www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 17:1209-1218(2017) DOI: 10.4194/1303-2712-v17_6_14

RESEARCH PAPER

Spatial and Temporal Disparity of Fish Assemblage Relationship with Hydrological Factors in Two Rivers Tangon and Kulik, Thakurgaon, Bangladesh

Md. Rashidul Islam[1,*], Md. Jewel Mia[1], Ulfat Jahan Lithi[2]

[1] Hajee Mohammad Danesh Science & Technology University, Department of Fisheries Biology & Genetics, Dinajpur-5200, Bangladesh.
[2] Hajee Mohammad Danesh Science & Technology University, Department of Fisheries Technology, Dinajpur-5200, Bangladesh.

* Corresponding Author: Tel.: +880.1717 289715; Fax: +880.531 61311;
E-mail: mrislalm_fbg@hstu.ac.bd

Received 19 October 2016
Accepted 17 April 2017

Abstract

Stream fish assemblage and their association with major ecological factors were spatiotemporally conducted from January to December 2015 at the Tangon and Kulik Rivers of Thakurgaon district in Bangladesh. A total of 6,561 specimens belonging to 53 fish species dominated (> 4.86%) by *Aspidoparia jaya*, *Pethia ticto*, *Puntius sophore*, *Channa punctatus* and *Canthophrys gongota* both in rivers and seasons. Significant differences (P<0.05) were spatiotemporally observed in the values of diversity indices between two rivers. Spatial and temporal patterns influenced species copiousness and richness that higher in winter season due to little water echelon. Fish communities were differed between rivers (*R* = 0.46, P<0.01) and seasons (*R* = 0.21, P<0.01) stressing as 0.24 and dividing into two clusters at a value of 87.65% union. Canonical Correspondence Analysis (CCA) specified that water depth, water temperature and transparency were key environmental factors affecting fish assembly, abundance and distribution. Therefore, advanced plans and management strategies should be taken to save threatened fishes at low water depth during dry and winter seasons than others.

Keywords: Spatiotemporal discrepancy, fish diversity indices, ecological factors, rivers.

Introduction

Aquatic ecologists has great interest to known the assemblages of fishes including their changing patterns in abundance and frequency familiar as imperative tools of fisheries management and conservation. Riverine or stream fishes of the developing world have faced to different ecological stresses affecting fish assemblage structure of that habitat (Terra *et al.,* 2016). However, association between fishes and their environments play central roles for managing and saving of riverine species where any modification of it can lead to transform in their population arrangement (Kadye and Moyo, 2007). The concentrations of environmental factors mainly water quality parameters have been accounted to persuade assemblage and distribution of fishes both in freshwater and marine networks (Tunesi *et al.,* 2006; Hossain *et al.,* 2012; Corpuz *et al.,* 2015). Biodiversity indicators i.e. dominance, evenness, Margalef and Shannon-Weiner diversity indices has used as pointer to discern the assortment status of aquatic residents (Magurran, 1988; Vyas *et al.*, 2012).

In Bangladesh, aquatic habitats gradually condense fish abundance and species (Chaki *et al.*, 2014), have endured and abused through extreme human interference (Hossain *et al.,* 2012). The Tangon and Kulik Rivers are said to be lifeline in Thakurgaon district northern part of Bangladesh but a feeble flow is now flowing in the middle of the rivers during dry and winter month. Due to siltation and petite water level, a number of freshwater fish species specially threatened one are gradually declined their abundance each year (Rahman *et al.*, 2003). So, a management plan and strategy should be taken to conserve fishes in this river. The central views of this research are firstly aimed 1) to explain the spatiotemporal variation of fish assemblage and 2) to detect the outline of relationship between fish grouping and major hydrological factors at the Tangon and Kulik Rivers of Bangladesh.

Materials and Methods

Study area

A study was planned at the Tangon and Kulik Rivers (Figure 1) in Thakurgaon district of Bangladesh from January to December 2015. Three months were considered as one season based on their similarities i.e. February, March and April as pre-monsoon (prm); May, June and July as monsoon

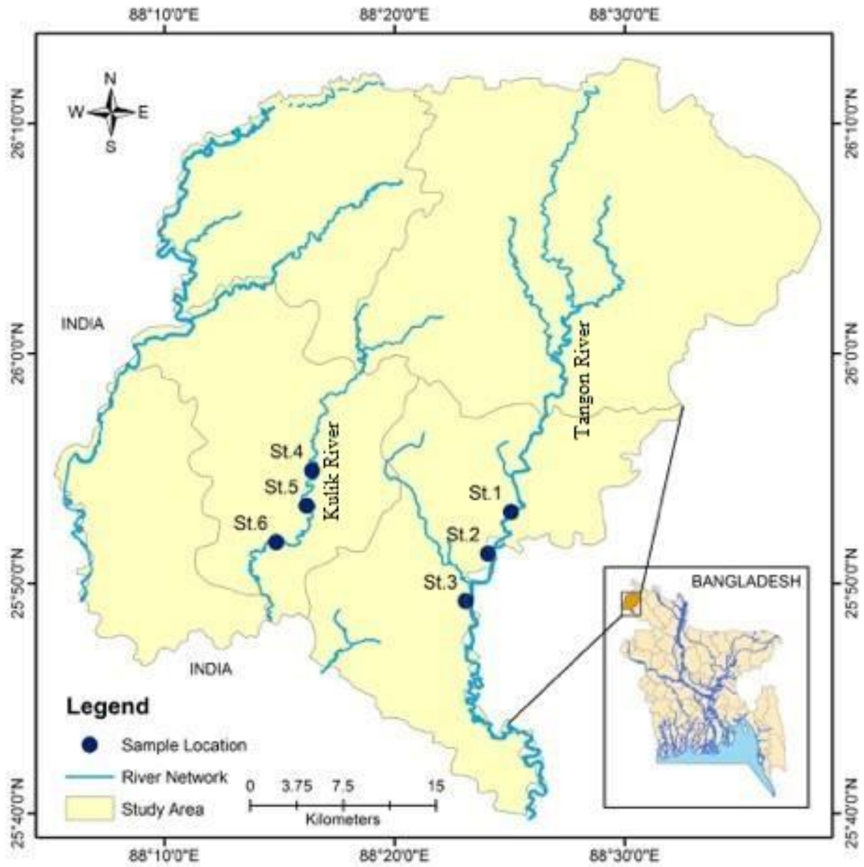

Figure 1. GIS location of sampling sites in the Tangon (St.1, St.2 and St.3) and Kulik (St.4, St.5 and St.6) Rivers during four seasons (pre-monsoon, monsoon, post-monsoon and winter season).

