Diversity of fishery resources and catch efficiency of fishing gears in the Feni River (Bangladesh)

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ABSTRACT. A thorough examination of fish diversity indices, gear efficiency, catch composition, and decline causes of fish diversity was carried out in the Feni River (Bangladesh). Monthly data collection took place from July to December 2023 at three stations of the river. A total of 8 fish species under 7 orders and 8 families were recorded. The order Perciformes was the most prevalent, representing 30% of the total. Approximately half of the identified species are classified as least concern, while the remaining 4 species are classified as Not Threatened (12.5%), Vulnerable (12.5%), Endangered (12.5%), and Critically Endangered (12.5%). The mean values of the Margalef's richness (d), Pielou's evenness (J), Simpson's index (1-D), Shannon-Weaver diversity (H), and 0.973 ± 0.002 were calculated as follows: 1.720 ± 0.139, 0.699 ± 0.112, and 0.248 ± 0.034, respectively. Based on the Bray-Curtis similarity matrix, two groups were observed at a similarity of 58% within six months across the three sites. The chandi net and ghera net recorded the highest CPUE (kg gear^{-1}day^{-1}) at 5.93 ± 0.966 and 0.53 ± 0.041, respectively. The highest fish catch was recorded in July (2249 ± 668.71 kg), while the lowest was in October (1564 ± 465.05 kg). There was no significant difference ($p > 0.05$) in the monthly fish catch. Fish biodiversity in the Feni River is declining day by day as a result of pollution, overfishing, the use of harmful gear, and a lack of optimal water and pollution. To improve and conserve fish species in the Feni River, it is strongly advised that appropriate fishery management techniques should be applied, that overfishing be closely monitored, and that fishermen be made more aware of their rights.

Keywords: The Feni River, abundance, fish diversity indices, CPUE, total catch

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1. Introduction

Bangladeshi people have depended on fish and fisheries for their basic requirements since the beginning of time, and it is a component of the nation's cultural heritage (DoF, 2012). The majority of Bangladesh's waterbodies are home to multiple aquatic species. The government has not yet recommended any equipment or vessels for use in inland waters. The choice and capital of the fish traders, who invest a substantial amount of money by paying the fishermen dadan, or advance credit, determined the type of nets, their length, breadth, and mesh size (Hasan et al., 2016). The possibility of catching a specific fish in a particular area that one specific type of fishing gear affect in a single operation is known as gear efficiency. The number, which represents the actual population size of the entire fish stock, is known as the catchability coefficient, or simply catchability (q). The distribution of the total fish stock by time, area, and depth influences fish availability for a fishing operation. Catchability is a function of both stock availability and gear efficiency (Q) (Zhou et al., 2019). Moreover, a variety of elements, such as fish behavior, angler skill, gear selectivity, and surrounding conditions, might impact the efficiency of fishing gear (Arreguín-Sánchez, 1996). Catch per unit effort (CPUE) is a measure of a fishing operation's efficiency as well as a measure of stock density and financial and physical production (Ghosh and Biswas, 2017). The diversity index is a useful tool that provides information not only the species number but also on the scarcity and frequency of species of a community in a given body of waterbody (Sultana et al., 2018).

With a catchment area of 3800 km^2, the Feni River is a transboundary river that rises in India and empties into the Sandwip Channel. The river is steep

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in its upper and middle sections, but it is flat and tidal in its lower reaches (Mondal et al., 2021). To evaluate the recorded species' status for both national and international conservation, the IUCN (2015) Red List was assessed. 36 of the 54 fish species found in the Feni River were classified as Least Concern, 9 species rated as Near Threatened, 6 species rated as Vulnerable, 1 as Endangered, 1 rated as Critically Endanger and 1 as Data Difficient. According to Yeasmin et al. (2017), there is a larger degree of species variety in the mouth of the Feni River Estuary than in the upper stream direction. The fish species of the Feni River struggle to maintain their biodiversity, just like the fish species in Bangladesh's other rivers. Threats to fish species' ability to maintain their biodiversity in terms of vulnerability, endangered status, and critical endangered status exist. As a result, present research on biodiversity and gear efficiency has been conducted. The purpose of this study is to determine the number of fish species and the factors contributing to the decline in fish variety, additionally to ascertain the primary gear types utilized by the fisherman when operating in the Feni River, Bangladesh.

2. Materials and Methods

2.1. Study area and study period

The present study was conducted in the Feni River (Bangladesh). Three sampling stations named Station 1- Musapur Closure (22˚46′N to 91˚21′E), Station 2- Char Khondokar (22˚49′N to 91˚24′E) and Station 3- Charkrisnaganj (22˚52′N to 91˚28′E) were selected for the study (Fig. 1). The investigation was conducted for a time of 6 months from July 2023-December 2023.

2.2. Sampling procedure

A simple random sampling method was employed for the data gathering (Siddiq et al., 2013). The selection of this sampling technique was based on the equal chances or probability that each fisherman would be chosen for an interview.

