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Effects of flood on fishes: Habitat, assemblage and growth

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Abstract

Present investigation was carried out to assess the effect of flood on fishes of Garhwal Himalyas of Uttrakhand state, India. Three different sites (Rishiganga, Dhauliganga and Alaknanda) were sampled before (October 2020) and after flood (March 2021).We have primarily focused on fishes of order Cypriniformes, Mastacembelis and Ophiocephaliformes. In this paper, we explained how regular floods of river Ganga which occur due to sudden landslide and glacial lake outburst affect the fishes of upper Ganga region.

Keywords: cypriniformes, mastacembelis, ophiocephaliformes, landslide, glacial

Introduction

Floods effect on both individuals and communities, and have social, economic, and environmental penalties. The significances of floods, both negative and positive, vary greatly depending on the location and extent of flooding, and the vulnerability and value of the natural and constructed environments they affect (1).The significances of floods, both negative and positive, vary greatly conditional on their location, duration, depth and speed, as well as the vulnerability and value of the affected natural and built environments (2). Floods influence both individuals and communities, and have social, economic, and environmental significances.

As most people are well aware, the abrupt impacts of flooding include loss of human life, damage to property, devastation of crops, loss of livestock, and corrosion of health conditions owing to waterborne diseases. As message links and infrastructure such as power plants, roads and bridges are injured and disrupted, some economic activities may come to a standstill, people are forced to leave their homes and normal life is dislocated (3).

Likewise, disruption to industry can lead to loss of livelihoods. Damage to infrastructure also causes long-term impacts, such as troubles to supplies of clean water, wastewater treatment, electricity, transport, communication, education and health care (4). Loss of livelihoods, reduction in buying power and loss of land value in the floodplains can leave communities economically vulnerable (5).

Importance of effect of flood on fish is major concern to fish biologist. Some of the important views are as follows:

Throughout the Himalayan river basins, flooding has become increasing problematic over the past couple decades, and in many areas the magnitude and frequency of severe floods is expected to increase further with climate change (Monirul Qader Mirza, 2003, Mirza *et al.*,2003) (6).In river systems extreme floods are primarily source of environmental changeability and trouble. Disturbances arise from a broad array of physical and biological effect which varies in their size, regularity and intensity (Michener 1998). Erosive flood can reduce the density of population (Seegrist and Gard 1972). The immediate effect of flood on individual fish seems largely to depend upon the fish size, lifestages and on habitat complication (Pearsons *et al* 1992, Laboncervia 1996). Flood can wash out larval and juvenile fish (Harvey 1987, Bishoff and Wolter 2001), while having little effect on adult life (John 1964, Hoops 1975). There is an evidence that both the time of flood and the type of river habitat affected can Effect the impact on fish assemblages (Kushlan 1976, Schlosser 1982, Mathews 1998). Extreme flooding is critical for maintaining ecological integrity and biological productivity of floodplainrivers (Rasmussen 1996, Poff *et al* 1997). Flood affect extremely on fish assemblage, habitat, growth and morphology (7). Certain fish species take complete benefit from flood and acutely depend upon, seasonal of periodic extreme flooding. Seasonal flooding coordinates natural systems by providing environmental cues from spawning migration processes (Leitmal el al 1991, John 1963, Poff and Ward 1981). Effects of extreme events on fish assemblage are divisible according to fish species, life stage and recovery period (8). Southern plains reservoirs such as Lake Texoma provide a situation analogous to African river systems described by Welcomme in that floods are seasonal and result in large organic matter inputs. Welch *et al.* (1977) found that fish and benthos were less abundant in streams near farms than in those flowing through natural and clear-out forests and they stated that chemical contamination and sedimentation had caused the reduction(9). The Physico-chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (George *et al.*, 2010).Likewise, variation in the amount of allochthonous inputs may be a cause of changes in growth rates of temperate-reservoir fishes, as it is in some tropical systems.Density-dependent growth regulation is another possible cause of year-to-year variation in the growth rates of reservoir fishes. The occurrence of two flood events of a large magnitude in Lake Texoma prior to and during one growing season (1982) provided a chance to examine the influence of flooding on reservoir fishes.