(ms); August, September and October as post-monsoon (pom); and November, December and January as winter (wm) season. Randomly six stations were selected having about 5 km distances from each other where station 1 (25.88751º N 88.40760º E, altitude 41.50 m), 2 (25.85501º N 88.40127º E, 43.60 m) and 3 (25.82056º N 88.38496º E, 40.40 m) in the Tangon River while stations 4 (25.91520º N 88.27375º E, 46.20 m), 5 (25.88960º N 88.26985º E, 43.70 m) and 6 (25.86703º N 88.25061º E, 42.40 m) in the Kulik River.

Sample Collection

During study period, data were collected at monthly intervals for water quality parameters and fish species. Water temperature (°C), water depth (m), dissolved oxygen (mg/l), water pH and transparency (cm) were measured by a standard method (APHA, 2012) *in-situ* using a digital thermometer (Digi-thermo), DO meter (Model: DO5509, Lutron), depth meter (traditional), pH meter (Model: HI-8014, HANNA instruments) and Secchi disk, respectively. Fish specimens were directly collected by fishermen where fishes were caught with seine net (15×3.5 m^2, mesh size 4 mm) and cast net (3.5×6.5 m^2, 8 mm). These fishing gears were operated at same sampling spot within 0.5 km area to ensure maximum harvesting of fishes. At each station (8.00 AM), five throws were made for cast net and three hauls for seine net to catch fishes. Sampling that less than two species per throws and hauls were kept out for counting. Then, collected fishes were sorted based on their key morphological characters and counted their individual abundance. Species that seemed difficult to identify on spot were preserved in 7 to 10% buffered formalin solution and conveyed to Laboratory of the Department of Fisheries Biology and Genetics under Hajee Mohammad Danesh Science and Technology University (HSTU) (Bangladesh) to facilitate identification and further study. The ichthyo-faunas were systematically identified and classified based on their morphology followed by Rahman (2005).

Statistical Analyses

In case of Kulik River, three months explicitly March, April and May known as dry season were excluded from analysis because of very low water depth (< 0.30 m) or somewhere dry out. For hydrological parameters (temperature, dissolved oxygen, pH and transparency) grouped by space and time, one-way analysis of variance (ANOVA) followed by Tukey's test were used to definite dissimilarities among between rivers and seasons. Canonical Correspondence Analysis (CCA) was designed to explore the correspondence between physical factors and species compositions, and to know the fish communities (Toham and Teugels, 1998). To assess the relative importance of each hydrological variable, we used CCA on each river and season derived from abundance and hydrological matrices. CCA was applied to overall fish data matrix and environmental data matrix obtaining a direct environmental interpretation of extracted ordination axes. To know the sample adequacy both in space and season, species accumulation curves were brought into play by AccuCurve version 1.0 (Drozd and Novotny, 2010). Four major biodiversity indices namely dominance, evenness, Margalef richness and Shannon-Weiner may used to know the discrepancy of aquatic communities or populations. However, to know the status of fish community structure and assembly, data were monthly collected and traced where diversity indices were calculated the as Buzas-Gibson's evenness $E = e^H/S$ (Pielou, 1966), Dominance index $D = \sum_i \left(\frac{n_i}{n}\right)^2$ (Harper, 1999), Margalef's richness index $d = (S-1)/\ln(n)$ (Margalef, 1968) and Shannon-Weiner diversity index $H = -\sum_i \frac{n_i}{n} \ln \frac{n_i}{n}$ (Shannon & Weiner, 1949). Where, n_i is the number of individuals of taxon *i; n* is total number of individuals; *ln* is natural logarithm; *S* is number of taxa; *e* is natural logarithm equal to 2.718. The irregular and scarce fish species (> 2 individuals) in both rivers were not considered for multivariate analysis. Using two-dimensional nonmetric multidimensional scaling (nMDS), fish abundance data were transforming as ln (x+1) in order to moderate influence of extreme values and fish assemblage were reviewed as spatial and temporal scales. Based on Bray-Curtis similarity method, major contributory fishes that responsible for parallel in grouping were dogged with SIMPER analysis (similarity percentage). Besides, one-way analysis of similarities (ANOSIM) was tested to assess the significant variations in spatiotemporal scales. A non-parametric test known as PERMANOVA was also used to compare the fish abundance data between rivers and seasons, respectively. An affiliation among fish assemblages from each station and month were graphically compared through cluster analysis by Unweighted Pair Group Method with Arithmetic mean (UPGMA) by Clarke and Warwick (1994). All statistical analysis was done using PAST (Paleontological Statistics, version 2.17 and 3.10) software (Hammer *et al.*, 2001).

Results

Water quality parameters

Average values of major hydrological factors from two rivers and four seasons are presented in Table 1. No considerable differences ($P > 0.05$) were observed in water temperature ($F = 0.02$), pH ($F = 2.29$) and transparency ($F = 0.09$) between Tangon and Kulik Rivers while significant variations ($P < 0.05$) were found in dissolved oxygen ($F = 6.23$) and water depth ($F = 14.73$), respectively. In contrast, significant differences were found in water temperature ($F = 43.73$, $P < 0.01$), dissolved oxygen ($F = 6.66$, $P < 0.01$), pH ($F = 7.68$, $P < 0.01$), transparency ($F = 13.57$, $P < 0.01$) and water depth ($F = 4.45$, $P < 0.05$) among seasons.