2.3. Questionnaire design and collection of data

A structured questionnaire was prepared prior to data collection (Raushon et al., 2017). A draft questionnaire must be manifested and pretested in the study area in order to meet the study's necessary objectives. The target was paid to prepare any fresh information for the pre-examination and fill up the draft interview cadaster with material that wasn't intended to be questioned. After that, the pretest results were used to adjust, modify, and rearrange the questionnaire. The last survey was then distributed in a manageable order so that the fishermen could complete it gradually. The questionnaire included questions about the current state of fish biodiversity in comparison to past data, the majority of fish species and fishing gear available in the study area (Aktar et al., 2020). Primary data were gathered from the full-time fishermen via questionnaires from each of the three stations. From each station, 8-10 fishermen were interviewed. Journal articles, books, newspapers, and the internet were the sources of the secondary data. Based on their external appearance, the samples were identified up to the species level (Rahman, 2005; IUCN Bangladesh, 2015). Weight of catch, duration of fishing, number of haul, individuals connected with each gear, number of species caught, number of individuals of each species per unit weight, number of fishing efforts of each gear were recorded.

2.4. Fishing Gear Survey

A variety of fishing gears are employed in the Feni River, with five particular types being the most prevalent among fishermen. These are the gill net, the seine net, the barrier net, the set bag net and the cast net. Some fry and fingerlings were collecting by nets (Mosari net, Moia net) were also found there.

2.5. Data Processing

2.5.1 Shannon-Weaver diversity index, $H = -\Sigma Pi \ln Pi$ (Shannon and Weaver, 1949)
where, H – diversity index, Pi is the relative abundance (s/N), s is the number of individuals of one species, N is the total number of individuals in the sample.

2.5.2 Simpson's index, $1\text{-}D = 1-(\Sigma n(n-1)/N(N-1))$ (Simpson, 1949)
where, n is the total number of organisms of a particular species, N the total number of organisms of all species.

2.5.3 Margalef's richness index, $d = S\text{-}1/\ln N$ (Margalef, 1958)
here, d is the richness index, S is the total number of species and N is the total number of individuals in the sample.

Fig.1. Map of the Feni River indicating three stations (google map)

2.5.4 Pielou's evenness index, J = H/lnS (Pielou, 1966)

here, J is the similarity or evenness index, S is the total number of species, ln is the natural logarithm and H is the Shannon-Weaver index.

2.5.5 Catch per unit effort (CPUE) and gear efficiency

Catch per unit of effort: Catch per unit of effort is the average catch rate estimated using the following formula: CPUE g $= \frac{w}{n}$;

where, CPUE g – daily mean catch per unit of effort, w – total weight of fish recorded from the gear sampled and n – number of gears sampled (Harikrishnan and Kurup, 2001).

2.6. Statistical Analysis

Tabular technique was applied for processing the data by using simple statistical tools like averages and percentages. The community succession at three stations during 6 months was summarized using the sub module of cluster of Bray-Curtis similarities from species abundance using the software PAST 4.03. The differences in CPUE, species composition and gear efficiency of the catch between months and fishing sites were analyzed, employing analysis of variance (ANOVA) techniques with significant differences ($p > 0.05$). The processed data were analyzed by Microsoft Excel and relevant tables and graphs were also prepared according to the objective of the study for clear understanding.

3. Results

3.1. Monthly abundance and biodiversity status of fish species

A total of 7 fish and 1 prawn species under 7 orders and 8 families were recorded from the study area over the course of a six-month study period (July 2023 to December 2023). Chaiya (Gobius schlosseri) ranked as the highest with the number of 57050 ± 844 and followed by Macrobrachium malcolmsonii (46550 ± 225), Mystus bleekeri (35800 ± 512), Otolithoides pama (17150 ± 299), Tenualosa ilisha (11300 ± 546), Ompok pabda (11100 ± 198), Labeo bata (8450 ± 501), Mastacembelus armatus (4400 ± 447) (Fig. 2). Though all recorded species were found available in every month of the study period but the intensity of abundance varied with the different months and different sampling sites (Table 1). Based on conservation status IUCN 2015; about 4 species Least Concern (LC; 50%) and other 4 species each Critically Endangered (CR; 12.5%), Vulnerable (VU, 12.5%) and Endangered (EN, 12.5%) and Not Threatened (NT; 12.5%) were recorded. Pabda (Ompok pabda), baim (Mastacembelus armatus) and chaiya (Gobius schlosseri) are mostly threatened species in the study area due to habitat loss, overexploitation, use of illegal nets etc. (Table 1).

In the present investigation, the dominant order was Perciformes comprising 30% of the total of fish species recorded. When other dominant orders were recorded Siluriformes (25%), Decapoda (24%), Tetraodontiformes (9%), Clupeiformes (6%), Cypriniformes (4%) and Synbranchiformes (2%) from the study area (Fig. 3).

