Int. Jr. Bioinformatic and Biological Sci. : v.2 n.3 and 4, p. 135-144. Dec. 2014

DOI No. 10.5958/2321-7111.2014.00011.0

Heterogeneity in habitat use of three threatened freshwater catfishes (Siluridae: Siluriformes) in five major tropical rivers of India

Abhishek Kr. Malakar[1]*, Pallavi[1], Vineet Kr. Dubey[1], Karan V. Singh[2], Wazir S. Lakra[3] and R. M. Mishra[4]

[1]*National Bureau of Fish Genetic Resources, Canal Ring Road, Lucknow 226002, Uttar Pradesh, India.*
[2]*National Bureau of Animal Genetic Resources, Makrampur Campus, Karnal-132001, Haryana, India.*
[3]*Central Institute of Fisheries Education, Versova, Andheri (W), Mumbai 400061, India.*
[4]*Awadhesh Pratap Singh University, Rewa 486003, Madhya Pradesh, India.*

**Corresponding author: abhishekmalakar@gmail.com*

ABSTRACT

To identify the *priority habitats of the threatened catfishes* of the genus Ompok viz. Ompok pabda, O. pabo and O. bimaculatus in India the effects of habitat variables on the structure of fish assemblage were evaluated from 40 sampling sites located in Tones, Gomti, Ganga, Bramhaputra and Hoogly Rivers. Canonical correspondence analyses were carried out to determine the influence of environmental conditions on species occurrences and assemblage characteristics. The microhabitat, hydromorphological parameters (depth and current velocity) followed by conductivity, temperature and total dissolve solid (TDS) were found to be significant in structuring the assemblage of the three catfishes. Fast water with shallow depth in different rivers was significantly associated with occurrence of O. pabda whereas slow water and higher depth were significantly associated with O. bimaculatus. Some other environmental parameters such as conductivity, TDS and pH were also found to be significant in shaping the habitat preference of the Ompok species studied. Our results depicted the importance of environment influences on the Ompok species which are of conservation and management interest.

Keywords: *Ompok* species, Habitat, Aquatic Biodiversity, Riverine System

Freshwater ecosystems have frequently been cited as the most altered and threatened habitats by human activities (Dudgeon, 1992). Disturbance to physical habitat and water quality have resulted in fish assemblage shifts, decreased native species diversity, community homogenization, range reduction and extinction (Gorman and Karr, 1978; Rabeni and Smale, 1995; Jones *et al.,* 1999; Marchetti and Moyle, 2000; Bonner and Wilde, 2002; Quist *et al.,* 2003). Fish species strongly depend on the characteristics water morphology and its dynamics. Fishes are therefore good indicator of ecomorphological habitat conditions and can be used in the environmental planning (Schiemer, 2000). In India, extensive studies on freshwater fishes have been conducted in relation to either taxonomy (Jayaram, 1981; Datta Munshi and Srivastava, 1988; Talwar and Jhingran, 1991; Menon, 1992) or capture fisheries or aquaculture (Jhingran, 1975). Studies on fish assemblage structure and their habitat requirements in Indian Rivers are scanty though few initiatives have been taken in South Indian streams (Arunachalam *et al.,* 1988, 1997, 2000) and river of Ganges basin (Sarkar *et al.,* 2007).