Fishes and Water Quality Parameters

In case of water quality parameters, eigen values of canonical correspondence analysis (CCA) of the first four axes were found to be 0.21 (CCA_1), 0.15 (CCA_2), 0.06 (CCA_3) and 0.04 (CCA_4) both for spatial and temporal scale where first (CCA_1) and second (CCA_2) axes were pooled and modeled as 45.73% and 32.95% of species data, respectively (Figure 2). Vector length of any specific parameters is a sign of magnitude of that variable in CCA analysis. The highest vector length of water depth at fourth axis showed significant correlation with the occurrence of *Cirrhinus reba*, *Gagata youssoufi* and *Xenentodon cancila* in post-monsoon and winter season at the Tangon and Kulik Rivers, respectively. Besides, vector length of water temperature was also correlated with the profusion of *Channa punctatus* and *Clarias batrachus* at both rivers in post-monsoon but at the Kulik River in winter months. The vector of pH was associated with the abundance of *Anabas tenstudineus*, *Aspidoparia jaya* and *Pethia ticto* in

Table 1. Average value (±SD) of major water quality parameters with their variation ($P < 0.05$) in both rivers and seasons

Hydrological factors	Rivers		Seasons			
	Tangon	Kulik	prm	ms	pom	wm
Water temperature (°C)	27.84±4.86	27.64±5.02	24.21±2.70^a	31.94±2.08^b	31.27±2.05^b	23.11±3.82^a
Water depth (m)	2.00±0.64^a	1.47±0.36^b	1.52±0.39^a	2.15±0.94^b	1.83±0.45	1.43±0.60
Dissolved oxygen (mg/l)	6.35±0.98^a	5.76±0.83^b	5.43±0.9^a	5.73±1.04^a	6.71±0.82^b	6.24±0.55
Water pH	7.27±0.41	7.09±0.55	7.00±0.47^a	6.95±0.33^a	7.58±0.18^b	7.14±0.58^a
Transparency (cm)	29.58±3.10	29.37±2.53	27.63±2.97^a	31.11±1.62^b	31.30±1.33^b	27.58±2.81^a

SD, standard deviation; prm, pre-monsoon; ms, monsoon; pom, post-monsoon; wm, winter; values of the parameter in each row with different superscripts (a, b and c) differs significantly (P < 0.05)

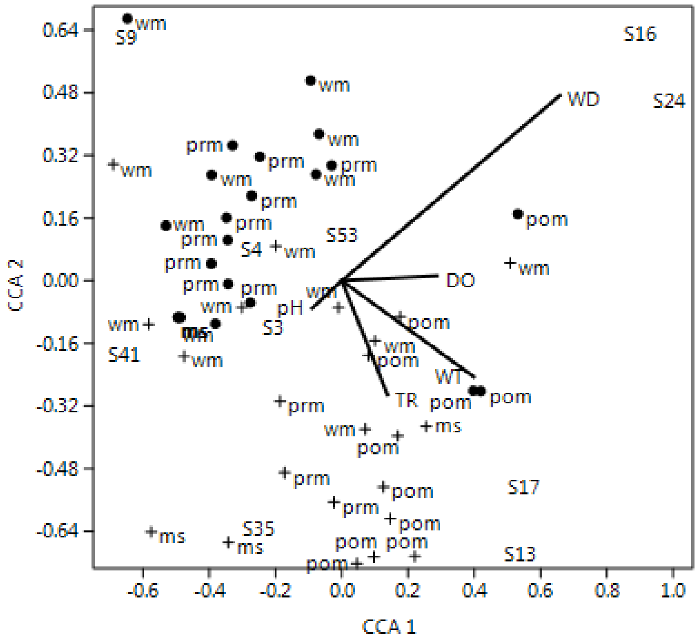

Figure 2. Canonical correspondence analysis (CCA) of fish abundance (S, species) and hydrological parameters (WT, water temperature; DO, dissolved oxygen; pH, water pH; TR, transparency) of the Tangon (●) and Kulik (+) Rivers during different seasons (prm, pre-monsoon; ms, monsoon; pom, post monsoon; wm, winter).

winter season at the Kulik River while in both pre-monsoon and monsoon at the Tangon River. The vector length of dissolved oxygen was only connected with the occurrence of *G. youssoufi* in winter season at the Kulik River where transparency with *C. punctatus* and *Macrognathus pancalus* in all seasons at the Kulik River.

Diversity Indices of Fishes

A total of 6,561 fish specimens, belonging to 38 genera and 53 fish species including 14 threatened species (Table 2), were collected both from the Tangon (82.73%) and Kulik (17.27%) Rivers. A species horizontal accumulation curve was arrived at an asymptote where fishes were accrued with a parallel and growing pattern leveling the effects of spatial and temporal heterogeneity both in Tangon and Kulik Rivers (Figure 3). Based on space and time, common values (mean±SD) of diversity indices from rivers and seasons are given in Table 3. Significant differences ($P < 0.01$) were spatially observed in the values of dominance ($F = 7.57$), evenness ($F = 10.72$) and Shannon ($F = 8.55$,) among two rivers except for Margalef ($F = 1.84$, $P > 0.05$). On the contrary, significant differences ($P < 0.01$) were also determined in the values of dominance ($F = 14.30$), evenness ($F = 3.80$), Margalef ($F = 27.89$) and Shannon ($F = 22.38$) among season from these rivers.