3.2. Diversity indices

The values of Shannon-Weaver diversity, Simpson's index, Margalef's richness and Pielou's evenness indices in each sampling month were recorded in the present investigation. Diversity was recorded highest (H = 1.867, 1-D = 0.977) in July and lowest in October (H = 1.520, 1-D = 0.969); richness was highest (d = 0.829) in December and lowest in

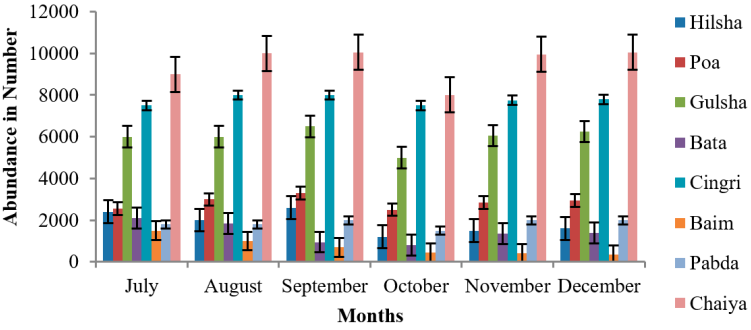

Fig.2. Abundance (number) of fish species in the Feni River

Table 1. Present status of fish diversity in the Feni River

Order	Family	Local Name	English Name	Scientific name	IUCN status (BD)
Clupeiformes	Clupeidae	Hilsha	Hilsa shad	*Tenualosa ilisha*	LC
Cypriniformes	Cyprinidae	Bata	Bata	*Labeo bata*	LC
Tetraodontiformes	Tetraodontidae	Poa	Red Jaw Fish	*Otolithoides pama*	NT
Siluriformes	Siluridae	Gulsha	Bleeker's Mystus	*Mystus bleekeri*	LC
	Siluridae	Pabda	Pabdah catfish	*Ompok pabda*	CR
Decapoda	Palaemonidae	Cingri	Monsoon river prawn	*Macrobrachium malcolmsonii*	LC
Synbranchiformes	Mastacembelidae	Baim	Tire-track Spinyeel	*Mastacembelus armatus*	EN
Perciformes	Gobiidae	Chaiya	Mud-skipper	*Gobius schlosseri*	VU

Note: * EN: Endangered, *CR: Critically Endangered, *VU: Vulnerable, *NT: Near Threatened, *LC: Least Concern, *Jul: July, *Aug: August, *Sep: September, *Oct: October, *Nov: November, *Dec: December.

August (d = 0.567) and the values of evenness index (J) was recorded highest (J = 0.302) in August and lowest in December (J = 0.199). The mean value of Shannon-Weaver diversity (H), Simpson's index (1-D), Margalef's richness (d) and Pielou's evenness (J) indices were recorded as, 1.720 ± 0.139, 0.973 ± 0.002, 0.699 ± 0.112 and 0.248 ± 0.034 respectively (Table 2).

3.3. Cluster Analysis

Cluster analysis indicates a clear structural variation in fish communities among the three stations in six months of the study area. Three stations of July, August, September November and December are closely related to one another and form a cluster then this cluster was found related to another cluster in which 3 stations of October were connected. At the similarity level of 58% separation, two major clusters were observed. The first cluster consists of July, August, September, November and December and second cluster contains only October for station 1, station 2, and station 3 (Fig. 4).

3.4. Fishing gears and catch composition of different fishing gears

About 5 types of fishing gears including gill net or chandi net, seine net, barrier net or ghera net, cast net and set bag net were found in the study area. Nets were nylon made, operated from chandi boat, dingi boat etc. Mesh size of gill net, seine net, barrier net, cast net and set bag net were recorded 1 to 1.5 cm, 0.2 to 0.8 cm, 0.3 to 5.1 cm, 0.5 to 1.5 cm and 1 to 10 cm respectively and all the identified fishing gears were operated by 1 to 8 persons. Chandi and seine net can capture almost all types of fish but barrier net is used to capture small species like cingri (*Macrobrachium malcolmsonii)* and gulsha (*Mystus bleekeri)* (Table 3).

3.5. Fishing Gear Efficiency

In the present study, fishing gear efficiency was calculated based on kg gear^{-1}day^{-1}, kg gear^{-1}person^{-1}, kg gear^{-1} haul^{-1} of different months were shown as graphical representation. Gill net showed higher CPUE (kg gear^{-1}day^{-1}) in July about 5.1 ± 0.674; seine and barrier net in August about 2.53 ± 0.278 and 0.74 ± 0.062; cast and set bag net in September about 1.05 ± 0.135 and 1.04 ± 0.128 respectively (Fig. 5).

