

## **Review on Fish Diversity and Habitat Relationship with Environmental Variables**

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### **Abstract**

*The fish diversity and habitat are correlated with environmental variables affecting their distribution and population dynamics. The study helps to assess the status of over-exploited and endangered species. The endemic species were found to be declining due to habitat loss, degradation, alterations or modifications. Migratory fishes got disturbed by the damming in river. Upstream site had more fish assemblage than downstream. The characteristics of habitat like substrate, elevation, flow velocity etc. contributed to the spatial and temporal distribution of fishes. This review aims to to expore the information related to the fish diversity and their habitat relationship to the existing environmental variables especially in river ecosystem. Majority of reviewed papers reported that fish diversity was decreased with the increase in altitude however, the result differed in terms of species richness of each taxon. The physico-chemical parameters of water played vital role in various aspects of fishes such as Juvenile stages of many fishes were found much more in well oxygenated and clear water while it was being retarded by urbanization, over-exploitation and anthropogenic activities. Fish yield was found to be increased during monsoon and summer than other seasons.*

**Keywords :** Diversity, habitat, environmental variables, upstream, downstream

### **Introduction**

River habitat is generally referred as the physical structure of rivers that includes the river bank, bed and riparian canopy. It is a key component of river ecosystems that plays vital role to determine the biotic assemblages and stream integrity (Newson *et al.* 2000). The alteration or modification in the physical habitat may lead to the significant changes in the composition of fish assemblages depending upon the severity of the disturbances (Reice *et al.* 1990). The diverse habitats tend to structure the riverine fish assemblages (Schlosser 1991). Hence re-establishment of the structural complexity lost by human impacts is essential for rehabilitation (Gore *et al.* 1995) such as clearing of stream for a long floating (Nilsson *et al.* 2005). Environmental variables determine the condition of fish assemblages (Li *et al.* 2012). Habitat factors like depth and distance to source (Vlach *et al.* 2005), water temperature (Limbu *et al.* 2019), substrate (Yan *et al.* 2010), altitude (Magalhaes *et al.* 2002), climate (Menni *et al.* 2005), chlorophyll-a (Blanc *et al.* 2001) and conductivity (Yu and Lee 2002) are responsible to influence the fish distribution. Fish assemblage in rivers and streams is globally found in longitudinal zonation. The active study on relationship between assemblage composition and physico-chemical variables is to be continued. The distribution and ecology of fishes in the mountains and lowlands of Nepal are relatively little known (Edds 1993).

## Results and Discussion

The reviewed papers principally dealt with the correlation between fish assemblage and environmental variables. Most of the papers described variation in water bodies or sites resulting the difference in number and diversity of fishes. A study was conducted in Koshi barrage to predict the diversity of fishes. Abundance, diversity and species richness were also studied corresponding physico-chemical parameters. Total of 59 species were collected (Shah 2016). Similarly Fishes from Bakrah river, Morang were collected by using cast net, mosquito net and bamboo fish trap. The diversity index was recorded highest as 1.58 in January and lowest as 1.27 in April (Limbu *et al.* 2018). A collection of fishes with economic values such as food, medicine, recreation and aesthetic purposes was done from Tamor river. *Psilorhynchoides pseudechenesis* is the endemic fish of Nepal recorded from all seven stations of Tamor river (Shrestha *et al.* 2009). Habitat loss and degradation were found to be responsible for the decline of endemic species. Nepalese fishes are yet to be studied for their distribution, ecology and occurrence (Gurung 2012). Altogether 16 fish species were recorded from Dewmai river belonging 3 orders, 6 families and 11 genera (Limbu *et al.* 2018). A study in Bhadra river, India showed that biological communities were less found in altered habitats however, undisturbed habitats got a diverse fish fauna. Physical barriers like rocks, logs etc. affected fish movement. Similarly, anthropogenic activities such as discharge of pollutants from the industries and overexploitation played vital role to retard the fish diversity (Shahnawaz *et al.* 2010). The studies on elevational and biogeographic gradients are common for terrestrial ecosystems but it remains largely neglected in freshwater ecosystems. Himalaya is a global biodiversity hotspot but very little is known about the species richness gradients and their drivers in this region (Bhatt *et al.* 2012). Fish assemblages reflect the various ecological zones of the rain-fed and glacial-fed headwaters. The threat status of the IUCN fish data is to be known for developing the effective conservation strategies (Jha *et al.* 2018). The choice of substrate to sample should depend on the assessment indicators to be used. The indicators for the choice of substrate to sample are based upon the autecology of many algal taxa. The samples are to be collected from a single type of substrate if total algal biovolume, algal diversity or abundance of algal taxa is used (Potapova and Charales 2005). A study was conducted to assess the impacts of dam on fish diversity of Marsyangdi river, Nepal and its continuous flow towards the downstream site. Due to physical barrier of the dam, many fishes could not migrate upstream such as *Tor putitora*, *Mastacembalus armatus* and *Anguilla bengalensis* found in the river (Mandal and Jha 2013). Especially composition of migratory fishes was influenced by the discharge of water altering water volume (Agostinho *et al.* 2008). Among the fishes collected from Tinau river, Cyprinidae family was dominant (81.73%) followed by Cobitidae (11.24%). Besides physico-chemical parameters of water from Tinau river were analyzed to determine abundance, frequency and distribution of fishes. The dam in the river had negative impact to migratory fishes like *Labeo angra*, *Tor tor* and *Bagarius bagarius*. The latter two species were completely disappeared from upstream of the dam (Sharma and Shrestha 2001). Water quality and ecological diversity with respect to distribution on banks and active channels of the rivers Gandak and Ghaghara, India were studied in 2011–2012. The agricultural land was the dominant class in both river basins as shown by land cover and land use map (Singh *et al.* 2017). The anthropogenic activities reduced the fish species in Teesta river, India. Catch per unit effort (CPUE) varied from 21-64 individual per 100 m while number of species (S) ranged from 5-26. Strong seasonal variations were shown by both CPUE and S. In contrast, altitudinal gradient of fish assemblage was found to be interrupted due to anthropogenic disturbances. Total of 36 species (55%) belonged to threatened category and 10 species were endemic to India (Acharjee and Barat 2013).