Assembly and Structure of Fishes

Based on SIMPER analysis (all pooling), about 83.73% and 79.19% average dissimilarity were found in rivers and seasons, respectively (Table 4). The highest contributing species were *A. jaya* (10.13% and 9.76%), *P. ticto* (7.77% and 7.79%), *Puntius sophore* (5.76% and 5.25%), *C. gongota* (5.13% and 4.86%) and *C. punctatus* (5.12% and 4.94%) while lowest was *Nandus nandus* (0.24% and 0.27%) both in spatiotemporal scales, respectively. A two-dimensional nMDS based on Bray-Curtis's similarity index suggests that fish assemblages at the Tangon River was speckled from Kulik River while monsoon was separated from another seasons pressuring as 0.24 (Figure 4 and 5). Analysis of similarity (ANOSIM) showed considerable variation in fish grouping at the rivers and seasons. The Tangon River showed significant difference ($R = 0.46$, $P < 0.01$) in fish assemblage with the Kulik River. Moreover, fish assemblage were significantly different ($R = 0.21$, $P < 0.01$) among season where highest contribution was found in winter but lowest in monsoon season. Based on Euclidean method, a non-parametric PERMANOVA test also exhibited significant variations ($P < 0.01$) in individual assemblage data between rivers ($F = 8.80$) and seasons ($F = 3.48$), respectively. Two clusters were spatiotemporally perceived as 12.35% partition using Bray-Curtis's similarity index where (Figure 6) the Kulik River was separated from the Tangon River in monsoon from other seasons. Besides, two sub-clusters were also viewed where 1st sub-cluster in monsoon months at the Tangon River which was also isolated from another season due to very close fish resemblance.

Discussion

Aquatic biodiversity of a stream is strongly influenced by water chemistry and habitat quality

Table 2. Spatiotemporal abundance and allocation of fishes from rivers and seasons including their present status

Genus name	Scientific name	Fish code	IUCN status	Rivers TR	Rivers KR	Contribution (%)	Seasons prm	Seasons ms	Seasons pom	Seasons wm
Acanthocobitis	*Acanthocobitis botia*	S1	LC	134	18	2.32	12	58	20	62
Amblypharyngodon	*Amblypharyngodon mola*	S2	LC	30	42	1.10	8	2	29	33
Anabas	*Anabas testudineus*	S3	LC	60	0	0.91	16	8	16	20
Aspidoparia	*Aspidoparia jaya*	S4	LC	690	103	12.09	51	120	261	361
	*Aspidoparia morar**	S5	VU	90	0	1.37	0	0	90	0
Barilius	*Barilius barna**	S6	EN	234	59	4.46	12	42	180	59
	*Barilius bendelisis**	S7	EN	42	0	0.64	0	0	0	42
Botia	*Botia lohachata**	S8	EN	84	15	1.51	24	30	0	45
Canthophrys	*Canthophrys gongota*	S9	NT	306	36	5.21	90	24	12	216
Chagunius	*Chagunius chagunio**	S10	VU	60	18	1.19	0	0	78	0
Chanda	*Chanda nama*	S11	LC	120	0	1.83	120	0	0	0
Channa	*Channa orientalis*	S12	LC	60	0	0.91	0	0	0	60
	Channa punctatus	S13	LC	330	24	5.40	24	0	219	111
	Channa striatus	S14	LC	48	18	1.01	48	0	9	9
Cirrhinus	*Cirrhinus cirrhosus*	S15	NT	96	0	1.46	30	0	0	66
	Cirrhinus reba	S16	NT	78	6	1.28	12	12	33	27
Clarias	*Clarias batrachus*	S17	LC	40	12	0.79	16	8	11	17
Crossocheilus	*Crossocheilus latius**	S18	EN	30	0	0.46	12	0	0	18
Devario	*Devario devario*	S19	LC	18	54	1.097	9	0	45	18
Erethistes	*Erethistes pussilus*	S20	LC	22	0	0.34	0	0	0	22
Esomus	*Esomus danricus*	S21	LC	78	0	1.19	0	0	0	78
Eutropiichthys	*Eutropiichthys vacha*	S22	LC	20	6	0.40	0	0	10	16
Gagata	*Gagata cenia*	S23	LC	110	23	2.03	27	14	35	57
	Gagata youssoufi	S24	NT	82	21	1.57	14	16	40	33
Glossogobius	*Glossogobius giuris*	S25	LC	180	21	3.06	48	42	30	81
Heteropneustes	*Heteropneustes fossilis*	S26	LC	42	0	0.64	0	0	42	0
Labeo	*Labeo angra*	S27	LC	62	10	1.10	0	0	7	65
	Labeo bata	S28	LC	72	6	1.19	0	51	18	9
	*Labeo boga**	S29	CR	20	4	0.36	0	0	0	24
	Labeo calbasu	S30	LC	18	0	0.27	10	0	2	6
	Labeo gonius	S31	NT	26	2	0.43	4	16	0	8
	Labeo rohita	S32	LC	138	6	2.19	30	48	9	57
Lepidocephalichthys	*Lepidocephalichthys guntea*	S33	LC	120	30	2.29	42	66	39	3
Macrognathus	*Macrognathus aculeatus*	S34	NT	48	0	0.73	48	0	0	0
	Macrognathus pancalus	S35	LC	240	71	4.74	9	78	113	111
Mastacembalus	*Mastacembalus armatus**	S36	EN	60	0	0.91	0	0	48	12
Mystus	*Mystus bleekeri*	S37	LC	20	4	0.37	0	0	2	22
	Mystus tengara	S38	LC	138	11	2.27	12	42	20	75
Nandus	*Nandus nandus*	S39	NT	14	3	0.26	0	0	0	17
Ompok	*Ompok pabda**	S40	EN	20	3	0.35	0	12	8	3
Pethia	*Pethia ticto**	S41	VU	558	138	10.61	141	72	189	294
Genus name	Scientific name	Fish code	IUCN status	Rivers TR	Rivers KR	Contribution (%)	Seasons prm	Seasons ms	Seasons pom	Seasons wm
Pseudambassis	*Pseudambassis lala*	S42	LC	18	9	0.41	0	0	0	27
Psilorhynchus	*Psilorhynchus balitora*	S43	LC	18	3	0.32	0	12	0	9
Puntius	*Puntius sophore*	S44	LC	264	48	4.76	72	132	87	21
Raiamas	*Raiamas bola**	S45	EN	24	0	0.37	0	0	6	18
Rita	*Rita rita**	S46	EN	8	9	0.26	8	0	0	9
Salmophasia	*Salmophasia bacaila*	S47	LC	108	200	4.69	66	49	87	106
Salmostoma	*Salmostoma phulo*	S48	NT	48	0	0.73	0	0	0	48
Sperata	*Sperata aor**	S49	VU	150	52	3.08	3	38	156	5
Tetraodon	*Tetraodon cutcutia*	S50	LC	42	0	0.64	0	0	0	42
Trichogaster	*Trichogaster fasciata*	S51	LC	64	3	1.02	0	0	40	27
Wallago	*Wallago attu**	S52	VU	11	7	0.27	0	7	6	5
Xenentodon	*Xenentodon cancila*	S53	LC	42	31	1.11	13	12	28	20
Total				5435	1126	100	1031	1011	2025	2494
Contribution (%)				82.84	17.16		15.71	15.41	30.86	38.01