Fish of different species and life stage exhibit exclusive sets of characteristics counting a biotic tolerance, feeding, habitat, preference, spawning habitats, physical appearance and physical capabilities. Individual characters let certain species of fish, particularly those that are adapted to broad range of conditions, to manage better with flood conditions (10). Besides this is observed that native fish that are naturally adapted to system extremes tend to perform fair better then exotic species during flood (Adler 1996) [2]. Abundant research has been done that juvenile life stage is particularly vulnerable to serious victims all through extreme floods in high gradient systems (11). Great amount of young fish are even lost during average seasonal flooding in systems where the timing of high flows coincides with fragile life stages (Nehring and Miller 1987). The impact of floods on adult population in upper Ganga is closely tied to extent of geomorphologic change linked with power of flows. No direct changes in an adult population are reported by Elwood and Walter 1969. U. S. Geological Survey (USGS), New York City Department of Environmental Protection (NYCDEP),and Cornell Cooperative Extension of Ulster County (CCEUC) collaborated on a study of fish communities at 18 sites from 2009-2011 (prior to the flood)(12). The pre-flood data at these sites provided an opportunity to quantify the impacts of Irene on stream fish assemblages and to assess the relations between landscape and channel features that limit the level of disturbance and hasten recovery (13). And reaches to the conclusions that local fish communities are fairly resilient to extreme hydrologic disturbance, individual species and sites were affected to different degrees by the flooding, the sampling interval was critical to correct interpretation of species and community impacts,the increase in some fish community metrics during the post-flood years (2012, 2013) may be attributed more to the poor pre-flood (2011) condition of the fish community than to direct effects of the flood (14).

A study of effect of fishes and their requirement in Indian streams are deficient. Though few initiatives happening in the 1980s in South India (Arunchalam el al., 1988; 1997a), Srilanka streams (Moyle and Senanayke 1984, Wikramanayke 1990); Western Himalaya (Negi at al, 2007). The present study aims to throw light on how annual variation in the hydrograph affects species with distinct life history and influence the composition and structure of fish. In this study we basically specify the effect of flood on fish species of Rishiganga, Dhauliganga and Alaknanda region of Uttrakhand state. That spawns in the stretches of the Ganga basin and uses these areas as nurseries (15).

Material and Method

Study Area

Chamoli district is a district of the Uttarakhand state of India. It is bounded by the Tibet region to the north, and by the Uttarakhand districts of Pithoragarh and Bageshwar to the east, Almora to the south, Pauri Garhwal to the southwest, Rudraprayag to the west, and Uttarkashi to the northwest (16). The administrative headquarters of Chamoli district is in Gopeshwar.

Chamoli district is intersected by several important rivers and their tributaries. Alaknanda, traversing a distance of 229 km. before it confluence with Bhagirathi at Devprayag and establishing the Ganges, is the major river.The Alaknanda instigates at a height of 3641 meters below Balakun peak 16 km. upstream from Badrinath form the two glaciers of Bhagirath Kharak and Satopanth. The two glaciers rise from the eastern slopes of Chaukhamba (7140 meters) peak, Badrinath peak and its satellite peaks (17). These peaks separates the Gangotri group of glaciers in the west. The chief portion of the Alaknanda basin falls in Chamoli district. From its source up to Hallang (58 km), the valley is treated as upper Alaknanda valley. The remaining part of the area is known as lower Alanknanda valley. While moving from its source, the river flows in a narrow deep gorge between the mountain slopes of Alkapuri, from which it Drives its name. All along its course, it drains its tributaries: Saraswati joins the Alaknanda 9 km downstream from Mana. Khir Ganga joins it underneath the Badrinath shrine and Bhyundar Ganga originated from Tipra glacier and Hemkund Sahib joins Alaknanda River at Govind ghat after merging with River Pushpawati at Ghangaria. Dhauli Ganga meets at Vishnuprayag overhead Joshimath. The river Dhauli Ganga rises from the Nitti Pass at about 5070 meters. Its valley lies between the Kamet groups of peaks in the west and Nandadevi group in the east (18). The Dhauli takes a northern course at Malari. Between Malari and Tapovan, it is almost a narrow gorge with perpendicular cliffs on either side. Several thousand meters high. The Dhauliganga in its turn is fed by GirthiGanga at Kurkuti and Rishiganga 500 metres below Reni.

