Gad, Galasar Canal, Kaplani Gad, Saran Gadhera, Gainar Gad, Lamtara Gad, Tuspati Gad & Bhadrapati Nala.
Sharda River (1608.5 km)	E –Ramganga, Goriganga, Dhauliganga, Sarju River, Jakula river, Bagri Gad, Bhojpatri Gad, Jhiniya Gad, Sil Gad, Titar Gad, Mangarh Gad, Shilang Gad & Kalapani Gad .

following methods given by APHA (1998). Density of phytoplankton was assessed by counting in Sedgwick Rafter cell.

Results and Discussion

The estimated total length of the three major rivers of the Kumaon region namely Kosi, Ramganga and Kali is about 584.5 km along with 1041.7 km of their tributaries.

Ichthyofaunal diversity and distributional pattern:

About 31 fish species (Table 2) have been reported in Kumaon region (Kumar, 2002). The dominant reported species are *Schizothorax richardsoni* and *Tor putitora*. Badola. Pant (1973) reported 18 species of fish from District Uttarkashi. Singh *et al.* (1987) published a geographical and distributional list of ichthyofauna and reported a total of 68 species from Garhwal Himalaya. The present study revealed that Uttarakhand possess 83 species belonging to 39 genera and 14 families, out of which 40 species have food value, 8 species are of exclusively ornamental value and 5 species are of sport fishery including world famous sport fish, Golden Mahseer.

As per the river wise distribution in the sampling, 22 species in Kosi, 27 in Ramganga, 16 in Kali were recorded with richness in the subsidiary tributaries of these rivers. Snow trout, *Schizothorax* spp. (68-58%) and Mahseer, *Tor* spp. (1-4%) are the dominant species observed in the main river course and in different tributaries along with minor fishes. These species in the normal course of its life cycle migrate within the stream/river from higher elevation to lower elevation during winter months and vice-versa during summer.

The W. Ramganga and its tributaries recorded the presence of 22 fish species belonging to 7 families. Barils, snow trout, minor carp and loaches were the major contributory groups of fish in the catch composition. Near Kheeda, presence of good number of mahseer was observed. This location might be serving as shelter ground and possibly breeding ground for mahseer. Near Bhikayasen, minor carps mainly *Bangana dero* and *Labeo dyocheilus* are found in abundance. *Raiamas bola* is also found, however, the occurrence was occasional. Near Masi, Mahseer is found in abundance in different size ranges (75-200 g). Based on the sampling it was found that the diversity is low in upper and middle stretches of the main river courses and Shannon index indicated towards the moderately stress condition of the main rivers. However, both the index reflects comparatively better diversity and low stress condition in the subsidiary tributaries of these rivers.

Catch per unit effort (CPUE):

Catch per unit effort (CPUE) is proportional to the average density of the location fished. CPUE was calculated during different months/season at

Table 2: Fish Species recorded in rivers and their tributaries of Kumaon region in Uttarakhand state

Sr. No.	Scientific Name	IUCN Red List Status	Importance
Family : Cyprinidae			
1.	*Barilius barna* (Ham.)	Least Concern	Ornamental/food value
2.	*Barilius bendelisis* (Ham.)	Least Concern	Ornamental/food value
3.	*Barilius barila* (Ham.)	Least Concern	Ornamental
4.	*Barilius vagra* (Ham.)	Vulnerable	Ornamental/food value
5.	*Barilius shacra* (Ham.)	Least Concern	Ornamental
6.	*Raiamas bola* (Ham.)	Endangered	Ornamental
7.	*Danio aequipinnatus* (McClelland)	Least Concern	Ornamental
8.	*Danio rerio* (Ham.)	Least Concern	Ornamental
9.	*Chagunius chagunio* (Ham.)	Least Concern	Food value/ornamental
10.	*Garra prashadi* (Ham.)	Least Concern	Ornamental
11.	*Garra lamta* (Ham.)	Least Concern	Ornamental
12.	*Garra gotyla gotyla* (Gray)	Vulnerable	Ornamental
13.	*Schizothorax richardsonii* (Gray)	Vulnerable	Ornamental
14.	*Schizothorax progastus* (McClelland)	Least Concern	Food value
15.	*Schizothorax plagiostomus* (Heckel)	Not Evaluated	Food value
16.	*Bangana dero* (Ham.)	Least Concern	Food value
17.	*Labeo dyocheilus* (McClelland)	Least Concern	Food value
18.	*Labeo gonius* (Ham.)	Least Concern	Food value
19.	*Cyprinus carpio* var. communis	Not Evaluated	Food value
20.	*Puntius sarana* (Ham.)	Least Concern	Food value/ornamental
21.	*Tor tor* (Ham.)	Near Threatened	Food value/sports
22.	*Tor putitora* (Ham.)	Endangered	Food value/sports
23.	*Naziritor chilinoides* (McClelland)	Vulnerable	Food value/sports
24.	*Rasbora daniconius* (Ham.)	Least Concern	Ornamental
25.	*Esomus danrica* (Ham.)	Least Concern	Ornamental
Family : Cobitidae			
26.	*Botia dario* (Hamilton, 1822)	Least Concern	Ornamental
27.	*Lepidocephalichthys guntea* (Ham.)	Least Concern	Ornamental
28.	*Nemacheilus botia* (Ham.)	Least Concern	Ornamental
29.	*Schistura rupecula* (McClelland)	Least Concern	Ornamental
Family : Sisoridae			
30.	*Glyptothorax cavia* (Ham.)	Least Concern	Ornamental
31.	*Glyptothorax pectinopterus* (McClelland)	Least Concern	Ornamental