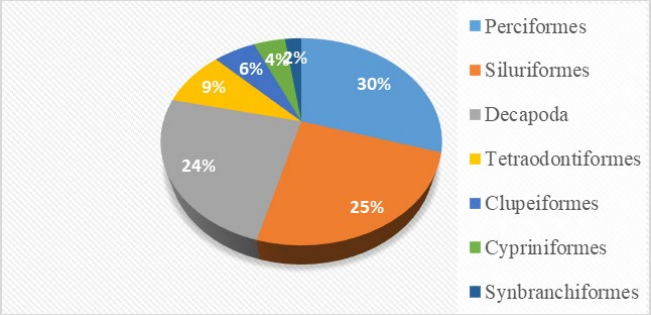

Fig.3. Diagrammatic representation of percent contribution in each order of the study area

The highest CPUE (kg gear^{-1}person^{-1}) was found 0.84 ± 0.026, 0.85 ± 0.05, 0.69 ± 0.01, 1.05 ± 0.007 and 0.52 ± 0.061 respectively in the months of July (gill net) and September (seine, barrier, cast and set bag net) (Fig. 6). CPUE (kg gear^{-1}haul^{-1}) for all identified fishing nets was found maximum in different months of the study period (Fig. 7). There was no significant difference ($p > 0.05$) was observed on monthly based CPUE of fishing gears in the study area.

3.6. Station based CPUE of fishing gears

For gill net, the maximum CPUE´s was found from station 1(5.14 ± 0.638 kg gear^{-1}day^{-1}), (0.9 ± 0.026 kg gear^{-1}person^{-1}) and (2.74 ± 0.071 kg gear^{-1}haul^{-1}) in the months of July, July and October respectively. On the other hand, the minimum CPUE´s were found respectively from station 2(3.30 ± 0.095 kg gear^{-1}day^{-1}), station 3(0.53 ± 0.073 kg gear^{-1}person^{-1}) and again station 2(1.64 ± 0.083 kg gear^{-1}haul^{-1}) in the month of December (Table 4). The highest and lowest CPUE (kg gear^{-1}day^{-1}) in the study area were recorded in station 1 and station 2 respectively for all types of identified gears. CPUE (kg gear^{-1}person^{-1}) was measured highest at station 1 in the study area but the lowest value was found at station 3 for all gears except cast net (station 2). Again, the highest CPUE (kg gear^{-1}haul^{-1}) was recorded at station 1 for all types of nets but the lowest values were observed at station 2 (gill net, barrier net and cast net) and station 3 (seine net and set bag net). However, there was no significant difference was observed ($p > 0.05$) in the station based CPUE.

The highest CPUE was observed in the months of July, August, September and October for station 1. But the lowest CPUE mostly was recorded for station 2 and

Table 2. Number of calculated species, individuals, and values of Shannon-Weaver diversity, Simpson's index, Margalef's richness and Pielou's evenness indices in each sampling month

Months	Species, S	Diversity, H	Simpsons, 1-D	Richness, d	Evenness, J
July	7	1.867	0.977	0.697	0.266
August	6	1.813	0.975	0.567	0.302
September	8	1.825	0.975	0.824	0.228
October	6	1.520	0.969	0.581	0.253
November	7	1.699	0.973	0.699	0.242
December	8	1.595	0.971	0.829	0.199
Mean ± SD	**7**	**1.720 ± 0.139**	**0.973 ± 0.002**	**0.699 ± 0.112**	**0.248 ± 0.034**

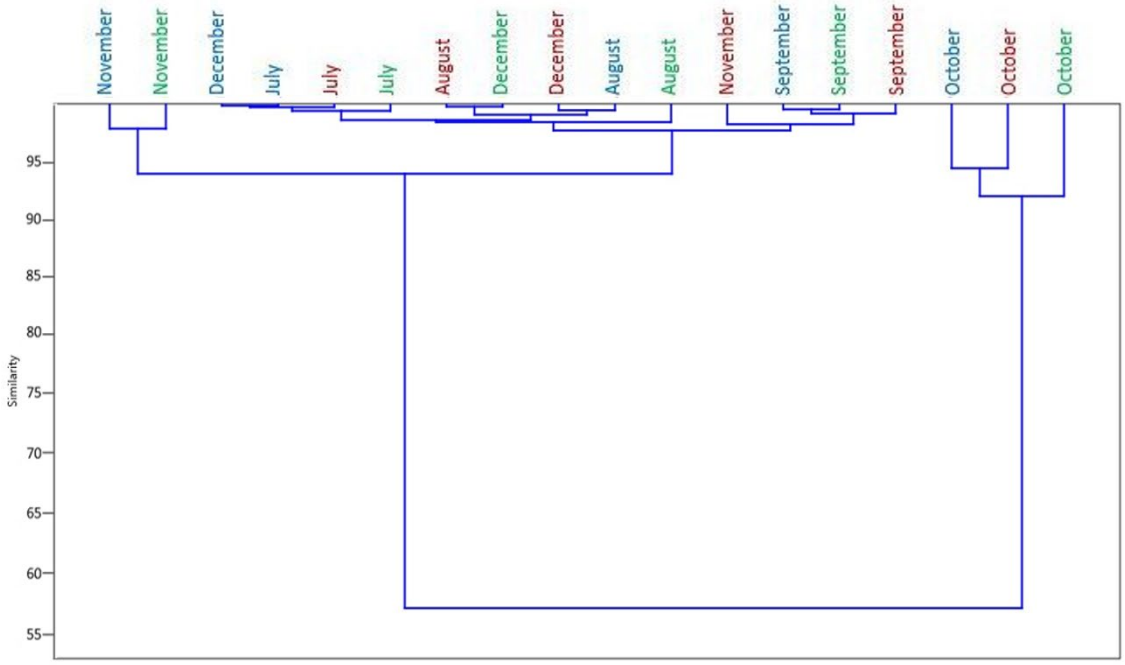

Fig.4. Dendrogram of clusters based on Bray-Curtis similarity matrix of different months and stations showing structural variability of the fish communities (Station 1, station 2, station 3).

station 3 in December (Table 4). No significant difference was observed among the stations for different fishing gears ($p > 0.05$) in the study area.