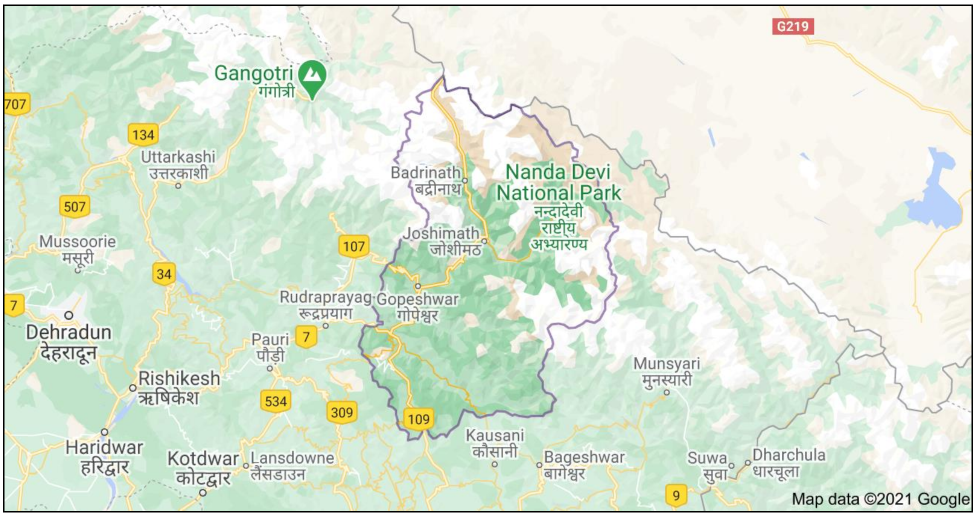

Fig 1: Study Area-Chamoli

Three different sites namely, Rishiganga, Dhauliganga and Alaknanda were selected for the present study. These sites diverse in altitude and geomorphological characters and environmental conditions.

Sampling

Fishes were collected from 3 sampling sites identified as Rishiganga, Dhauliganga and Alaknanda. Fishes were collected during day light hours in the month of November before the flood and in middle of March after the flood. The sites were chosen such that: three on the higher elevation zone and one on the lower elevation zones. Thus, regional comparisons along a river were made across the upstream and downstream sites. Before flood fishes were sampled with a 1.8-m x 90-m gill net with 10-cm bar mesh set on the bottom, at depths of 7 to 12 m (19). After flood sampling was done during period of comparable discharge from a boat along the shoreline and focused on the near shore zone where most fishes are found and where our sampling methods most efficient. A selection of about 150 to 200 m was sampled upstream at every river kilometer marker within the study stretch. The 4 selective sites were sampled after the floods in upper Ganga region. Captured fish were stored in a big container in the boat. As sampling was done at each stretch, all fishes were identified, measured (SL) and dropped back to water. The relative density (catch per unit efforts) was explained as the number of individual per 100 meter of sampled shoreline, with a standard width 3.0 m of the sample area. We used rare fraction method to study and compare species richness before and after flood, as sampling effort varied between seasons. This method standardized samples by estimating the number of species expected in a sub-sample of an individual recommended selection from a large sample. Because the relation between species richness and sampling of effort is not linear, this method compares samples of unequal sampling effort better than comparison of number of individuals and other indices (20). On the other hand Kendall coefficient of rank correlation was used to compare similarity in communities' structure before and after flood of Ganga.

The 10 species belong to 3 orders namely Cypriniformes, Mastacembelis and Ophiocephaliformes were used in the analysis. Quantitative data (CPUE) were in (x+1) transformed and subjected two way fractional ANOVA, with season (preflood, postflood) and river stretch are as effected. In addition to this some analysis and observation were made on the research sites.

Result and Discussion

Results

Before Flood: Total number of 50 samples from 3 different sites belongs to 3 different orders namely Cypriniformes, Mastacembelis and Ophiocephaliformes were recorded during research.

*: Dominant

**: Abundant

NR: Not Recorded

Table 1

Species	Rishi ganga,	Dhauli ganga	Alaknanda
Order: Cypriniformes			
Family: Cyprinidae			
Genus: Tor			
Tor putitora	*	**	**
Genus: Bariliux			
Barilius bendelisis			
Barilius barila	*	*	*
Genus: Puntius			
Puntius conchonius	**	NR	NR
Genus: Garra			
Garra gotyla gotyla	*	*	*
Genus Chrosochelus			
Chrosochelus latuis	**	**	NR
Genus: Schizothorax			
Schizothorax richardsonii	**	**	**
Genus: Nemachelius			
Nemachelius Montanus	**	**	NR
Order: Mastacembelidae			
Family: Mastacembelidae			
Genus: Mastacembelus			
Mastacembelus armatus	**	**	NR
Order: Ophiocephaliformes			
Family: Ophiocephalidae			
Genus: Channa			
Channa punctatus	**	NR	NR

