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Determination on fish diversity indices from Chalan *Beel*, Bangladesh

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Abstract
An assessment was carried out to determine the fish diversity indices from Ruhul *beel* 1, 2 and Bamonji *beel* 1, 2 under Chalan *beel* in Pabna district of Bangladesh. Data were collected from selected sanctuary sites, focus group discussion, personal and group contract as well as Government and Non-Government organizations with prepared and pretested questionnaire. The fish diversity of the study areas was calculated by various methods namely Species richness (S), Shannon-Wiener diversity indices (H_0), Species evenness (E) and Simpson's diversity Index (D) of fish observed in Ruhul *beel* and Bamonji *beel* during the whole study period. The highest species richness was found in Ruhul *beel* whereas it was less amount in Bamonji *beel* during the study period. Overall species richness was higher in Ruhul *beel*. The monthly species richness was significantly ($P<0.01$) varied among the months. The highest values were found 37 in November and December for Ruhul *beel*-1 and in October and November for Ruhul *beel*-2. On the other hand, the highest value was found in November and December for Bamonji *beel*-1 and same value in November for Bamonji *beel*-2. The lowest values were found 13, 15, 9 and 8 for Ruhul *beel*-1, Ruhul *beel*-2, Bamonji *beel*-1 and Bamonji *beel*-2, respectively in January.

Keywords: Fish diversity indices, Chalan *beel*

1. Introduction
The Chalan *beel* was once the largest and best known of the *beels* in northern Bangladesh. Once upon a time it covered an area belonging to 26 Upazillas under 6 districts which was Natore, Pabna, Sirajgonj, Chapai Nawabgong, Naogon and Rajshahi district (DoF, 2011) [9].
However, the *beel* is presently spreads concisely over mainly 10 Upazilas under three districts because of siltation and human interference. The included Upazillas are Singra, Gurudaspur and Boraigram under Natore district, Chatmohar, Bhangura and Faridpur under Pabna district, Shahjadpur, Ullapara, Tarash and Raigonj under Sirajgonj district (Hossain *et al.,* 2008) [15] although Galib *et al.,* (2009) [10] stated that now it is confined among 9 Upazilla under 4 districts.
The fishes are the most diverse and most abundant vertebrate in the world and about 40% of them live in freshwater (Hossain and Haque 2005) [14]. There are about 85 definitions of biodiversity one of which is; "Biological Diversity that is Biodiversity" means the variability among living organisms from all sources including, *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; it includes diversity within species between species and of ecosystems. According to Natasha (2008) [26] "The word biodiversity is used to explain the variety of life on Earth, and is considered at different levels of biological organization including genes, species and ecosystems". Gaston and Spicer (2004) [11] defined biodiversity as "Biodiversity is the variety of life on earth and includes variation at all levels of biological organization from genes to species to ecosystems". "Biological diversity provides resources for food, construction and raw materials for industry. It provides the basis for improvement of the domesticated species; maintains functions of ecosystems, including evolutionary processes; stores and cycles nutrients essential for life; absorbs and breaks down pollutants, including organic waste, pesticides, and heavy metals; recharges ground water, protects catchment basins, and buffers extreme water conditions; and produces soil and protects it from excessive erosion" UNESCO (1994) [38].

We are continuously losing fish biodiversity in our country as well as in the whole world. With the degradation of the biodiversity society can be affected seriously specially the fisher-folk. Freshwater biodiversity has declined faster than either terrestrial or marine biology over the past 30 years (Vijaylaxmi *et al.,* 2010) [40]. The fish diversity and production in Bangladesh decreased a lot in last few decades due to habitat destruction (Sayeed, 2010) [33] by siltation of *beels*-rivers-canals, general reduction of floodplain and *beel* area, over exploitation, unplanned constructions of dams, regulators, culverts, cross roads and high ways which prevents the spawning, feeding and migration of fishes, embankments that cut off canals connecting the *beels* with rivers which is preventing replenishment of *beels* with fishes, indiscriminate use of pesticides and chemical fertilizers in agricultural land, excessive removal of surface water and extraction of ground water for irrigation, water pollution due to discharges of untreated effluents from industries like sugar mills, tannery, changes in cropping pattern and many other causes created by human interference. It was revealed by Department of Fisheries (DoF) that in this region fish output alone has declined by 60 % during the last 15 years. As many as 51 fish species have become threatened and many fish are on the verge of extinction which was once abundant in *beels.*

2. Materials and Methods
2.1 Data Collection: Data was collected through weekly field survey from selected professional fishermen's catch in the study area during May 2012 to April 2014. The fishermen used 10 types of fishing gears to harvest fishes in the locality which were Nets (Badai jal, Current jal, Khora jal, Thela jal, Dhormo jal), Traps (Dhundi, Polo), Hooks (Borshi). Other than these gears they used to fish with bare hand (Hand fishing) and fishing by dewatering. In the afternoon the Current jal and traps (Dhundi) were fixed in the *beel* and early in the morning of next day the nets and traps were taken out from the *beel* water. Ber jal (seine net) was operated at late night for 3 to 5 hours with the professional fishers. Thela jal and Dhormo jal were used at day time for 3 to 6 hours and catch of 20 hauls were considered for each sample (Mohsin *et al.,* 2013) [25]. A digital balance (measurable up to 0.01 g) for small fish and pan balance for the bigger fishes were used to measure the amount of harvested sample individually (Hossain, 2010) [18].

