International Journal of Education and Science Research Review
E- ISSN 2348-6457
Volume-1, Issue-5 October- 2014 P- ISSN2349-1817
www.ijesrr.org Email- editor@ijesrr.org

Effects of Flood on Fishes of Ganga (Devprayag to Haridwar)

Priyanka Sharma
Research Scholar
Mewar University
Rajasthan

ABSTRACT:
Present investigation was carried out to assess the effect of flood on fishes of Upper Ganga of Uttrakhand state, India. Three different sites (Kosi, Gagas & Gomti) were sampled before (February 2013) and after flood (October 2013).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 cyclones in the Bay of Bengal affect the fishes of upper Ganga region.

INTRODUCTION:
Flooding is one of the major environmental crises one has to contend of within the century. This is especially the case in most wetlands of the world. The reason of this is the general rise in sea level globally, due to global warming as well as the saturated nature of the wetlands in the Ganga Delta. Periodic floods occur on many rivers, forming a surrounding region known as flood plain. In the deltaic upper Ganga region, floods occur very frequently in the form of high river discharges during the monsoons as well as when sudden cyclones in the Bay of Bengal whip up tidal waves. The Brahmaputra and the Ganga generally have climax floods in August and September respectively. This flood is like a curse for the poor and marginal hill farmers in the uplands, not only this flood effect quantitative relationships and the qualitative aspects of several important natural populations namely, macro invertebrate communities, fish habitat, growth ,assemblage, mortality and river corridor vegetation.
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).In river systems extreme floods are primarily source of environmental variability and disturbance. Disturbances arise from a broad array of physical and biological effect which varies in their size, frequency 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 complexity (Pearsons et al 1992, Laboncervia 1996). Flood can wash out larval and juvenile fish (Harvey 1987, Bishoff and Wolter 2001), while having little impact on adult life (John 1964, Hoops 1975). There is evidence that both the time of flood and the type of river habitat affected can influence the impact on fish assemblages (Kushlan 1976, Schlosser 1982, Mathews 1998). Extreme flooding is critical for maintaining ecological integrity and biological productivity of Floodplain Rivers (Rasmussen 1996, Poff et al 1997).

Flood affect extremely on fish assemblage, habitat, growth and morphology. 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. Southern plains reservoirs such as Lake Texoma provide a situation analogous to African river systems described by Welcome 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. 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. 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) Abundant research has been done that juvenile life stage is particularly vulnerable to serious victims all through extreme floods in high gradient systems. 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). 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. 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 .

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 upper Ganga Devprayag region of Uttrakhand state. That spawns in the stretches of the Ganga basin and uses these areas as nurseries.

Study Area

The Ganga River originates at Gaumukh and flows down to Gangasagar traversing a distance of 2525 km. During its course through eleven states, the river receives numerous tributaries (with characteristic quality, pollution load and biota) including Bhilangana, Alaknanda, Ram Ganga, Kali, Yamuna, Gomti, Ghagra,Gandak, and Kosi.The study was conducted in UttaraKhand (Devprayag to Haridwar). Uttarakhand came into existence as a 27th state of India on November 9, 2000. It is located between latitude $28^{0}40'$ – 31^{o} 29’ N and longitude

77^{o} 35' – 81^{o} 5' E. It covers about 53,483 Km2 area and is inhabited by 8.5 million (according to 2001 Counting) people. It encompasses thirteen districts i.e. Uttarkashi,Chamoli, Rudraprayag, Tehri Garhwal,Dehradun, Pauri Garhwal, Pithoragarh,Champawat, Almora, Bageshwar, Nainital,Udham Singh Nagar and Haridwar. Uttarakhand is enriched with aquatic ecosystem of various disciplines like rivers, streams, lakes and rivulets, have very rich flora and fauna. The climate of the region is mainly tropical with a well defined rainy season between June and October, a very mild winter between December and February and a relatively dry pre-monsoon summer between March and May.

Devprayag (Latitude: 30o08'49.4"N; Longitude:78o35'51.9"E; Elevation: 474 m above mean sea level) to Haridwar (Latitude: 29o57'20.1"N; Longitude: 78o10'56.3"E; Elevation: 290 m above mean sea level)
in Tehri Gharwal District in the state of Uttrakhand, India and Devprayag is the confluence point of the rivers Bhagirathi and Alaknanda, and the river Ganga downstream descends at Rishikesh and traverses up to Haridwar in plains. Before reaching Rishikesh it is joined by another tributary Nayar The river stretch consists of rapids, riffles and pools. The substrate consists of mature boulders,cobbles and pebbles. Sand is also present at few places in this zone. The river water in this stretch appears clean and clear, and has high transparency with moderate depth. The current velocity ranges between 0.1-3.0 m/s (Kishor, 1998). The water temperature is also moderate and varies between 15-23°C. The flows are substantially fluctuating and the river meanders into few channels at Haridwar d/s of Rishikesh.

