Journal of
Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Journal of Fisheries and Aquatic Science

ISSN 1816-4927
DOI: 10.3923/jfas.2016.361.369

Research Article

Assessment of Species Specificity of Fishing Gears and Fish Diversity Status in the Andharmanik River of Coastal Bangladesh

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Abstract

Background and Objective: In Southern Bangladesh, the Andharmanik river is an ichthyofaunal resourceful coastal water body due to adjacent to the Bay of Bengal. An investigation has been undertaken to identify available fishing gears and their specificity on the fishes as well as the fish diversity status of the river for a period of one year from November, 2014 to October, 2015. **Methodology:** The PRA tools were employed for data collection. **Results:** The survey revealed total 17 different types of fishing gears under 8 major groups of net. A total of 48 fish species under 10 orders and 26 families were identified by using these gears. Mesh size of the gears were varied from 0.508-15.24 cm depending on targeted fish species and some of them were very selective to specific species. Fish diversity was assessed by using Shannon-Weiner index (H), evenness (E), Simpson's dominance index (D), Simpson's index of diversity (1-D) and Margalef's index (d) ranges between 3.33-3.42, 0.67-0.73, 0.042-0.048, 0.952-0.958 and 4.72-5.24, respectively for three stations of the river. The highest fish occurrence belongs to the Perciformes order (33.33%) and lowest five orders viz., Aulopiformes, Beloniformes, Osteoglossiformes, Pleuronectiformes and Tetraodontiformes were found as same (2.08%) among the total fish population. Conservation status disclosed that out of 48 species 3, 3 and 8 species belonged to endangered, critically endangered and vulnerable, respectively. **Conclusion:** The fishes of the river were under pressure by different non-selective, illegal and restricted fishing gears. So, scientific based management is prerequisite to guide the fish fauna from near extinction.

Key words: Andharmanik river, fishing gears, mesh size, conservation status, diversity indexes

Received: March 25, 2016 Accepted: June 15, 2016 Published: August 15, 2016

Citation: Md. Mizanur Rahman, Md. Bokthier Rahman, Emiko Okazaki and Mst. Nazira Akhter Rithu, 2016. Assessment of species specificity of fishing gears and fish diversity status in the Andharmanik river of coastal Bangladesh. J. Fish. Aquat. Sci., 11: 361-369.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Bangladesh is blessed with an abundance of fresh and marine water resources. Along with potential water resources, Bangladesh is also rich in the diversity of fish fauna, with approximately 800 species of fresh, brackish and marine water[1]. The fisheries sectors of Bangladesh have a notable function mentioned as poverty alleviation, food security, nutrition supply, sources of income, employment opportunities, foreign exchange earnings and overall on the socio-economic development of Bangladesh. This sector contributes 3.69% in Gross Domestic Product (GDP) and offers 60% of the national animal protein intake to meet the country's health demand[2].

The coastal rivers of Bangladesh supports a valuable natural ecosystem of which Andharmanik river is very especial one, located at Kalapara upazila under Patuakhali district of Bangladesh. The river is the breeding ground of national fish of Bangladesh and also contains plentiful aquatic resources. This helps the river to make an important contribution to the lifeline of countless fishers mostly for fishing activities. For this reason, some researches already concerned about the diversity of fish fauna of the river. Mohsin *et al.*[3] studied on the fish fauna of the Andharmanik river for a period of one year from March, 2011 to February, 2012. Further no attempt has been initiated so far to study fishing gears specificity to species and fisheries diversity of Andharmanik river due to its geographical remoteness and distance from fisheries research centers of the country. However, the aquatic resources especially fish in water bodies of Bangladesh are under excess fishing pressure, Andharmanik river is not beyond them.