3.7. Total catch of Fish

The total fish catch was recorded 12008 ± 727.08 kg in the study area. Most of the fishes were caught in July (2249 ± 668.71) kg and least in October (1564 ± 465.05) kg. During October, reduced number of fishing efforts were seen due to banning period. *Tenualosa ilisha* had the highest catch (2825 ± 136.39) kg and followed by *Otolithoides pama* (2144 ± 37.38) kg, *Macrobrachium malcolmsonii* (1862 ± 8.98) kg, *Gobius schlosseri* (1268 ± 18.74) kg, *Mystus bleekeri* (1194 ± 17.05) kg, *Ompok pabda* (1110 ± 19.74) kg, *Labeo bata* (1056 ± 62.68) kg and *Mastacembelus armatus* (550 ± 55.85) kg in the study period (Fig. 8). However, no significance difference ($p > 0.05$) in monthly variation of fish catch was observed in the study area.

3.8. Decline Causes of Fish Diversity in the Feni River

Over-exploitation and indiscriminate fishing due to lack of knowledge, use of illegal fishing gear, catching of brood fish, fry, fingerlings and juvenile, low water depth, improper implementation of fishing rules and regulations are the reasons behind loss of fish diversity in the river.

4. Discussion

4.1. Fish Species Abundance

During the study period, 7 species of fishes and 1prawn species were found in the Feni River

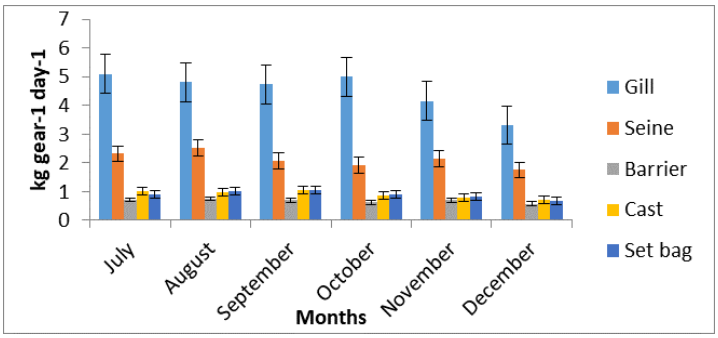

Fig.5. Monthly variation of fishing nets based on CPUE (kg gear^{-1}day^{-1})

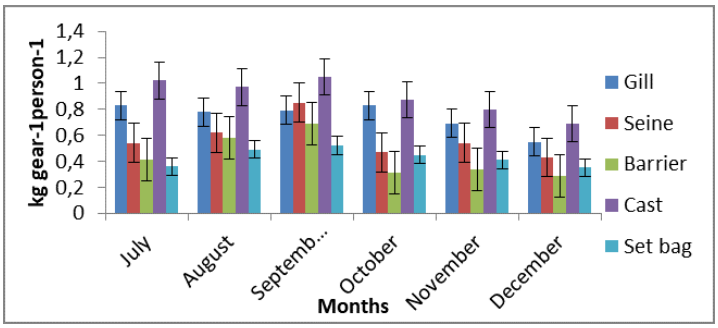

Fig.6. Monthly variation of fishing nets based on CPUE (kg gear^{-1}person^{-1})

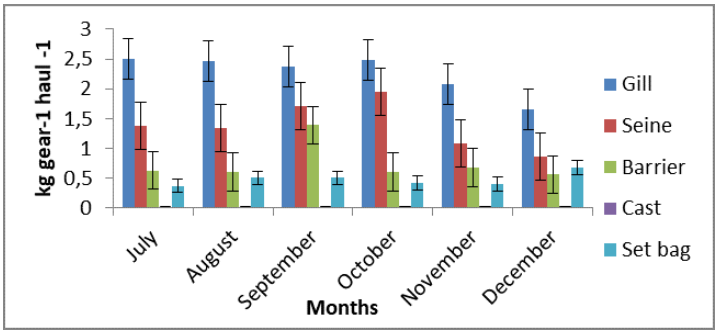

Fig.7. Monthly variation of fishing nets based on CPUE (kg gear^{-1}haul^{-1})