2.2 Species Count and Identification: The collected samples were counted on the spots those were easily identifiable species and the other species were brought to the laboratory by preserving in 10% formalin solution for farther analysis (Hasan *et al.,* 2012) [13]. The species count was done by direct count method. Samples were divided into sub-sample when the amount of the samples was bigger than 200 individuals. Collected fish specimens were identified following Bhuiyan (1964), Rahman (1989), Rahman (2005) [29], Talwar and Jhingran (1991), Shafi and Quddus (2001) and Shahjahan *et al.* (2001) [6, 28, 29, 37, 34, 35].

2.3 Data Analysis: The fish species diversity was analyzed using different indices (Vijaylaxmi *et al.,* 2010) [40] like Species Richness, Shannon–Weiner index (Shannon and Weaver 1949) [36] Simpson's Diversity index (Krebs, 1978) [22] and Pileups Evenness (Norton 2001, Zar, 1996) [27]. Species richness is simply the number of species present in an area. Species evenness refers to the proportion that each species

comprises of the whole population (Kathleen *et al.,* 2005) [21]. Shannon index is an important statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. The following procedures were considered to estimate the fish diversity which was as follows;

2.4 Species Richness
Species richness (Zar, 1966) [41] is the number of different species present in an area. The more species present in a sample the 'richer' the area. It is expressed by 'S'.

$$\text{That is, Species Richness (S)} = \sum_{i}^{s} p_i^0$$

The higher value of 'S' indicates the higher diversity.

2.5 Shannon-Wiener diversity index (H₀)
It combines species richness (S) and evenness (E), and also it is most commonly used diversity indices in ecology.
The formula for calculating the index is as follows:

$$H_0 = -\sum_{i=1}^{S} p_i \ln p_i$$

Where
H_0 = the species diversity index,
S = the number of species, and
pi = the proportion of individuals of each species belonging to the species of the total number of individuals (Kathleen *et al.,* 2005) [21].

The value of 'H₀' ranges from 0 to 5, usually ranging from 1.5 to 3.5. It interpreted as low values (within limit) of 'H₀' indicates low diversity and that means the most individuals are concentrated in a few species, while high values (within limit) of 'H₀' indicate greater diversity or greater evenness in the distribution of individuals among species. A positive change indicates increased diversity and evenness, a negative change indicates reduced diversity and evenness (Hunter, 1996 and Hossain *et al.,* 1999) [19, 16].

2.6 Species Abundance or Evenness
Species Abundance or Evenness is the relative abundance of species. It is expressed by 'E' and was calculated using the following formula:
Species Evenness   (E) = H_0/H_{max}
Here, H_0 = Pi(lnPi) = Shannon Wiener's Index.
H_{mx} = Natural log (ln) of Species richness = ln(S)
The higher value of 'E' indicates the higher diversity. Values range from 0 to 1.

Simpson's Diversity Index (D) $D = \dfrac{\sum n_i(n_i - 1)}{N(N-1)}$
2.7
Where,
ni = number of individuals or amount of each species (i.e., the number of individuals of the *ith* species) and
N = total number of individuals for the site.
The value of 'D' ranges from 0 to 1. With this index, 0 represents infinite diversity and 1 no diversity. That is, the bigger 'D' value (within limit) indicates the lower diversity (Source: Internet; Biodiversity, measuring biodiversity,

student and teachers guide).

Simpson's diversity index is less sensitive to species richness and heavily weighted towards the most abundant species. Generally, less sensitive than Shannon-Weiner index 'H₀' (Source: Internet; Measuring Species Diversity).

3. Results
Species richness, evenness and diversity are all fun concepts to teach biology students. But these are somewhat intuitive, easy to calculate and can be used to compare different populations (Kathleen *et al.,* 2005) [21]. The fish diversity of the study areas was calculated by various methods which has been presented below (Table 1).