TR, Tangon River; KR, Kulik River; prm, pre-monsoon; ms, monsoon; pom, post monsoon; wm, winter; *Threatened fishes; *IUCN*: International Union for Conservation of Nature; *CR*: Critically endangered; *EN*: Endangered; *VU*: vulnerable; *NT*: Near threatened; *LC*: Least concern

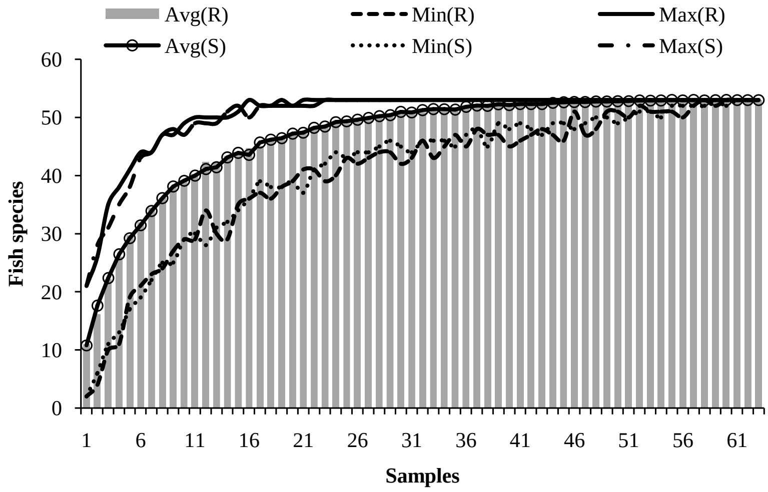

Figure 3. A species accumulation curve at the Tangon and Kulik Rivers (R) during four seasons (S).

Table 3. Descriptive statistics with one way ANOVA of diversity indices at the Tangon and Kulik Rivers during different seasons

Rivers/seasons		Statistics	Diversity indices			
			Dominance	Evenness	Margalef	Shannon
Rivers	Tangon	Min	0.07	0.69	0.83	1.52
		Max	0.23	0.94	3.61	2.75
		Mean±SD	$0.13±0.04^a$	0.81±0.07	2.23±0.76	2.22±0.35
	Kulik	Min	0.09	0.69	0.42	0.47
		Max	0.70	0.97	3.09	2.48
		Mean±SD	$0.23±0.19^b$	0.87±0.07	1.96±0.84	1.84±0.65
Seasons	prm	Min	0.08	0.81	1.02	1.52
		Max	0.23	0.97	3.52	2.73
		Mean±SD	$0.13±0.04^a$	$0.88±0.06^a$	$2.34±0.77^a$	$2.21±0.37^a$
	ms	Min	0.15	0.79	0.42	0.47
		Max	0.70	0.96	1.92	2.06
		Mean±SD	$0.33±0.2^b$	0.86±0.05	$1.05±0.49^b$	$1.38±0.59^b$
	pom	Min	0.09	0.69	1.82	1.92
		Max	0.17	0.95	2.98	2.53
		Mean±SD	$0.13±0.03^a$	$0.81±0.09^b$	$2.37±0.39^a$	$2.22±0.18^a$
	wm	Min	0.07	0.69	1.89	1.82
		Max	0.21	0.93	3.61	2.75
		Mean±SD	0.12±0.04	$0.81±0.07^b$	$2.61±0.48^a$	$2.35±0.26^a$

prm, pre-monsoon; ms, monsoon; pom, post-monsoon; wm, winter; min, minimum; max, maximum; SD, standard deviation; values of the parameter in each column with different superscripts (a, b and c) differs significantly ($P < 0.05$)

Table 4. Discriminating contribution of fishes (> 2.0%) through SIMPER analysis in rivers and seasons

Rivers (83.73%)	Average dissimilarity	Seasons (79.19%)
Contribution (%)	Major contributory fishes	Contribution (%)
10.13	*Aspidoparia joya*	9.76
7.77	*Pethia ticto*	7.79
5.76	*Puntius sophore*	5.25
5.13	*Canthophrys gongota*	4.86
5.12	*Channa punctatus*	4.94
4.40	*Macrognathus pancalus*	4.56
4.38	*Salmophasia bacaila*	4.33
3.77	*Barilius barna*	4.01
3.33	*Sperata aor*	3.79
3.20	*Lepidocephalichthys guntea*	3.23
3.18	*Glossogobius giuris*	3.00
2.68	*Labeo rohita*	2.37
2.58	*Mystus tengara*	2.38
2.54	*Chanda nama*	2.56
2.40	*Acanthocobitis botia*	2.35