Table 3. Various fishing gears with species composition and gear efficiency

Net Type	Local Name	Mesh (cm)	People	Species	Period of operation (months)
Gill Net	Chandi Jal	1-1.5	6-8	Hilsha (*Tenualosa ilisha)*, Punti (*Puntius sophore*), Baim (*Mastacembelus armatus*), Koi (*Anabas testudineus*)	All months except Oct
Seine Net	Ber Jal	0.2-0.8	4-5	Gulsha (*Mystus bleekeri)*, Cingri (*Macrobrachium malcolmsonii)*, Poa (*Otolithoides pama)*	All
Barrier Net	Char ghera Jal	0.3-5.1	2-3	Cingri, Gulsha	Sep, Oct, Nov and Dec
Cast Net	Jhaki Jal	0.5-1.5	1	Bata (*Labeo bata)*, Dhela (*Osteobrama cotio*), Koi, Poa, Boal (*Wallago attu*), Baila (*Glossogobius giuris*), Baim	All
Set bag Net	Behundi Jal	1-10	2	Pabda (*Ompok pabda)*, Koi, Pangus (*Pangasius pangasius*)	All

Note: *Sep: September, *Oct: October, *Nov: November, *Dec: December.

(Bangladesh). Among them, highest species belonged to the order Perciformes (30%) followed by Siluiriformes (25%), Decapoda (24%), Tetraodontiformes (9%), Clupeiformes (6%), Cypriniformes (4%) and Synbranchiformes (2%) (Fig. 3). The present study was similar to Rubel et al. (2016) in case of order dominance where highest species belonged to the order Perciformes (40%) in the Lohalia River. As dominant order Cypriniformes was identified by Galib et al. (2013) and Islam et al. (2018) in the Choto Jamuna River and the Ghaghat River, respectively. Gobius schlosseri, Macrobrachium malcolmsonii, Mystus bleekeri were the dominant species in the study area (Table 1). The most common fish species found in Bangladesh's the Bangshi River are jat punti (Puntius sophore) and kalo bujuri (Mystus tengara), as reported by Kamrujjaman and Nabi (2015). According to Galib et al. (2013), the most prevalent species in Bangladesh's Halti beel is jat punti (Puntius sophore). These results are different from the present study due to the difference in geographical location of these water bodies, survey periods, choice of fishing gear, etc.

4.2. Present Status of Fish Biodiversity

In the study area from 8 species 50% are under least concern (LC) and 12.5% each under critically endangered (CR), vulnerable (VU) and endangered (EN) in Bangladesh were recorded (Table 1). Rubel et al. (2016) found 40% species NT, 37% of species as VU, 17% species EN and 6% species CR in Lohalia River. Chaki et al. (2014) identified and recorded thirty (30) locally threatened species, among them, 13.51%,18.92% and 8.11% were vulnerable, endangered and critically endangered at the Atrai River (Bangladesh). These findings are different from the present study due to differences in sample size, survey duration, geographical location and variation in fishing techniques.

4.3. Diversity Indices

The **Shannon-Weaver variety (H)** index takes into account both the total number of species and the population distribution within the Feni River's species. From the study area we see that diversity of fishes was high in July and low in October for both diversity and Simpson's index. Highest value of H was 1.867 and lowest was 1.520 with an average of 1.720 ± 0.13 (Table 2). It is close to the findings of Iqbal et al. (2015) between 1.8 to 3.40 in the Hakaluki River. Rahman et al. (2015) carried out a study on the Talma River found slightly lower and Jewel et al. (2018) recorded higher value of the diversity index (H) in the Atrai River of Bangladesh. So, these findings which are slightly different from the present findings because of different geographical locations, survey periods, different fishing methods and choice of fishing gear in the Feni River.

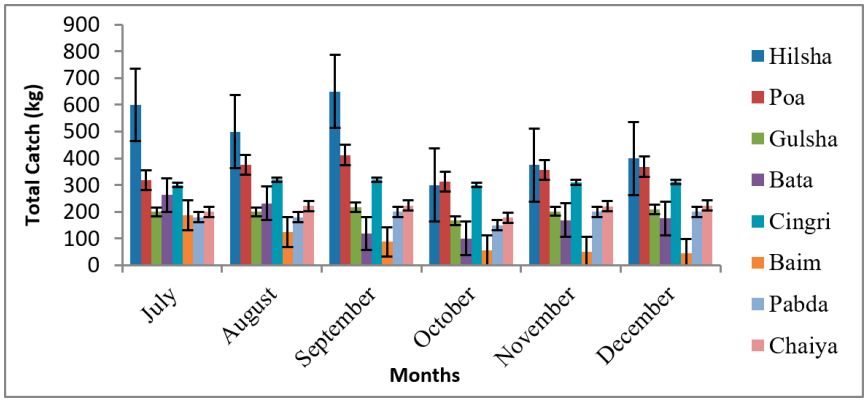

Fig.8. Total catch of fish species

Table 4. Station based CPUE for every net during the study period (July – December)