Ompok is an important genus of family Siluridae that retains four freshwater fish species in India namely: *O. bimaculatus* (Indian butter catfish), widely distributed in India and other countries of Southeast Asia; *O. malabaricus,* found in Western Ghats of Kerala, Goa and Maharashtra; *O. pabda* (pabdah catfish), distribution confined to Indus and Brahmaputra drainages; and *O. pabo*, mainly found in Ganga and Brahmaputra River systems in North Bengal and Assam, respectively. Because of a great morphological and wide distribution, these fishes are obviously an attractive group for experimental and evolutionary biologist. The three *Ompok* species viz. *O. pabda, O. pabo* and *O. bimaculatus* are highly priced delicious catfishes and well preferred because of their relatively few bones. The natural populations of these catfishes have been greatly declined in the tributaries of river Ganga basin (Sarkar *et al.,* 2008, 2010). Due to reduced abundance, these species have been listed as threatened species as per IUCN criterion (CAMP, 1998; CAFF, 2006; Lakra and Sarkar, 2006). Lack of definite information on the habitat preference of these threatened Silurids in their distributional range has been hindering species-specific conservation and management strategies. The study aimed at identifying priority habitat of the three Silurids (*O. pabda, O. pabo* and *O. bimaculatus*) in Tones, Gomti, Ganga, Bramhaputra and Hoogly rivers of India.

Materials and Methods

Samples Collection

The fish samples were collected from 40 selected sites as the representatives of landscapes in all the studied rivers viz. Chak Ghat (River Tones), Lucknow (River Gomti), Malda (River Ganga), Guwhati (River Bramhaputra) and Kolkata (River Hoogly). Sampling were performed five times at each site covering premonsoon (March–June), monsoon (July–August) and postmonsoon (September and October) seasons from 2007 to 2010. The habitat data were analyzed from 318 individuals of *Ompok* species *viz*. *O. pabda, O. pabo* and *O. bimaculatus.* In each of these sampling sites, fishing has been done at night (17 H to 7 H) and during the day (7 H to 13 H). The nets (75×1.3 m, 50×1m, and 30×1m) were weighted bottom sets with varied mesh sizes ranging from 2.5 to 7cm. All fish specimens were identified following Jayaram (1999), Talwar and Jhingran (1991).

Pysicochemical Characterization

Environmental variables were measured each time in the same site where fishes were sampled. Eleven environmental variables were used to interpret the variation in species composition (Table 1). The physical and chemical variables followed were temperature (°C), turbidity (NTU), water flow (cms), depth (m), conductivity (µmhoscm), total dissolve solid (TDS) (ppm), dissolve oxygen (DO) (mg.l) and pH. Water temperature, conductivity, pH, TDS and DO were measured by Cyber Scan Waterproof PC 300 multiparameter at the sampling locations. The total percentage of each substrate class was calculated using transects within each sampling site. The dominant substrate material for each sampling site was determined by inspection and striking the river bottom with a bamboo pole. Substrate classes included sand (0.06–2mm), gravel (2–64mm) and cobble (64–250 mm) according to Bain and Stevension (1999) with some modifications.

Table 1. Environmental variables mean (standard deviation in parenthesis) and ranges from the 40 sampling sites in different rivers

Variables	Mean	Range
Water flow (cm/sec)	22.6 (10.5)	11.21-39.70
Depth (m)	3.38 (1.7)	1.10-6.47
Temperature (ºC)	22.98 (3.6)	16.22-26.8
Dissolved Oxygen (mg/L)	5.4 (1.1)	3.3-7.20
pH	7.14 (.4720)	7.0-8.4
Turbidity (NTU)	17.88 (13.3)	6.21-80.2
Conductivity (µS/cm)	414.16 (207)	165-667
Total Dissolved Solids (ppm)	223.4 (127.1)	110-589
Fine Substrate (%)	46.75 (32.4)	0.01-86.2
Fine Gravel (%)	22.2 (16.2)	0.01-65.2
Coarse Gravel (%)	16.37 (17.7)	0.01-69.3

Statistical Analysis

A data matrix was constructed with habitat values and catch numbers by species for each of the 40 sampling sites. Each habitat variable was represented by mean value when repeated habitat measurements were made in different seasons Principal component analyses (PCA) were performed on the 11 environmental variables to reduce the dimensionality of the data and to examine initially the influence of habitat characteristics. All variables are transformed log10(x + 1) before data analysis to meet the assumptions of normality. Only principal components with eigenvalues more than 1 were interpreted from PCA on the correlation matrix of the environmental variables. Variable loadings more than 0.25 were considered in structuring the stream using the method of Chatfield and Collins (1980). A multiple analysis of variance (MANOVA) was conducted to compare environmental variables. Relative abundance of each species was calculated from the total number of individual sampled from all the sampling sites.