3.1 Species Richness
The highest 'S' (species richness) value (38) was found for the RB whereas it was 37 for the BB during the study period. Overall species richness was higher in RB (Table 2). The monthly species richness was significantly ($P<0.01$) varied among the months (Table 2). The highest values (37) were found in November and December for RB-1 and 37 in October and November for RB-2. The highest value (35) were found in November and December for BB-1 and same value in November for BB-2. The lowest values were found 13, 15,

9 and 8 for RB-1, RB-2, BB-1 and BB-2, respectively in January (Figure 1).

3.2 Shannon-Wiener Diversity Indices (H₀)
The highest Shannon-Wiever diversity indices (H₀ value) were recorded in RB-2 (2.97430) followed by RB-1 (2.33668). The lowest H₀ value was calculated in BB-2 (1.43806). According to Shannon Weiner indices (H₀) fish diversity was increased in RB.

3.3 Species Abundance or Evenness (E)
The 'E' value was 0.64072, 0.81766, 0.46637 and 0.40130 for RB-1, RB-2, BB-1 and BB-2, respectively. From the 'E' value it was revealed that fish diversity was increased in RB-2. On the other hand, 'E' value was decreased in Bamonji *beel* i.e. fish diversity decreased in BB-2 than BB-1.

3.4 Simpson's Diversity Index
The 'D' value was 0.14445, 0.13938, 0.15538 and 0.14032 at RB-1, RB-2, BB-1 and BB-2, respectively. The 'D' values indicate that fish diversity increased in RB-2 from RB-1 that is fish diversity was higher in RB-2. On the other hand, fish diversity was decreased in BB-2.

Table 1: Calculative value of Species richness (S), Shannon-Wiener diversity indices (H₀), Species evenness (E) and Simpson's diversity Index (D) of fish and prawn observed in RB and Bamonji *beel* during the whole study period

Month	S¹ value	H₀² value	E³ value	D⁴ value
RB-1	38	2.33668	0.64072	0.14445
RB-2	38	2.97430	0.81766	0.13938
BB-1	37	1.67125	0.46637	0.15538
BB-2	37	1.43806	0.40130	0.14032

1. S = Species richness the higher value of 'S' indicates the higher diversity.
2. H₀ = Shannon Wiener index. The higher value of 'H₀' indicates the higher diversity. Values range from 0 to 5, usually ranging from 1.5 to 3.5
3. E = Species evenness; the higher value of 'E' indicates the higher diversity. Values range from 0 to 1.
4. D = Simpson's index. The lower value of 'D' indicates the higher diversity. The value of 'D' ranges from 0 to 1. With this index, 0 represents infinite diversity and, '1' represents no diversity. That is, the bigger the value the lower the diversity.

Table 2: Correlations of fish numbers with inter month, inter gear and inter year

		Site	Year	Month	Gear	Fish amounts
Site	PC¹	1				
	Sig. (2-tailed)					
Year	PC	-.022	1			
	Sig. (2-tailed)	.119				
Month	PC	.008	.075(**)	1		
	Sig. (2-tailed)	.591	.000			
Gear	PC	.058(**)	.018	.090(**)	1	
	Sig. (2-tailed)	.000	.206	.000		
Fish amounts	PC	-.148(**)	.036(*)	-.072(**)	.079(**)	1
	Sig. (2-tailed)	.000	.011	.000	.000	

** Correlation is significant at the 0.001 level (2-tailed).
* Correlation is significant at the 0.01 level (2-tailed).
¹PC = Pearson Correlation

3.5 Monthly Variation in Fish Diversity Indices (S) in Different Sites and Years.
The highest fish diversity was recorded in the month of November for both the *beels* in both the years. The lowest fish

diversity was recorded in the month of January for both the *beels* in both years. However, there was no catch in the month of March in both the *beels.*
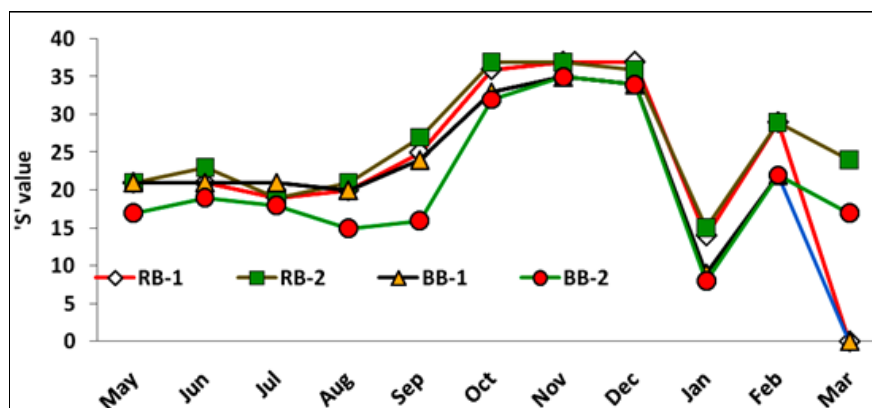
Fig 1: Trends of monthly variation in diversity index (Species richness) in different site during the whole study period.