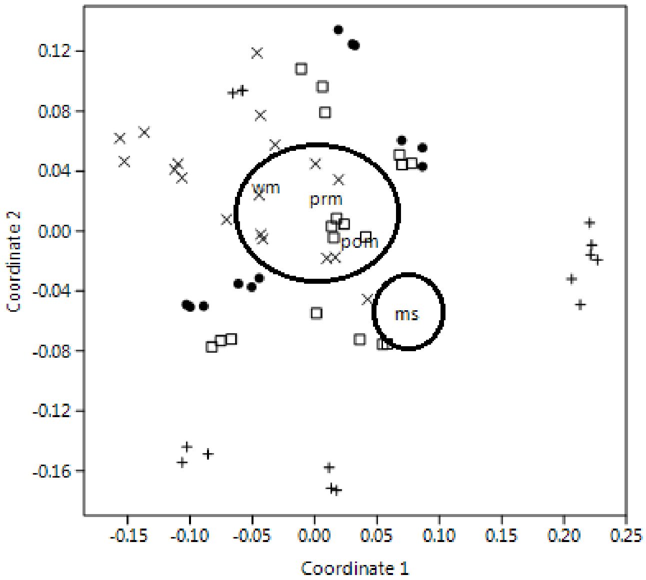

Figure 5. Two dimensional nMDS scaling of comparative fish assemblage data among seasons (prm, pre-monsoon; ms, monsoon; pom, post monsoon; wm, winter) in the Tangon and Kulik Rivers stressing as 0.24.

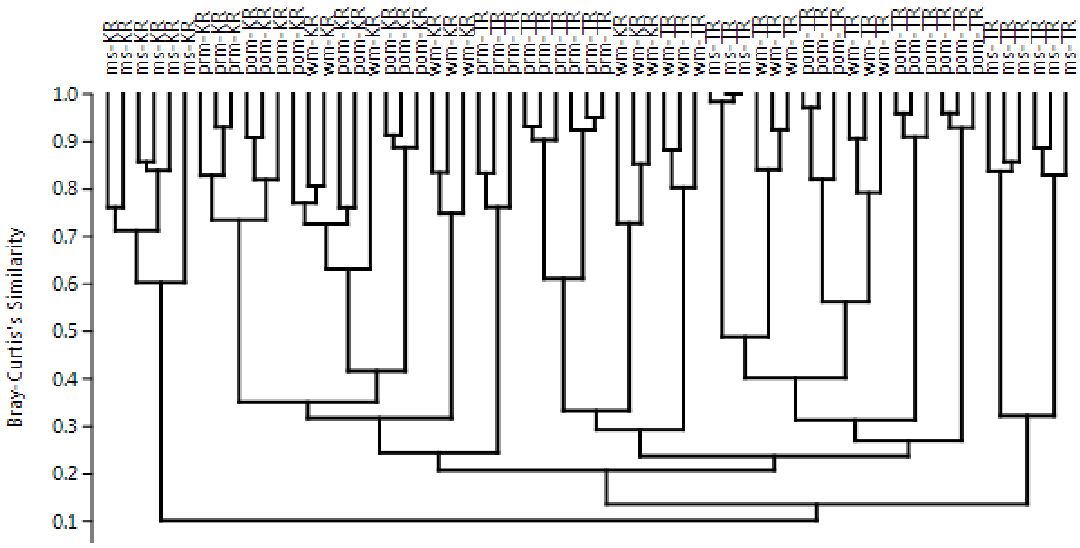

Figure 6. Classical UPGMA clustering based on Bray-Curtis's similarity index of fish assemblage both in space (TR, Tangon River; KR, Kulik River) and time (prm, pre-monsoon; ms, monsoon; pom, post monsoon; wm, winter).

(Bio *et al.*, 2011). Variations of water temperature among seasons showed more impacts on species distribution in Kulik River may be due to water depth than Tangon River. From these rivers, maximum level of fish abundance was detected at low water temperature and small flowing discharge in winter but minimum fish diversity viewed with comparatively high temperature and water discharge in summer differed by Yan *et al.* (2010) due to geographical variation. Alteration in water quality parameters such as water temperature, dissolved oxygen, pH, transparency and depth influence the uniqueness of aquatic environment and fish breeding (Kathiresan and Bingham, 2001; Rashleigh, 2004), profusion and allotment (Maes *et al.*, 2004), migration and distribution (Vega-Cendejas *et al.*, 2013) and survival of fishes (Whitfield, 1999) ultimately altering fish assemblage and structure. However, significant differences ($P < 0.05$) were observed in hydrological parameters among habitat and season similar to Grimaldo *et al.* (2012). Besides, values of water quality parameters from these rivers were within the limits reported by Rakiba and Ferdoushi (2013) due to close ecological area. Fish assemblage and structure are mainly affected by seasonal changes along with ecological factors in estuaries (Loneragan and Potter, 1990; Young and Potter, 2003).

The number of fishes and individuals, native and susceptible species, were found more from Tangon River than Kulik River over the successive seasons might be due to more periphyton community, charitable shelters, food staffs and breeding places. Quantity of fish species and specimens may vary due to scattering from the Tangon River in early April for breeding purposes. Maximum number of individuals was observed at Tangon River may be as a result of most favorable environmental condition mainly for water depth than Kulik River. From both rivers, highest number of species and specimens were caught in winter season may be due to reduced volume of water. Minimum fish species and specimen were recorded in monsoon would be due to low effectiveness of fishing gears used at higher depth as a result of heavy rainfall and floods during this period. The highest abundance of fishes recorded in November but lowest in June and August from Padma River (Chaki *et al.*, 2014) and was deviated with Jahan *et al.* (2014) loads cresting in October and lowing in February may be because of geographical and environmental variations. An asymptote species accumulation curve attained for sampling sufficiency supported by Malcolm *et al.* (2007). Values of all diversity indices were comparable between two rivers and seasons observing significant variations both in space and time. The incongruities may be occurred due to nutrients dissimilarity (Huh and Kitting, 1985), water currents and environmental incidents (Keskin and Unsal, 1998) and fish migrations (Ryer and Orth, 1987) as well as seasonal difference in species diversity. In Bangladesh, a number of fish species breed and recruit as new stocks in their habitat from April to May that would be another rationale to alter diversity indices (Hossain *et al.*, 2012).