After Effect of Flood

Effect of flood on Water Quality

This contains Water supplies that results in adulteration of water (water pollution). Clean drinking water becomes scarce. Unsanitary conditions and Spread of water-borne diseases result. The effects of flooding from the sources outlined above are felt by various 'receptors'. These include, people, buildings, infrastructure, agriculture, open recreational space and the natural world. In extreme cases flooding may cause a loss of life. At least 100s people are now thought to have been killed by floods in and around the Uttarakhand. Floods took a deadly toll in Uttarakhand in Feb 2021.Glacier melt pushed rivers over their banks, collapsed mud houses and washed away livestock (21)

Floodwater, smashed three bridges and caused a dam to overflow, submerging buildings across the city. Most of the sufferers were children (22). The social and emotional costs from flooding can also be significant and are often extensive and uncritical in flooded areas. These costs include: displacement from homes, the loss of personal valuables and the ongoing fear and insecurity caused by the experience. Potable water supplies may be lost or contaminated in a flood and this can have direct health effects upon people and animals. It is the source of deposits and all types of water pollution thus affecting both physical and chemical condition of water. Water quality plays a role in the allocation of fish (23). The Physico-chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (George *et al*., 2010).

Discrepancy of water quality influences the toxicity levels of heavy metals on estuarine organisms as it affects the Physico-chemical symphony of the ecosystem. Water rising from market stalls and kill houses, streets washing and flushing of sewage which flow through drains into rivers

altered the chemical composition of the water body thereby causing pollution. Optimum fish production can be achieved only when the water quality is effectively managed. The required levels of physical and chemical characteristics of the culture medium, is necessary for fish culture. The availability of food organisms (planktons) and the influence of naturally occurring substances such as dissolved oxygen, carbon dioxide, ammonium nitrite and hydrogen ions (H+) are important factors affecting the growth and survival of cultured fish. The role of temperature, salinity and various pollutants in fish culture cannot be over looked. Thus, the water used for the cultivation of fish cannot yield maximum production, if the environmental conditions are not optimal for the growth of fish and other aquatic organisms. Therefore, there is the need to ensure that, these environmental factors are properly managed and regulated on a daily basis. This maintains these factors within a desirable range for the survival and growth of the fish.
Sediment is the loose sand, silt and other soil particles that settle at the bottom of a body of water (USEPA, 2002). It can come from soil erosion or from the decomposition of plants and animals. Wind, water and ice help to carry these particles to rivers, lakes and streams. Sediment strata serve as an important habitat for the benthic macro invertebrates whose metabolic activities contribute to aquatic productivity (Abowei and Sikoki, 2005). Sediment is also the major site for organic matter decomposition which is largely carried out by bacteria. Important macro-nutrients such as nitrogen and phosphorous are continuously being interchanged between sediment and overlying water (Abowei and Sikoki, 2005).

Table 2: Effects of flooding on surface water quality

Parameter	Flooding effects
Surface water temperature	Increases
Salinity	Reduces
Dissolved oxygen	Increases
Conductivity	Increases
Turbidity	Increases
pH	Increases
Biochemical Oxygen Demand (BOD)	Increases
Total dissolved solids in water	Increases
Depth	Increases
Waves	Increases
Current	Increases
Planktons	Reduces
Nektons	Reduces

Effect of flood on fishes

Flood effect lot on the life of fishes flood bring entire change in the life cycle, habitat, growth, mortality, assemblage structure etc on fishes. With the help of this paper we clarified the what effect ganga, s flood made on fish community. Some of the effects are as follows-

Habitat: The great impact on fish habitat was there from original flooding. Initial effects of flooding on habitat depend upon duration and time of flood. A single large flood took place in Ganga impact extremely on the life of fishes. Upstream migration of adult anadromous fish affected by flooding. During initial flooding, many adult avoided the river because of extreme high sediment load (24). As turbidity declines with time, fish probably would return, but may change their relocation timing and habitat use. Flooding affect spawning habitat of fishes also. Spawning area of most of fishes got affected directly by the flood. During initial flooding, a high percentage of spawning habitat in Ganga river destroyed by scouring and deposition (25). Egg in the gravel washed away or got buried. Eggs deposited after the river stabilized have larger incubation periods because of the cooler water, later emergence could cause increased fresh water residence delays seawed relocation and reduced survival.