different locations in main rivers and their tributaries during the field survey. The data of CPUE indicated decrease in main river courses, but richness in their tributaries after flood. The CPUE recorded in the range of 0.03 kg/h to 0.32 kg/h in the main river courses after the flood condition during the month of September, 2021, while it was in the range of 0.12 kg/h to 1.28 kg/h during the summer months (June-July, 2021) in main river courses of these rivers. In side tributaries of these

rivers, the CPUE was recorded in the range of 1.14kg/h to 2.30 kg/h before the flood, while it was recorded in little higher side as 1.84 kg/h to 3.12 kg/h after the flood.

Fish migration:

These river basins inhabit two major types of migratory species viz. Snow trout (*Schizothorax* spp.) and Mahseer (*Tor* spp.). During the extensive survey, Snow trout was found as dominant species in the middle zones of these rivers. Snow trout is a short distance migratory species and in the normal course of its life cycle migrates within the stream/tributary to main River from higher elevation to lower elevation during winter months and vice-versa during summer. During its upstream movement in the month of April and May this species breeds in the certain pockets especially at the confluence point of the tributaries where there is suitable pool like shelters are available. Similarly during the winter season (late September-early November) the Snow trout migrates towards the lower elevation and during the course of migration breeds in the khads where suitable water temperature and substratum is available. Flood badly affected the off springs and adult mature brood fish.

Major breeding/spawning sites and spawning season:

The presence of larvae, juvenile and adult of different species indicated the suitability of the sites for fish spawning, nursery for larval development, growth and survival of fish species. The larvae/juvenile of snow trout species spotted only in tributaries at different altitudes and indicate its breeding in the side streams. The juvenile of *Schizothorax* spp. was in abundance in different side tributaries (Khads) but not at confluence points of the main river courses, which were the conducive places for breeding and nursing. The presence of gravid female in tributaries also confirmed its natural breeding only in the streams and side tributaries. Certain isolated pools created at meandering of these streams also provide the spawning habitat such as breeding pools near Bhikiyasen. Mahseer (*Tor* spp.) is a multiple spawner and it breeds in batches during the April-May and July-September. Its breeding is correlated with its migratory behavior for suitable breeding grounds and conducive physico-chemical parameters for its gonadal maturity and spawning. Least occurrence of adult mahseer and their juveniles in main river courses indicate the negative impact of heavy rain and flood on the occurrence of this species.

Food and feeding ground:

In periphyton community, *Gomphonema* contributes more than 56% of the total periphytic population. After the flood, phytoplankton were present in dominance with least occurrence of the zooplankton. The density of the plankton was in the range of 112-346 unit/l in main river courses to 188-11244 units/l in tributaries. Bacillariophyceae (14.4-45.0%) was the dominant group of phytoplankton followed by green algae and blue green algae.

Conclusion

Habitat features such as suitable water quality, migration routes, spawning grounds, feeding sites, resting sites and shelter from enemies and adverse weather are determining factors for the propagation and survival of riverine fish species in uplands. Species occurrence/richness and diversity have a decreasing pattern with increasing altitude and there was a seasonal difference in species diversity. Occurrence of the fish is fragmented and confined in certain pockets due to heavy flood and diversion of the main river course. In this context, small streams and side tributaries, which occur across or in sides of the rivers and remain differ from the main steams at little higher elevation with different temperature gradient, water chemistry, hydrological regime, substrate type, food resources and riparian pools, all of which provide the shelters and serve a source of colonists, providing spawning sites and rearing area having rich food sources during disaster situation such as heavy rain and flood. Tributaries also provide shelters and protected areas to the local migratory fish species during

natural calamity and high turbidity in the main river course. These resources are important for ichthyofaunal diversity and sustainability of aquatic ecosystem.

Acknowledgements

The authors express sincere gratitude to the State Fisheries Department for providing facilities and able guidance to carry out the study.

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