Recently the demand for fish have increased in line with population growth resides along the coast of the river and nearby village. As a result, the number of fishermen fishing both for subsistence and for employment has increased in figures. This together with the introduction of more efficient fishing gears, caused the size of the catch to dwindle as wild fish stocks of the river became threatened by over-fishing. Besides, water pollution from point and nonpoint sources, construction of dams by local government, siltation, river erosion, agricultural runoff, industrialization, oil discharged from launch, streamer and mechanical fishing vessels, human encroachment, recreational activities and finally indiscriminating catching of fish fry and juvenile through small mesh sized gears are also the added up factors probably responsible for declining of fish fauna from the river. So scientific management based studies on fishing gears and fish fauna and avoidance of various restricted fishing gears are the most important conservation and sustainable fisheries resource management issues of the Andharmanik river. However, there is not satisfactory information found in the literature regarding the recent fish fauna and fishing gears used to capture fish of the river. Therefore, it is central aspect to conduct scientific investigation on available fishing gears including their mesh size and catch composition of respective gears, fishing crafts and diversity of fish fauna to understand the ecosystem of Andharmanik river. Rahman *et al.*[4] studied on the selectivity of fishing gears and their effects on fisheries diversity of Rabnabad channel of Patuakhali district in Bangladesh for a period of 8 months, which supports the present study. Again, the present study was supported by the study of fishing gear selectivity and ichthyofaunal diversity of Paira river in Southern Bangladesh for a period of 7 months[5]. Moreover, Ullah *et al.*[6] studied on the fish diversity status of mid-coastal region of Bangladesh. Considering all the current issues, the objectives of the study designed as to identify fishing gears, their mesh size and catch composition of different gears, selectivity of fishing gears, fish diversity and their conservation status in the country along with the globe in the Andharmanik river of coastal area of Bangladesh. Efficiency of different fishing gears and fish diversity status of Chalan beel in Bangladesh was observed by Sayeed *et al.*[7] which partially supports the present study. Finally this study investigates the fish fauna of the river to present much needed baseline data for improved and sustainable exploitation and management of the fisheries resources.

MATERIALS AND METHODS

Location of study area and duration: The present investigation was carried out on three different sampling stations (S_1, S_2 and S_3) of Andharmanik river, situated at Kalapara upazila under Patuakhali district of Bangladesh and falls approximately between 21°50′-22°00′ N latitude and 90°05′-90°15′ E longitude[3] (Fig. 1). The river originates from Tiakhali river of Barguna district and finally falls into the Bay of Bengal with total length about 40 km. To execute the objectives of existing study relevant data were collected fortnightly basis, i.e., twice a month for a period of one year from November, 2014 to October, 2015.

Gears surveyed: The fishing gears including their mesh size, major species caught and catch composition of respective fishing gears were surveyed based on Participatory Rural Appraisal (PRA) such as Focus Groups Discussion (FGD), social mapping and cross checking Key Informant Interviews (KIA)