Canonical correspondence analysis (CCA) (ter Braak, 1986) was used to identify the relationships of environmental variables with fish assemblage. Results of CCA were tested with a Monte Carlo randomization method, which randomly reassigns the values for the species data to the values for the environmental variables. Partial CCAs were used to determine the variance explained by individual variables after the removal of variables with inflation factors more than 10 (ter Braak and Smilauer, 2002). All statistical analyses were conducted using the Multivariate Statistical Package (MVSP) trial version 3.1 (Kovach, 1999).

Results and Discussion

Physicochemical Characterization

The PCA produced three axes that cumulatively explained 68.6% of the environmental variation in sites (Table 2). The first axis had high loadings for water flow, depth, temperature, turbidity and TDS. The second axis had high loadings for temperature, dissolve oxygen, pH and TDS. The third axis had high loadings for DO and conductivity. Eight variables (water flow, depth, temperature, dissolved oxygen, pH, turbidity, conductivity and TDS) of eleven total environmental variables had high loadings on at least one of the principal component axis interpreted. In contrast, fine substrate, fine gravel, coarse gravel did not have high loadings on any of the first three axis. The ANOVA on the habitat variables indicated a significant difference in habitat structure among sampling sites ($F = 8.55$, $p<0.05$).

Table 2. Principal component (PC) Loadings from principal component analysis of physical habitat structure and physiochemical environmental variables from 40 sampling sites

Variables	PC1	PC2	PC3
Water flow (m/sec)	-0.32	-0.04	-0.02
Depth (m)	0.34	-0.01	0.04
Temperature (ºC)	-0.31	-0.32	0.17
Dissolved Oxygen (mg/L)	0.02	0.54	0.31
Conductivity (µS/cm)	-0.05	-0.02	0.54
Turbidity (mg/L)	0.32	0.18	-0.16
pH	-0.15	0.61	-0.23
Total Dissolved Solids (ppm)	-0.29	0.27	-0.20
Fine Substrate (%)	0.01	0.07	0.15
Fine Gravel (%)	-0.08	0.16	-0.10
Coarse Gravel (%)	-0.18	0.05	0.02

*values > 0.25 are in bold.

Table 3. Canonical correspondence analysis summary statistics for the fish and environment sampled in different rivers. (Tolerance of eigen analysis set at 1E-009)
Fish Assemblage and Habitat Use Pattern

	Axis 1	Axis 2
Eigenvalues	0.41	0.17
Species - Environment Correlations	0.90	0.64
Cumulative Percentage Variance		
Explained by Species Only	44.83	18.62
Explained by Species + Environmental Variables	44.83	63.46
Interest Correlations with Axis		
Water Flow (m/sec)	0.83	-0.07
Depth (m)	-0.72	-0.01
Temperature (ºC)	0.79	0.09
Dissolved Oxygen (mg/L)	0.05	-0.01
Conductivity (µS/cm)	0.23	0.44

The forward selection procedure for the CCA resulted in the retention of eight variables as significant contributors to variation in the ordination. The first ordination axis accounted for 44.83% of the variance of the species data, whereas the second axis accounted for 18.62% of this variance (Table 3). Species abundances were significantly correlated with the environmental factors (P=0.001 along axes one and two, Monte Carlo test with 1,000 permutations). Flow, temperature and TDS were positively correlated with first ordination axis, whereas depth and turbidity were negatively correlated (Figure 1). Conductivity was positively correlated with second ordination axis. The species environment correlations of each axis were 0.90 (axis 1) and 0.64 (axis 2). Each significant environmental factor increased along a vector away from the origin with its length being a measure of the magnitude. *O. pabda, O. pabo* and *O. bimaculatus* were separated significantly from each other in habitat space with respect to the significant habitat characteristics. *O. pabda* was associated with the sites with fast water with shallow depth, high dissolve solids with higher water temperature conditions. *O. bimaculatus* was associated with the sites containing deep waters with slow water current and turbid water whereas, *O. pabo* was associated themselves with the sites containing higher conductivity.