Assemblage: No Significant difference was observed in community structure before and after the flood on the basis of 10 different species (Kendal t, t=0.402, P< 0.045) Tor purlitora, Garra gotyla gotyla, barilius bandelisis were the most abundant species before and after the flood.The relative density (CPUE) of all fishes pooled was not significantly different before (mean +_ SD =27.625.7 incs/100m, n=17) and after flood (mean +_ SD = 16.0 +_ 12.4, n=17) (ANOVA, F=2.5, df=130, P=0.125)
However, a substantial interaction between season and reach (F=6.4, df=2.30, P=0.069) showed that a decrease in CPUE occurred in all forms (26). Relative densities of the dominant species (Tor puritora, Garra Gotyla Gotyla) did not decrease following the flood, though the interaction effect on their density was similar to that for the total catch, with cube density decrease in all 4 sites. 2 species of fishes show increase in the density after the flood. Species like Barilus bendelisis and Schizothorax richardsonsi show decrease in density after flood. Some species show variation in their sizes after the flood.

Growth: Due to increase in allochthonous material and increase in flooded water in river Ganga shows increase in productivity of the system and thereby influence of growth rate of some species. Apparently increased input of nutrients and detritus would differently affect the growth of some species, depending upon whether an increased input as being directly expended or being taken up by preys such as zooplantons. It was observed that bottom feeder took full advantage of increased input and forage area (27). Some of the bottom feeder species shown extraordinary increase in growth rate. In addition to that allochthonous input into reservoir becomes increasingly important in the ageing, dystrophication stage not only this it also affect the distribution and condition of some larval fishes.

Discussion

The wide flood on the Ganga presented a exclusive opportunity to assess the direct effect on fish in the deltaic region. Our research displays that the number of species has not significantly affected the flood. The difference in individual species occurrence before and after the flood was almost exclusively caused by rare fish species. The catch of more rare fish species before the flood was affected by unequal sampling effort rather than the flood itself, as concluded by the results of rare fraction analysis.
Due to floods, soil erosion took place and large volume of soil from the river bottom was displaced and the main channel habitat was heavily impacted by a high current velocity (28). These effects may decline fish abundance, mainly in channel section without tributaries, which is the case for the study stretch. At the time of erosive floods with high discharges, fishes remain closed to waterlogged structures; seek low velocity stream margins of tributaries,

and can remain in a given reach of river even during main flood (Mathews 1998). In this study which took place in river Ganga shows that fish probably used submerged refuges along the channel margin and space between borders on the submerged shoreline, since no tributaries were present. Fish assemblage structure was not meaningfully different before and after the flood. Harrell 1978 found that the species subject before the flood also dominated after the flood and hypothesized that dominant species were well adapted to the flood prone environment (29). He also added that the long term effect of flood on structuring fish assemblage might be minimal. Gerking 1950 also concluded same results that most individual may remain in place during flood events in small streams, with floods having minimal effect on the fish assemblage as a whole. The fish assemblage at Rishiganga, Dhauliganga and Alaknanda region of all 3 sites shows the same results that in this region fishes were adopted to floods, but it is notable that not much difference in richness of fish from all 3 sides was measured before and after flood. CPUE of all 2 sides were same before and after flood with exception of 1 side i.e. side II which shows slight difference in CPUE value which is higher in this side after flood. According to the view of Gerking 1950, Harrel 1978, resemblances of the assemblage before and after was due to fish remaining in place, or if fish swept downstream were swapped by fish in steady stretches, remain unclear, this also shows that sheltered or native fishes were less affected by the flood, compared with open water species. Malthews 1998 explained that the instant effect of flood on individual fishes may largely depend upon habitat density.

Higher growth rates in 2021, as compared to previous years, were found for most observed age classes in seven of the ten species. The three species, had no similar trend in its considered growth rates. These species are diverse in size, habitat use, and trophic position. Possible causes for the experimental increase in growth rates for the three species include changes in temperature, food abundance, or fish density (30). The only observed difference in the water temperature of river Ganga in 2021 as compared to the other years in this study was a slower warming of the waters in 2021, apparently because of the increased volume of the warming had any effect, it would probably be to decrease the growth rates of these warm water fishes. Matthews reservoir (W.J. Matthews, Univ. of Okla. Biological Station, personal communication). If slower *et al*. reported that large but unquantified numbers of fishes were passed through the flood gates of river Ganga. Along with changes in the spreading and condition of larval fishes noted by Matthews, this reduction in the number of fishes in river ganga could have created the chance for density-dependent changes in growth rates.

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