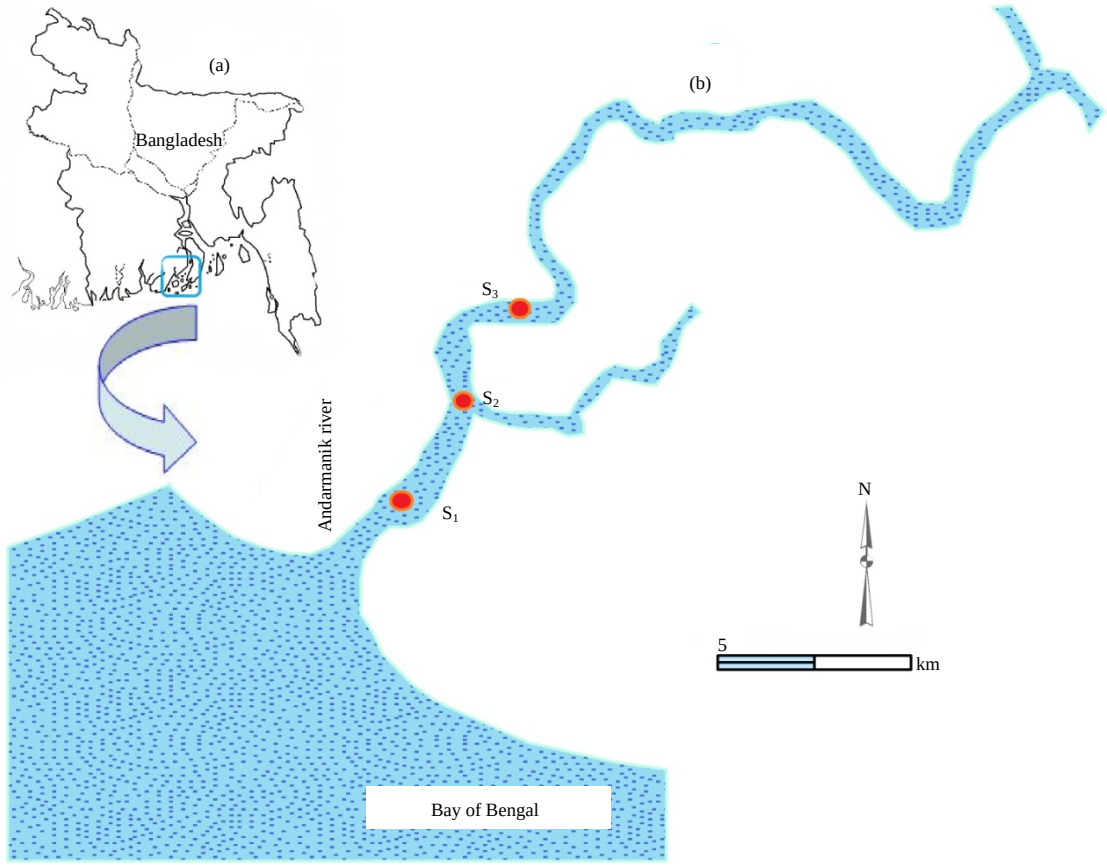

Fig. 1(a-b): Geographical location of study area, (a) Map of Bangladesh and (b) Map of Andharmanik river with three sampling stations S_1, S_2 and S_3 manifested as red rounded

with fisher's community fishing in the three dissimilar spots of Andharmanik river. The mesh size of the gears was estimated using a centimeter scale (CRESCENT, Made in China). The fishing gears were categorized under different major groups followed by Ahmed[8].

Fish specimen collection: Fish samples were also collected from the local fish landing centers and fish markets from previously contacted fishermen. Total numbers of individual species were counted in each sampling day from these three stations.

Laboratory analysis: For laboratory study, 10% of the total catch was taken from each sampling station and preserved in 10% buffered formalin solution in a previously leveled plastic jars according to species and size. In the laboratory, the collected specimens were identified to species level with the help of standard taxonomic keys of Talwar and Jhingran[9], Nelson[10], Rahman[11] and Hossain *et al.*[12]. Fish base software was also used as a guide[13].

Data analysis: Fish diversity was assessed using five different indices viz., Shannon-Wiener index, evenness, dominance indices, Simpson's index and species richness. The Shannon-Weiner index and Gibson's evenness was measured to evaluate species diversity[14]. The dominance index like Simpson's dominance index and Simpson's index of diversity was measured to determine whether or not particular species dominate in a particular aquatic system. Margalef index (d) was used to measure species richness[15].

Diversity indexes were calculated using following formula:

- Shannon-Wiener index (H):

$$H = -\sum[(\frac{ni}{N}) \times In(\frac{ni}{N})]$$

- Gibson's evenness:

$$E = eH/S$$

- Simpson's dominance index:

$$D = \sum[\frac{ni(ni-1)}{N(N-1)}]$$

- Simpson's index of diversity:

$$1-D = 1-\sum[\frac{ni(ni-1)}{N(N-1)}]$$

- Margalef's index:

$$d = S\text{-}1/InN$$

where, N is total number of organisms of all species found, ni is number of individuals of a particular species, i is an index number for each species present in a sample, S is the number of species of a single population, ln is the natural log of the number and $\sum$ is the sum values for each species.

Bangladesh conservation status and population trend were detected by following IUCN[16]. For the analysis of present findings statistical analysis were carried out by using microsoft Excel 2007 and Statistical Packages for Social Sciences (SPSS) version 16.00.

RESULTS AND DISCUSSION

Species specificity of fishing gears: Different types of fishing gears with their mesh size, major species caught and catch composition were recorded during the study period (Table 1). From the study, total 17 different types of fishing gears were identified under 8 major groups such as gill nets (poa jal, koral jal, koi jal, shahin jal, current jal and khuta jal), seine net (jagat ber jal), fixed purse nets (benti jal and badha jal), cast nets (jhaki jal), trawl net (goria jal), lift nets (dharma jal, chabi jal and ghuchoin jal), push nets (moia jal and thela jal) and hook and line (chhip barshi). Eight major types of fishing gears including gill net, seine net, set bag net, lift net, cast net, push net, trap and hook and line also recorded from Ramnabad river[17]. However, Khan *et al.*[18] identified total 7 gears namely current jal, cast net, jhayetjal, thela jal, dharma jal, borshi and long line in the Tista river. Flowra *et al.*[19] listed cast net, seine net, gill net, lift net, push net, traps and hook and line from Baral river.