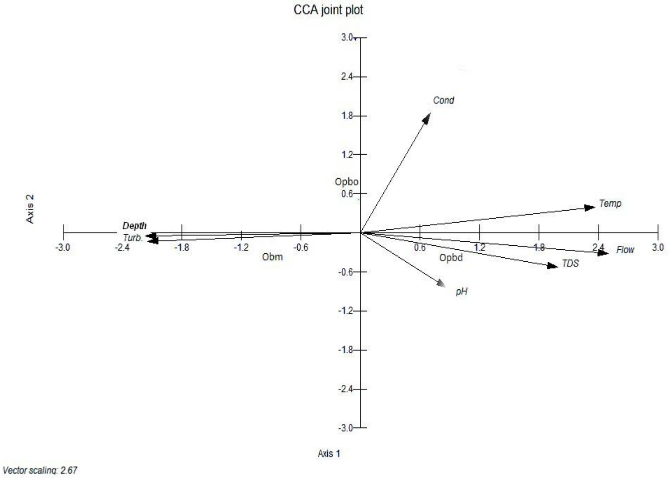

Figure 1. Canonical correspondence analysis showing correlation between species composition and environmental variables.

ID: Opbo = *Ompok pabo*; Opbd = *Ompok pabda*; Obm = *Ompok bimaculatus*.

Local fish assemblages are structured by environmental influences at multiple spatial scales (Schlosser, 1982, 1987; Marsh-Matthews and Matthews, 2000). Species in the present study displayed considerable differences in habitat associations. The most important environmental variables for the assemblage of *Ompok* species in different rivers were water flow and depth which showed conformity with Gorman and Karr (1978), Angremeier and Schlosser (1989), Copp *et al.* (1994), Garner (1996) and Sarkar and Bain (2007). The habitat preference of endangered *O. pabda* with slower and deeper water in all the studied rivers was also observed in other fishes by Lamouroux *et al.* (1999), Lamouroux and Souchon (2002) and Carter *et al.* (2004). Sarkar and Bain (2007) reported the habitat preference towards slow water current in some Cyprinids.

Besides from velocity and depth, the physicochemical variables conductivity, pH and temperature have been found to be significant variables in structuring sites and assemblage of the three Silurids (*O. pabda, O. pabo* and *O. bimaculatus*) in the tropical rivers under study of India. In the present study, *O. pabo* associated with conductivity in abundance showed the available favorable conditions for these species. Taylor *et al.* (1993) and Wilkie and Wood (1981) are reported conductivity to be the most important variables in structuring fish assemblages at local spatial scales across a broad region. The employed forward selection procedures of the CCA make it possible to identify those environmental variables, which influenced the abundance of three *Ompok* species.

The study is the first of its kind in the tropical rivers of India which identified significant, comprehensive dataset where depth and flow are identified as a major component of that structure. The water depth and flow are found to be the most important habitat variable in shaping fish distributions for Silurids in India (Bain and Knight, 1996; Arunachalam, 2000; Sarkar and Bain, 2007). The present study generated new information on priority habitat use of three threatened Silurid fishes which will provide specific guidance on channel habitats with inclusive ranges of depths, substrate and current velocities needed to support the threatened fish species therefore to include in conservation planning. Furthermore, our results suggests that the importance of environmental influences on the threatened fishes can be used to guide protection and management activities and support restoration efforts of relatively unaltered fish habitat. Conservation measures should be planned keeping in view the habitat requirements and associated relationship with the fish assemblage at local scale.