The main cause behind selecting this area is firstly is that floods in river Ganga and its tributaries are very frequent. The main causes of flood are extensive heavy rainfall in the catchment areas and inadequate capacity of river channel to contain the flood within the banks of the river. In the tidal reach and delta area widespread inundation occurs where high flood in river synchronize with the high tidal level from the sea. The plains of Uttrakhand, Uttar Pradesh, Bihar and West Bengal are affected by the spills from either parent river Ganga or by the spills from the tributaries namely Ghagra, Gandak, Kosi etc. Secondly is that this area is breeding ground for the most important game fish of Ganga, referred as Mahseer (Tor sp.).
Three different sites namely, Kosi, Ganga & Gomti were selected for the present study. These sites diverse in altitude and geomorphological characters and environmental conditions.

Material and Methods

Fishes were collected from 3 sampling sites identified as Kosi ,Ganga and Gomti. Fishes were collected during day light hours in the month of February before the flood and in middle of September 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.

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. 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

SPECIES	KOSI	GANGA	GOMTI
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 on Flood

1. Effect of flood on Water Quality

This includes Water supplies that results in contamination of water (water pollution).Clean drinking water becomes scarce. Unhygienic 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 10 thousand people are now thought to have been killed by floods in and around the Uttarakhand. Floods took a deadly toll in Uttarakhand in July 2013.Torrential rains pushed rivers over their banks, collapsed mud houses and washed away livestock.

Floodwater, resulting from heavy rains, smashed three bridges and caused a dam to overflow, submerging buildings across the city. Most of the sufferers were children. The social and emotional costs from flooding can also be significant and are often extensive and indiscriminate 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 immediate health effects upon people and animals.

It is the source of sediments 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. 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).

Inconsistency 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

2. Effect of flood on fishes

Flood effect lot on the life of fishes flood bring complete change in the life cycle ,habitat ,growth ,mortality ,assemblage structure etc on fishes .With the help of this paper we explained 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 initial flooding. Initial effects of flooding on habitat depend upon duration and time of flood. A single large flood took place in Ganga impact seriously 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. As turbidity decreases with time, fish probably would return, but may change their migration 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. 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 migration 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 significant interaction between season and reach (F=6.4, df=2.30, P=0.069) showed that a decrease in CPUE occurred in all forms. 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. Presumably increased input of nutrients and detritus would differently affect the growth of some species, depending upon whether an increased input as being directly consumed or being taken up by preys such as zoo plantons. It was observed that bottom feeder took full advantage of increased input and forage area. Some of the bottom feeder species shown remarkable 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 summer flood on the Ganga offered a exclusive opportunity to evaluate the direct effect on fish in the deltaic region. Our research shows 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 amount of soil from the river bottom was displaced and the main channel habitat was heavily impacted by a high current velocity. These effects may decrease 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 submerged structures; seek low velocity stream margins of tributaries, and can remain in a given reach of river even during major 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 significantly different before and after the flood. Harrell 1978 found that the species dominated before the flood also dominated after the flood and hypothesized that dominant species were well adapted to the flood prone environment. 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 Devprayag region of all 4 sides shows the same results that in this region fishes were adopted to floods, but it is notable that not much difference in abundance of fish from all 4 sides was measured before and after flood. CPUE of all 3 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, similarities of the assemblage before and after was due to fish remaining in place, or if fish swept downstream were replaced 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 immediate effect of flood on individual fishes may largely depend upon habitat complexity.

Higher growth rates in 2013, 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 calculated growth rates. These species are diverse in size, habitat use, and trophic position. Possible causes for the observed increase in growth rates for the three species include changes in temperature, food abundance, or fish density. The only observed difference in the water temperature of river Ganga in 2013 as compared to the other years in this study was a slower warming of the waters in 2013, presumably 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 distribution and condition of larval fishes noted by Matthews , this decrease in the number of fishes in river ganga could have created the opportunity for density-dependent changes in growth rates.

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