Principal component analysis showed that dissolved oxygen, sand percentage and vegetation width separated river sandbanks from other habitats. The finding of canonical correspondence analysis, forward selection procedure and Hill's numbers suggested that species composition and diversity were significantly influenced by the structural complexity index of habitat and conductivity (Montoya *et al.* 2020). Species richness, evenness index and Shannon Wiener fish diversity index varied according to different sites. The cluster analysis showed the decrease in fish species when increased the distance between the sites. In the redundancy analysis (RDA), the distribution of fish species was found among four groups with respect to the significant habitat characteristics (Mishra and Baniya 2016). A study from eastern Nepal showed total of 151 fish species consisting of 10 orders, 27 families and 75 genera. The highest number of fish species (86, 56.95%) belonged to the order Cypriniformes (Limbu *et al.* 2019). A work was carried out to find the relationships between the fish assemblage and selected habitat features from north Tiaoxi river, one of headwaters of Taihu Lake, China. A total of 33 native species and one invasive species were recorded from the collected 3,348 fishes belonging to 5 orders, 11 families, 25 genera and 34 species. About 20 species among them were endemic to China (Li *et al.* 2012). The habitat preference of seven native fish species was studied in a regulated river in Southeastern Brazil. The fishes used stretches of the river varied in hydraulic characteristics and substrate type. The fishes differed in habitat preference and they were classified into four habitat guilds: (a) a slow-flowing water guild found in mud-sand substrate containing two Siluriformes in either shallow (< 4 m, i.e., *H. littorale*) or deep (> 8 m, *L. castaneus*) waters (b) a run-dwelling guild occurred in deep backwaters with clay-mud substrate containing the Characiformes *O. hepsetus* and *A. aff. bimaculatus* (c) a run-dwelling guild occurred in shallow and sandy substrate consisting of *T. striatulus* and (d) a fast-flowing guild occurred along shorelines with shallow mud bottoms consisting of *P. maculatus* and *H. malabaricus* (Costa *et al.* 2013).

The habitat structure such as substrate, elevation, flow velocity etc. contributed to the spatial and temporal pattern of fish assemblages in the Puxi Stream, China as suggested by Standard Deviation Redundancy Analysis (RDA). The fish assemblages in Puxi Stream revealed significant spatial variation but not temporal. Human activities induced the decrease in species diversity in the lower regions. But there was not significant change observed for fish assemblages in sites far and immediately downstream from low-head dams (Yan *et al.* 2010). The habitat ecology, distribution, species diversity and various indices of fish biodiversity management were being studied in Betwa river, a tributary of river Ganga. Fish species richness was correlated with the hydrological attributes that revealed significant relationship. The factors like pH, water depth and dissolved oxygen were found to be shaping fish assemblage (Lakra *et al.* 2010). The largest estuarine ecosystem of Bangladesh is the Meghna river estuary that supports diverse fish communities. The study was carried out to assess the fish diversity status with relation to major hydrological and meteorological parameters in both spatial and temporal scales. Fishes were collected together with the measurement of water quality indicators. The major influential factors for species distribution were found as water temperature and rainfall (Hossain *et al.* 2012). The spatial, seasonal and annual variations in fish assemblages were observed over 17 months in three small to medium-sized, incised streams of northwestern Mississippi streams. Little evidence was found from the correlation between changes in habitat conditions and fish assemblage structure. Both natural and anthropogenic causes like watershed deforestation, stream channelization and incision might play a vital role in structuring the fish assemblages. Extreme annual variation in assemblages due to habitat change had important implications for the fish monitoring programs designed to find out the trends in fish assemblages over time (Adams *et al.* 2004). There is not found sufficient work in spatial and temporal distribution of the fishes in rivers and streams of Nepal. A study was carried out in Ratuwa river on fish community and environmental variables covering all four seasons (Winter/January,