Acknowledgements

The authors are thankful to Director, National Bureau of Fish Genetic Resources (NBFGR), Lucknow for financial support and laboratory facility.

References

Angermeier PL, Schlosser IJ. 1989. Species-area relationships for stream fishes. *Ecology.* **70**: 1450-1462.

Arunachalam M. 2000. Assemblage structure of stream fishes in the Western Ghats (India). *Hydrobiologia*. **430**:1-31.

Arunachalam M, Johnson JA, Sankaranarayanan A. 1997. Fish diversity in Rivers of Northern Karnataka. *International Journal of Environmental Science and Technology.* **23**: 327-333.

Arunachalam M, Madhusoodanan KC, Vijverberg NJ, Kortmulder K. 1988. Food and habitat usage of Cyprinid fish assemblage in stream pools of a south Indian River, Limnological Institute of the Royal Academy of Sciences, The Netherlands.

Bain MB, Knight JG. 1996. Classifying stream habitat using fish community analysis in: Proceedings of the second IAHR symposium on habitat hydraulics. *Ecohydraulics*. 2000.

Bonner TH, Wilde GR. 2002. Effects of turbidity of prey consumption by prairie stream fishes. *Transactions of the American Fisheries Society.* **131**:1203-1208.

CAFF. 2006. Conservation Assessment of Freshwater Fish Diversity for Central India. Proc. workshop, organized by National Bureau of Fish Genetic Resources, 25 Nov, CIAE, Bhopal, MP, India.

CAMP. 1998. Conservation Assessment and Management Plan (CAMP) for freshwater fishes of India. Workshop report, Zoo Outreach Organization, Coimbatore/CBSG and NBFGR. Lucknow, India, pp. 1–158.

Carter MG, Copp GH, Szomlai V. 2004. Seasonal abundance and microhabitat use of bullhead *Cottus gobio* and accompanying fish species in the River Avon (Hampshire), and implications for conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems.* **14**:395–412.

Chatfield C, Collin AJ. 1980. Introduction to multivariate analysis, Chapman and Hall, London pp 248.

Copp GH, Guti G, Rovny J. 1994. Hierarchical analysis of habitat use by 0+ juvenile fish in Hungarian/Slovak flood plain of the Danube River. *Environmental Biology of Fishes.* **40**: 329-348.

Datta Munshi JS, Srivastava MP. 1988. Natural history of fishes and systematic of freshwater fishes in India. Narendra Publishing Co. Delhi, India, pp 421.

Dudgeon D. 1992. Endangered ecosystems: a review of the conservation status of tropical Asian Rivers. *Hydrobiologia.* **248**: 167–191.

Garner P. 1996. Microhabitat use and diet of 0+ cyprinid fish in a lentic, regulated reach of the River Great Ouse. *Journal of Fish Biology.* **48**: 367-382.

Gorman OT, Karr JR. 1978. Habitat structure and stream fish communities. *Ecology* **59**: 507-515.

Jayaram KC. 1981. Freshwater fishes Indian region. Narendra Publishing House, New Delhi, pp 551.

Jayaram KC. 1999. The freshwater fishes of the Indian region. Narendra Publ. House, New Delhi, pp 551.

Jhingran VG. 1975. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi, pp 9540.

Jones EBD III, Helfman GS, Harper JO, Bolstad PV. 1999. Effects of riparian forest removal on fish assemblages in southern Appalachian streams. *Conservation Biology.* **13**: 1454-1465.

Kovach WL. 1999. MVSP-A Multivariate Statistical Package for Windows, ver. 3.1. Kovach Computing Services, Pentraeth, Wales, Great Britain.

Lakra WS, Sarkar UK. 2006. Freshwater fish diversity of central India. Edited and published by National Bureau of Fish Genetic Resources, Lucknow, pp 1–200.