Net	CPUE	July			August			September			October			November			December		
		St. 1	St. 2	St. 3	St. 1	St. 2	St. 3	St. 1	St. 2	St. 3	St. 1	St. 2	St. 3	St. 1	St. 2	St. 3	St. 1	St. 2	St. 3
Gill	kg gear^{-1}day^{-1}	5.14	5.10	5.08	4.89	4.74	4.81	4.79	4.73	4.69	5.03	4.00	5.06	4.19	4.15	4.14	3.33	3.30	3.31
	kg gear^{-1}person^{-1}	0.90	0.78	0.8	0.85	0.81	0.69	0.80	0.80	0.78	0.84	0.86	0.81	0.72	0.69	0.68	0.57	0.56	0.53
	kg gear^{-1}haul^{-1}	2.60	2.46	2.42	2.55	2.44	2.43	2.31	2.41	2.38	2.74	2.29	2.43	2.11	2.08	2.06	1.66	1.64	1.65
Seine	kg gear^{-1}day^{-1}	2.45	2.25	2.26	2.61	2.46	2.52	2.11	2.06	2.08	1.93	1.92	1.91	2.17	2.14	2.19	1.76	1.74	1.75
	kg gear^{-1}person^{-1}	0.57	0.53	0.54	0.63	0.62	0.60	0.90	0.80	0.86	0.45	0.43	0.53	0.56	0.56	0.52	0.44	0.43	0.42
	kg gear^{-1}haul^{-1}	1.48	1.25	1.42	1.37	1.25	1.41	1.75	1.72	1.68	0.98	0.93	0.94	1.096	1.093	1.07	0.87	0.88	0.86
Barrier	kg gear^{-1}day^{-1}	0.74	0.72	0.7	0.82	0.64	0.77	0.77	0.70	0.63	0.64	0.58	0.63	0.71	0.68	0.70	0.61	0.53	0.59
	kg gear^{-1}person^{-1}	0.45	0.40	0.40	0.44	0.29	0.41	0.71	0.69	0.69	0.32	0.33	0.27	0.29	0.35	0.34	0.29	0.28	0.30
	kg gear^{-1}haul^{-1}	0.71	0.58	0.61	0.7	0.65	0.66	1.43	1.35	1.39	0.60	0.58	0.64	0.70	0.66	0.68	0.6	0.54	0.55
Set bag	kg gear^{-1}day^{-1}	0.90	0.75	0.76	1.11	1.03	0.93	1.04	1.05	1.01	0.94	0.85	0.93	0.92	0.84	0.72	0.74	0.68	0.70
	kg gear^{-1}person^{-1}	0.46	0.34	0.31	0.53	0.43	0.5	0.59	0.52	0.47	0.47	0.43	0.45	0.46	0.42	0.36	0.40	0.35	0.30
	kg gear^{-1}haul^{-1}	0.45	0.37	0.30	0.60	0.49	0.44	0.57	0.50	0.52	0.43	0.41	0.40	0.45	0.40	0.34	0.70	0.66	0.68
Cast	kg gear^{-1}day^{-1}	1.06	1.01	1.00	1.00	0.97	0.94	1.07	1.05	1.05	0.89	0.83	0.88	0.83	0.78	0.79	0.75	0.65	0.68
	kg gear^{-1}person^{-1}	1.07	1.01	1.00	1.00	0.97	0.94	1.06	1.05	1.05	0.89	0.83	0.88	0.83	0.78	0.79	0.75	0.65	0.68
	kg gear^{-1}haul^{-1}	0.035	0.01	0.02	0.012	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.025	0.03	0.02	0.01	0.011	0.009	0.014

But Biligrami (1988) recommended improve water body conditions for fish variety when the H^0 index was between 3.0 and 4.5. According to this recommendation, the Feni River is strongly degraded which led to decline the fish diversity.

Simpson's dominance index gave the possibility that any two individuals chosen at random from an indefinitely huge community would be of different species. The present research observed highest Simpson's dominance index (1-D) value as 0.97 in July and lowest in October 0.96 with an average of 0.97 ± 0.002 (Table 2). Tikadar et al. (2021) found the highest Simpson Dominance index value 0.84 was observed in June and the lowest 0.21 in September with a mean value of 0.57 ± 0.197 in the Gorai River. Dominance index 0.325 to 0.893 was recorded in the Dhaleshwari River, Bangladesh, by Islam and Yasmin (2018). According to Hossain et al. (2012), the monthly dominance diversity index value in March had the maximum value of 0.102, while the lowest value was 0.062 in December. The finding of this study was slightly higher might be due to different geographical location, duration of survey and sample size.

Margalef's richness, which is only a count of the various species present in a specific area, is the most basic indicator of biodiversity. The present study result in observation of maximum Margalef's richness index was recorded in December as 0.829 while minimum in August 0.567 with an average of 0.699 ± 0.112 (Table 2). Most fish species started breeding from June when the monsoon start in Bangladesh which might be the purpose in the back of the lowest and very best richness value during August and December. Galib et al. (2013) have calculated fish species richness value in the Choto Jamuna River and found values varied from 6.973 in June to 8.932 in November. The species richness in winter grew as more participants joined the fish shares (Siddique et al., 2016). Because of the lower water depth brought on by the lack of rainfall, which caused fishermen to adjust their fishing gear more effectively, the Margalef's index may slightly differ from the actual diversity value (Iqbal et al., 2015). Furthermore, the distribution of the fish species was influenced by ecological factors as well (Siddique et al., 2021).