Spring/April, Summer/June and Autumn/October) over two years (Limbu *et al.* 2019). The fishes varied spatially and temporally in the riffles of the upper Roanoke River system, Virginia. It was analyzed in three ways: (a) Comparison between temporally consecutive and spatially adjacent fish assemblages by Morisita's Index of similarity (b) Two-way (time and space) analysis of variance (ANOVA) of species abundance and (c) Comparison of all-time x space samples by cluster analysis (Matthews 2016). The width/depth ratio of streams was inversely related to variation in fish density as indicated by Regression quantile models but not to stream width or depth alone (Dunham 2002). A study was carried out on fish assemblages and physico-chemical parameters in different habitats in the headwater stream section of Lijiang river, China to determine the relationship between fish assemblages and stream habitat. The habitat heterogeneity played vital role in fish diversity although the overall fish assemblages were not affected by habitat type. So, restoring and maintaining the diverse stream habitats were significant for sustainability management of rivers and fish diversity conservation (Hunag *et al.* 2019). It was found by Detrended Canonical Correspondence Analysis that water quality, geography and stream hydraulics were the major environmental variables of fish assemblage structure. Besides vegetation composition, abundance, monsoon rain and associated parameters had significant influence. Gandaki river in Nepal is an excellent case study in longitudinal succession and environmental correlates of fish assemblage structure due to its rich ichthyofauna and tremendous ecological and altitudinal gradients of the drainage (Edds 1993). Seasonal fluctuations in water and agricultural runoff influenced the physical and chemical characteristics of water in reservoir. The productivity of the Jagadishpur reservoir was affected by the seasonal variation in soil and water nutrients (Gautam *et al.* 2008). Physico-chemical properties of the water showed changes with seasons (Niroula *et al.* 2010). Water quality was measured to check the pollution status of Ratuwa river. The study helped to create the awareness in the local people (Shrestha and Basnet 2018). A work was performed on water quality maintenance from Itahari Municipality ponds and Baidya fish farm, both located along the industrial corridor. The variations in physico-chemical parameters influenced the aquatic flora and fauna especially fishes by increasing the chances of diseases that lead to high mortality (Thapa and Pal 2012). The increase in conductivity, turbidity, free CO<sub>2</sub>, nitrates and phosphates but decrease in transparency, DO and pH at the urban area indicated the urban influence (Pokharel *et al.* 2018). Early life and juvenile stages of many taxa were most numerous in clear and well oxygenated water. Lower oxygen caused stress and limited the distribution and activity of fish. (Matthews 1998).

### **Conclusion**

A significant difference in water transparency was observed in upstream compared to downstream stations. Lower transparency was found in downstream than upstream because of higher water turbulence in downstream caused by anthropogenic impact and strong tidal fluctuation. The dam in the river had negative impact to migratory fishes. Habitat loss and degradation were found to be responsible for the decline of endemic species. The habitat structure such as substrate, elevation, flow velocity etc. contributed to the spatial and temporal pattern of fish assemblages. The composition of migratory fishes was influenced by the discharge of water altering water volume. So far as elevation gradient is concerned, fish diversity was found to be decreased with increase in altitude. But the result differed in terms of species richness of each taxon. An average of monthly fish yield was found higher during monsoon and summer than other seasons. Number of fish species caught was high during night time than day time. The number of fishes occurring varied due to the type of the fishing gears used. The increase in conductivity, turbidity, free CO<sub>2</sub>, nitrates and phosphates but decrease in transparency, DO and pH at the urban area indicated the urban influence. Turbidity and oxygen concentration were important parameters in determining the variation in young fish density. The fish diversity was increased in clear, well-oxygenated and pollution free water while it was retarded by urbanization, over-exploitation and anthropogenic activities.

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