Besides, present study found almost same similarity in case of occurrence of finfish assemblage between space and spell where main donating species were also similar but their percentage of contribution varied from each other. At this point, resemblance was found in more among rivers rather than seasons where major causal fishes were related to the Chalan beel for *P. sophore* and *P. ticto* (Kostori *et al.*, 2011) while was disparate with Meghna River estuary (Hossain *et al.*, 2012). The non-metric multidimensional scaling (nMDS) composed of associations among assemblages in particular coordination rooted in their similarity or dissimilarity. The spatiotemporal fish assemblage and structure of these rivers (stress as 0.24) just above the minimum values of nMDS (< 0.15) model indicate improved fitting with petite suspects by lessening the stress supported by Kruskal and Wish (1984) and Sanches *et al.* (2016) in relative abundance for Brazilian reservoir (stress as 0.20). Base on ANOSIM and PERMANOVA analysis, Tangon River showed dissimilarity in fish assemblage with Kulik River during monsoon may be due to have more different ecosystems. Fish assemblage was dissected among habitats and seasons would be attributable to particular ecological variables for breeding, feeding, rearing and sheltering fluctuated seasonally with water quality parameters (Agostinho *et al.*, 2008). In addition, the Tangon River was isolated from the Kulik River in rainy season may be resulted as more suitable breeding and feeding habitat or due to seasonal variations of ecological factors. Seasonality also controls the spawning activity of fishes accelerating to alter catch composition (van Overzee and Rijnsdorp, 2015).

In conclusion, spatiotemporal connection between fish species and ecological factors play a causative role to complete the life cycle of fishes (*A. jaya*, *P. ticto*, *P. sophore*, *C. gongota* and *C. punctatus*). Water depth and water temperature are main leading factors altering fish assemblage and structure spatiotemporally. So, the government of Bangladesh, scientists and other authorities should recompense their attentions to protect the indigenous fishes essentially threatened species during dry or winter season in these rivers. Through further research, monitoring and raising awareness among local people adjacent these rivers, rare fishes would be regenerated and dominant species may be sustained at the Tangon and Kulik Rivers in Thankurgaon district of Bangladesh.

Acknowledgements

The authors are thankful to Institute of Research and Training (IRT), HSTU and University Grand Commission (UGC) for their founding to conduct this research in the Tangon and Kulik Rivers of Bangladesh.

References

Agostinho, A. A., Pelicice, F. M. and Gomes, L. C. 2008. Dams and the fish fauna of the Neotropical region: Impacts and management related to diversity and fisheries. Brazilian Journal of Biology, 68: 1119-1132.
doi: http://dx.doi.org/10.1590/S1519-69842008000500019

APHA, 2012. Standard methods for examination of water and wastewater. 22nd edition, American Public Health Association, Washington, 1360 pp.

Bio, A., Vieira, N., Costa, M. J. and Valente, A. 2011. Assessment of habitat and water quality of the Portuguese Febros River and one of its tributaries. Limnetica, 30: 103-116.

Chaki, N., Jahan, S., Fahad, M. F. H., Galib, S. M. and Mohsin, A. B. M. 2014. Environment and fish fauna of the Atrai River: Global and local conservation perspective. Journal of Fisheries, 2: 163-172.
doi: dx.doi.org/10.17017/jfish.v2i3.2014.46

Clarke, K. R. and Warwick, R. M. 1994. Change in marine communities: An approach to statistical analysis and interpretation. 2nd edition, Plymouth Marine Laboratory, UK, 144 pp.

Corpuz, M. N. C., Paller, V. G. V. and Ocampo, P. P. 2015. Environmental variables structuring the stream gobioid assemblages in the three protected areas in Southern Luzon, Philippines. Raffles Bulletin of Zoology, 63: 357-365.

Drozd, P. and Novotny, V. 2010. AccuCurve. Version 1. Available from:
http://prf.osu.cz/kbe/dokumenty/sw/AccuCurve/AccuCurve.xls

Grimaldo, L. F., Miller, R. E., Peregrin, C. M. and Hymanson, Z. 2012. Fish assemblages in reference and restored tidal freshwater marshes of the San Francisco estuary. San Francisco Estuary and Watershed Science, 10: 1-21.

Hammer, Ø., Harper, D. A. T. and Ryan, P. D. 2001. PAST: Paleontological statistics Software package for education and data analysis. Palaeontologia Electronica, 4: 9 pp.

Harper, D. A. T. 1999. Numerical palaeobiology. Computer-based modelling and analysis of fossils and their distributions. John Wiley and Sons, Chichester, New York, x+468 pp.

Hossain, M. S., Das, N. G., Sarker, S. and Rahman, M. Z. 2012. Fish diversity and habitat relationship with environmental variables at Meghna River estuary, Bangladesh. Egyptian Journal of Aquatic Research, 38: 213-226.
doi: http://dx.doi.org/10.1016/j.ejar.2012.12.006

Huh, S. H. and Kitting, C. L. 1985. Trophic relationships among concentrated populations of small fishes in seagrass meadows. Journal of Experimental Marine Biology and Ecology, 92: 29-43. doi: 10.1016/0022-0981(85)90020-6

Jahan, R., Quaiyum, M. A., Saker, B. S., Hossain, M. B., Jaman, K. M. K. B. and Rahman, S. 2014. Biodiversity and seasonal abundance of small indigenous fish species (SIS) in the rivers and adjacent beels of Karimganj (Kishoreganj, Bangladesh). Asian Journal of Animal Sciences, 8, 38-46.
doi: 10.3923/ajas.2014.38.46

Kadye, W. T. and Moyo, N. A. G. 2007. Stream fish assemblage and habitat structure in a tropical African river basin (Nyagui River, Zimbabwe). African Journal of Ecology, 46: 333-340.
doi: 10.1111/j.1365-2028.2007.00843.x

Kathiresan, K. and Bingham, B. 2001. Biology of mangroves and mangrove ecosystems. Advances in Marine Biology, 40, 81-215.
doi: http://dx.doi.org/10.1016/S0065-2881(01)40003-4

Keskin, C. and Unsal, N. 1998. The fish fauna of Gokceada Island, NE Aegean Sea, Turkey. Italian Journal of Zoology, 65: 299-302. doi: 10.1080/11250009809386836

Kostori, F. A., Parween, S. and Islam, M. N. 2011. Availability of small indigenous species (SIS) of fish in the Chalan beel-the largest wetland of Bangladesh. University Journal of Zoology, Rajshahi University, 30: 67-72. doi: http://dx.doi.org/10.3329/ujzru.v30i0.10756

Kruskal, J. B. and Wish, M. 1984. Multidimensional scaling. Sage Publications, London.