4. Discussion
The present study revealed that overall total species richness for RB and Bamonji *beel* were 38 and 37, respectively which was closely related to the results of Vanderpuye (1982), Dankwa (1982) and Antwi and Ofori-Danson (1993) [39, 8, 3]. Overall species richness was higher in RB during the study period. It was might be due to the establishment of sanctuary which protect the fishes from over exploitation and create shelter, spawning ground, feeding ground which ultimately increase the species richness. The result of present study was more or less similar with the findings of Aliko *et al.* (2010) [2], who showed the species richness at riverine zone was 42, 43 for the transitional zone, 45 for the lacustrine, 33 for the transitional zone and 18 for riverine and lacustrine zones. The result was also more or less relevant to the findings of Saha and Hossain (2002) [32]. However, the findings of present study were differed from the findings of Sayeed (2010), Biswas and Sugunan (2005), Azhar (2009), Saha and Hossain (2002), BFRI (2002) and Hossain *et al.,* (1999) [32, 33, 37, 7, 4, 32, 5, 16].

The species richness was increased in RB after establishing the sanctuary which is supported by the findings of Hasan *et al.* (2012), Rahman *et al.,* (1999), Kadir *et al.* (1999) and MACH (2001) [13, 30, 20, 24].

The fish diversity of species in a particular area depends on not only the number of species found, but also in their quantity. The 'H_0'value was increased in RB and decreased for BB which indicates that the fish diversity was increased in sanctuary (RB) site and decrease in the control site which is supported by Azher (2009) and Hossain *et al.,* (1996) [4, 13].

Rahman (2009) [31] observed that the H_0 value was varied from 0.46 to 1.03 in three *beel*s under Rangpur district which was lowed that the present study. Syeed (2010) [33] showed Shannon Index (H_0) varied between 3.13 and 3.44 which were closely related to the present study.

From the calculated value of 'E' it was observed that the overall fish more diversification in RB. It was revealed that the fish diversity was shown decreasing trends in BB. In the meantime, overall fish diversity showed increasing trends in RB. So it is concluded that diversity of RB was increased might be due to the sanctuary setup in the locality.

In the present study, the increasing trends of species evenness or relative abundance (E) and decreasing trends of 'D' value indicates the higher fish diversification for RB during the whole study period. Sayeed (2010) [33] also showed that the value of species evenness varied between 0.72 and 0.76 at different sites under his study. So the findings of the present study were supported by many other researchers.

The monthly species richness was significantly (*P*<0.001)

varied among the months. The highest fish diversity was found in the month of November in both the *beels* which might be due to high abundance of fish, suitable water level and god weather condition for fish and fishing which is supported by the results of Hallier and Kulbicki (1985) [12] who showed that the Seasonal variations in Leiognathidae are known to exist in New Caledonia and the tuna live bait fishery in the bay St Vincent has maximum catches of fish (mainly *L. bindus)* during the *dry* season between August and November. In Bangladesh, these species showed strong seasonal fluctuations with two peaks of abundance (April-May and November-December) that correspondent to the beginning and end of the dry season (Lamboeuf, 1987) [23]. The lowest fish diversity was recorded in the month of January in both *beels* and in both the years which might be due to very cold situation and normally fishers were reluctant to operate traps (especially Dhundi). Aliko *et al.* (2010) [2] also found the seasonal variation at the riverine zone, at transitional zone and lacustrine zone.

Considering all the recorded data it was found that the fish diversity was higher in RB than other site in both years. All diversity indexes (i.e. value of S, H_0, E and D) showed that fish diversity was gradually increased RB which might be due to the sanctuary establishment.

The total number of species was not increase in the *beels* because there has a barrier to connect the *beel*s with the rivers and canals. The abundance and production of fish species were tightly bound to the flooding pattern during the monsoon season (Ahmed and Singh, 1991) [1].

5. Conclusion
There are a series of small *beel* under the Chalan *beel* which is quite different from biodiversity, water depth, hydrography, physico-chemical characteristics and biological conditions. Fish species richness were higher in Ruhul *beel*. The monthly species richness was significantly varied among the months. The highest values were found in November and December for Ruhul *beel*-1 and 37 in October and November for Ruhul *beel*-2. On the other hand, the highest value were found in November and December for Bamonji *beel*-1 and same value in November for Bamonji *beel*-2. The lowest values were found 13, 15, 9 and 8 for Ruhul *beel*-1, Ruhul *beel*-2, Bamonji *beel*-1 and Bamonji *beel*-2, respectively in January.

6. Acknowledgement

7. Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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