Lamouroux N, Souchon Y. 2002. Simple prdictions of instream habitat model outputs for target fish populations. *Freshwater Biology.* **47**: 1543-1556.

Lamouroux N, Olivier JM, Persat H, Pouilly M, Souchon Y, Statzner B. 1999. Predicting community characteristics from habitat conditions: fluvial fish and hydraulics. *Freshwater Biology.* **42**: 673-687.

Marchetti MP, Moyle PB. 2000. Effects of flow regime on fish assemblages in a regulated California stream. *Ecological Applications.* **11**: 530–539.

Marsh-Matthews E, Matthews WJ. 2000. Geographic, terrestrial and aquatic factors: which most influence the structure of stream fish assemblages in the Midwestern United States. *Ecology of Freshwater Fish.* **9**: 9–21.

Menon AGK. 1992. Conservation of freshwater fishes of Peninsular India. Final report submitted to Minist. *Envit. and Forests*. pp 137 (Unpublished).

Quist MC, Fay PA, Guy CS, Knapp AK, Rubenstein BN. 2003. Effects of military training on terrestrial and aquatic communities on a grassland military installation. *Ecological Applications.* **13**: 432-442.

Rabeni CF,. Smale MA. 1995. Effects of siltation on stream fishes and the potential mitigating role of buffering riparian zone. *Hydrobiologia.* **303**: 211-219.

Sarkar UK, Bain MB. 2007. Priority habitats for the conservation of large River fishes in the Ganges River basin. *Aquatic Conservation: Marine and Freshwater Ecosystems.* **17**: 349–359.

Sarkar UK, Sani R. 2008. Habitat fingerprinting by elemental analysis of otolith-as a powerful tool for detecting potential fish habitat: a review. *Fish Chimes.* **28**(6): 52-54.

Sarkar UK, Gupta BK, Lakra WS. 2010. Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of River Gomti, a tributary of River Ganga (India). *Environmentalist* doi 10.1007/s10669-009-9237-1.

Schiemer F. 2000. Fish as indicators for the assessment of the ecological integrity of large Rivers. *Hydrobiologia.* **422/423**:271-278.

Schlosser IJ. 1982. Fish community structure and function along two habitat gradients in a headwater stream. *Ecological Monographs.* **52**: 395-414.

Schlosser IJ. 1987. A conceptual framework for fish communities in small warmwater streams (pp. 17–2400. In: Matthews WJ and Heins DC, eds. Community and evolutionary ecology of North American stream fishes. Norman, OK: University of Oklahoma Press.

Talwar PK, Jhingran AG. 1991. Inland fishes of India and adjacent countries (pp. 1158) Oxford and IBH Publishing Co., pvt. Ltd., New Delhi. Vol. I and II.

Taylor KC, Lamorey GW, Doyle GA, Alley RB, Grootes PM, Mayewski PA, White JWC, Barlowl KL. 1993. The flickering switch of late Pleistocene climate change, *Nature.* **361**, 432-436.

ter Braak CJF, Smilauer P. 1998. CANOCO Reference Manual and User's Guide to Canoco for Windows: Software for Canonical Community Ordination (version 4). Microcomputer Power (Ithaca, NY USA) 352 pp.

ter Braak CJF. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology.* **67**:1167-1179.

ter Braak CJF, Smilauer P. 2002. Canoco reference manual and CanoDraw for Windows user's guide: software for canonical community ordination, version 4.5. Ithaca, NY: Microcomputer Power.

Wikramanayake, E.D. 1990. Ecomorphology and biogeography of a tropical stream fish assemblage: evolution of assemblage structure. *Ecology.* **71**:1756–1764.

Wilkie MP, Wood C. 1991. Nitrogenous waste excretion, acid base regulation and onoregulation in rainbow trout (*Oncorhynchus mykiss*) exposed to extremely alkaline water. *Physiological Zoology.* **64**: 1069-1086.