Loneragan, N. R. and Potter, I. C. 1990. Factors influencing community structure and distribution of different life-cycle categories of fishes in shallow waters of a large Australian estuary. Marine Biology, 106: 25-37.
doi: 10.1007/BF02114671

Maes, J., Van Damme, S., Meire, P. and Ollevier, F. 2004. Statistical modeling of seasonal and environmental influences on the population dynamics of an estuarine fish community. Marine Biology, 145: 1033-1042.
doi: 10.1007/s00227-004-1394-7

Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, New Jersey.
doi: 10.1007/978-94-015-7358-0

Malcolm, H. A., Gladstone, W., Lindfield, S., Wraith, J. and Lynch, T. P. 2007. Spatial and temporal variation in reef fish assemblages of marine parks in New South Wales, Australia-baited video observations. Marine Ecology Progress Series, 350: 277-290. doi: 10.3354/meps07195

Margalef, R. 1968. Perspectives in ecological theory. University of Chicago Press, Chicago, 111 pp.

Rahman, A. K. A. 2005. Freshwater fishes of Bangladesh. 2nd edition, Zoological Society of Bangladesh, Department of Zoology, University of Dhaka, Dhaka, 263 pp.

Rahman, M. K., Akhter, J. N., Nima, A., Ahmed, S.U. and Mazid, M. A. 2003. Studies on geo-morphology, ecology and fish production of the 92 rivers of Rajshahi Division, Bangladesh. Bangladesh Journal of Fisheries and Research, 7: 141-150.

Rakiba, K. and Ferdoushi, Z. 2013. Physico-chemical properties of Dhepa River in Dinajpur district of Bangladesh. Journal of Environmental Science and Natural Resources, 6: 59-67.
doi: http://dx.doi.org/10.3329/jesnr.v6i1.22041

Rashleigh, B. 2004. Relation of environmental characteristics to fish assemblages in the upper French broad river basin, North Carolina. Environmental Monitoring and Assessment, 93: 139-156.
doi: 10.1023/B:EMAS.0000016806.69647.3e

Ryer, C. H. and Orth, R. J. 1987. Feeding ecology of the northern pipefish, *Syngnathusfuscus*, in a sea grass community of the lower Chesapeake Bay. Estuaries, 10: 330-336. doi: 10.2307/1351891

Sanches, B. O., Hughes, R. M., Macedo, D. R., Callisto, M. and Santos, G. B. 2016. Spatial variations in fish assemblage structure in a southeastern Brazilian reservoir. Brazilian Journal of Biology, 76: 185-193.
doi: http://dx.doi.org/10.1590/1519-6984.16614

Shannon, C. E. and Weaver, W. 1949. The mathematical theory of communication. University of Illinois Press, Urbana and Chicago.

Terra, B. De F., Hughes, R. M. and Araujo, F. G. 2016. Fish assemblages in Atlantic forest streams: the relative influence of local and catchment environments on taxonomic and functional species. Ecology of Freshwater of Fish, 25: 527-544. doi: 10.1111/eff.12231

Toham, A. K. and Teugels, G. G. 1998. Diversity patterns of fish assemblages in the lower Ntem River Basin (Cameroon) with notes on potential effects of deforestation. Archives Hydrobiology, 141: 421-446.
doi: 10.1127/archiv-hydrobiol/141/1998/421

Tunesi, L., Molinari, A., Salvati, E. and Mori, M. 2006. Depth and substrate type driven patterns in the infralittoral fish assemblage of the NW Mediterranean Sea. Cybium, 30: 151-159.

van Overzee, H. M. J. and Rijnsdorp, A. D. 2015. Effects of fishing during the spawning period: implications for sustainable management. Reviews in Fish Biology and Fisheries, 25: 65-83.

Vega-Cendejas, M. E., De Santillana, M. H. and Norris, S. 2013. Habitat characteristics and environmental parameters influencing fish assemblages of karstic pools in southern Mexico. Neotropical Ichthyology, 11: 859-870.

doi: http://dx.doi.org/10.1590/S1679-62252013000400014

Vyas, V., Damde, V. and Parashar, V. 2012. Fish biodiversity of Betwa River in Madhya Pradesh, India with special reference to a sacred ghat. International Journal of Biodiversity and Conservation, 4: 71-77.
doi: 10.5897/IJBC10.015

Whitfield, K. A. 1999. Ichthyofaunal assemblages in estuaries: A South African case study. Reviews in Fish Biology and Fisheries, 9: 151-186.
doi: 10.1023/A:1008994405375

Yan, Y., Shan, H. E., Ling, C. H. U., Xiang, X., Jia, Y., Tao, J. and Chen, Y. 2010. Spatial and temporal variation of fish assemblages in a subtropical small stream of the Huangshan Mountain. Current Zoology, 56: 670-677.

Young, G. C. and Potter, I. C. 2003. Do the characteristics of the ichthyoplankton in an artificial and a natural entrance channel of a large estuary differ? Estuarine, Coastal and Shelf Science, 56: 765-779.
doi: /10.1016/S0272-7714(02)00300-1