Pielou's evenness index measures the stability of an ecosystem. A low level of evenness suggests that a small number of species dominate an ecosystem. During the study period, the recorded highest evenness (J^o) value was found as 0.302 (August) and the lowest as 0.199 (December) whereas the mean value was recorded as 0.248 ± 0.03 in the sampling area of the Feni River (Table 2). Therefore, the species equitability index among the sampling area in the different months reveals that the distribution of fish population of the Feni River is more or less equally distributed. This was close to the finding of Islam and Yasmin (2018); they recorded evenness index (J) 0.117 to 0.588 in the Dhaleshwari River. Tikadar et al. (2021) recorded highest evenness (J) as 0.763 (August) and the lowest as 0.235(September) whereas the average value was recorded as 0.481 in the sampling area of the Gorai River.

4.4. Cluster Analysis

Two groups reached in a similarity level of 58% separation in the study area (Fig. 4). All the other months (July to December) of the study period stand in the same cluster but October was found in different cluster. Month October was the banning period for capturing fish declared by government which might be the reason behind this difference. Shamsuzzaman et al. (2016) and Hossain et al. (2012) found lower similarity percentages in the Karnafully and Meghna Rivers (Bangladesh) respectively. On the other hand, Rashed-Un-Nabi et al. (2011) discovered that the finfish and shellfish in estuary of the Bakkhali River were 65% similar throughout the year which was higher from present findings. Their findings are dissimilar from the present result because of the different geographical locations, different survey periods and sample size. Almost same types and number of species were recorded in all months of the present study period with small differences so the least percentages of separation in clusters was observed.

4.5. Fishing Gears, Gear Efficiency and Total Fish Catch

In the present study, 5 types of fishing nets were found in the Feni River (Table 3) which is much more similar to the findings of Mondal et al. (2013). Sultana et al. (2018) and Sayeed et al. (2014) recorded higher amount of fishing gears used respectively in the Payra River and the Chalan Beel than the present study findings. Because the choice of fishing gears by the fishermen depends on many factors like types of fish species available in the river, the physical condition of the river such as the presence of currents, bottom conditions, and types of aquatic vegetation present in the river. In the Old Brahmaputra River, Saberin et al. (2018) have documented 19 different kinds of fishing gear between April 2011 and March 2012. Seine nets, with fishing effort of 0.0224 $gear^{-1}haul^{-1}day^{-1}$ and a CPUE of 5.56 56 kg $gear^{-1}$ day^{-1}, demonstrated the greatest CPUE among them, followed by push and lift nets. According to Ahmed and Hambery's (2005), the CPUE varied from 2.91 to 30.86 kg $gear^{-1}day^{-1}$. According to Sayeed et al. (2014), there were 34 distinct kinds of fishing gear used in the Chalan Beel, with seine nets being the most common type, followed by gill nets and set bag nets. These previously documented study on CPUE is different from the present study due to dependence on same old gears, types of fish species available in the river, the physical condition of the river such as the presence of currents, low availability of other gears etc.

4.6. Total catch of fish

In this study the highest and lowest fish catch was in July (2249 ± 668.71) kg and in October (1564 ± 465.05) kg respectively (Fig. 8). Tikadar et al. (2021) have recorded higher fish catch from the present study in the Gorai River. The current study was deviated from reference value due to little survey period, sample

size, efficiency of fishing gears, different geographical pattern.

5. Conclusion and Recommendations

The Feni River is a moderate productive waterbody with a reasonable range of declining fish species. The species selectivity associated with various types of fishing gear differed greatly. It was shown that fine-meshed seine nets and gill nets were more damaging than those with varied gears. These illegal fishing practices were widespread, and poor fishermen continued to practice them for their staff members since they were unable to find alternative leisure activities during the periods. This study is an initial attempt to consider factors such as the fish variety index, CPUE, gear efficiency, and catch composition of different fishing gears, as well as the causes of the declining fish population in the Feni River. Therefore, while fisheries investigate foundation, NGOs and the government should forbid fishing during breeding seasons. Fishing gear should be designed with the intended species of fish in mind. Large mesh fishing nets, such as seine and gill nets, could be an effective tool for fish species conservation. While the introduction of new fishing methods always requires effective management and control, their adaption may assist small-scale fisheries increase their catch. Since it is not possible to immediately outlaw every kind of gear, it is crucial to determine which gear poses a risk to the public and ought to be prohibited. Simultaneously, a government-supervised and non-governmental organization-led awareness or training program should be held for fishermen to teach knowledge of fishing rules and to raise awareness of the long-term impacts of various fishing equipment.

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Conflict of interests

The authors declare no conflicts of interest.

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