Mesh size of the nets were varied depending on targeted fish species. However, maximum (10.16-15.24 cm) and minimum (0.508 cm) mesh size was found in case of koral jal and moia jal under the group of gill net and push net. Present finding was supported by Siddique *et al.*[20] who found mesh size 4-4.5 cm for ilish net, 3.5 cm for poa jal, 0.5-2.3 cm for jagat ber jal, 0.5-1.25 cm for behundi jal, 0.625-1.25 cm for jhaki jal and 0.5-2 cm for dharma jal in the Meghna river estuary. The highest catch composition was found for jagat ber jal (35±12 kg day^{-1}) followed by shahin jal (30±5) and lowest for chabi jal (0.5±0.2 kg day^{-1}). But Sayeed *et al.*[7] observed the mean CPUE from gill net, jhaki jal, seine net, thela jal, lift net, traps, wounding gears, moi jal, hook and line and sutijal was 2.83±0.92, 2.05±0.81, 48.99±12.34, 2.60±1.56, 2.66±1.46, 4.69±2.11, 1.83±1.07, 3.03±1.76, 3.11±1.76 and 224.54±126.89 kg, respectively in the Chalan beel.

Fish diversity status: The study described total 48 species of fishes under 10 orders and 26 families listed with their scientific name, common english and local name and IUCN red list status of Bangladesh (Table 2). The order basis percentage

Table 1: Illustration of available fishing gears with their mesh size, target fish species and catch composition documented from three stations (S_1, S_2 and S_3) of Andharmanik river

Gear types	Local name (Name of jal*)	Mesh size (cm)	Target fish species	**CC/haul/day/gear (kg)
	Poa jal	5.08-7.62	Poa, Ramchos	3±2
	Koral jal	10.16-15.24	Koral, Pangus, Ayr	8±3
Gill net	Koi jal	1.27-5.08	Koi, Magur, Shing, Shol	0.8±0.5
	Shahin jal	5.08-10.16	Ilish, Koral, Boal, Ayr, Loitta	30±5
	Current jal	7.62-15.24	Pangus, Ilish, Chapila, Indian major carps	20±2
	Khuta jal	5.08-10.16	Poa, Pangus, Gagra	20±10
Seine net	Jagat ber jal	0.508-1.27	All species	35±12
Fixed purse net	Badha jal	0.635-2.54	All species	15±7
	Benti jal	0.508-1.02	Cheua, Punti	3±2
Cast nets	Jhaki jal	0.508-1.02	Faissa, Gulsha, Bogni, Boiragi, Bele, Punti, Shol	1±0.5
Trawl net	Goria jal	1.27-2.54	All small species	2±1
Lift nets	Dharma jal	0.508-1.02	Gagra, Tengra, Gulsa	3±2
	Chabi jal	0.254-1.016	Punti, Tengra, Mola, Chela	0.5±0.2
	Ghuchoin jal	0.508-1.02	Magur, Shing, Koi, Kholisa, Faissa, Gulsa, Tengra	1.2±0.5
Push nets	Moia jal	0.508	Fry, Larvae and Fingerling of various species	1±0.5
	Thela jal	0.508-1.02	Gulsha, Punti, Tengra, Mola, Chela	1.5±0.5
Hook and line	Chhip Barshi	-	Koi, Boal, Shol, Taki, Gozar	1±0.4

*Jal: Fishing net, **CC: Catch composition

Table 2: Systematic position of finfish species with their local name, common english name, individual encountered and IUCN red list status of recorded fishes from Andharmanik river

Order	Family	Scientific name	Common english name	Local name	Individual encountered				IUCN red list status
					S_1	S_2	S_3	Sub-total	
Aulopiformes	Synodontidae	*Harpadon nehereus* (Hamilton, 1822)	Bombay duck	Loitta	18	12	0	30	NA
Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton, 1822)	Freshwater garfish	Kakila	55	54	73	182	NA
Clupeiformes	Clupeidae	*Tenualosa ilisha* (Hamilton, 1822)	Hilsa shad	Ilish	209	134	179	522	NA
		Tenualosa toli (Valenciennes, 1847)	Toli shad	Chandana ilish	31	0	0	31	NA
		Corica soborna (Hamilton, 1822)	Ganges river sprat	Kachki	156	178	163	497	NO
		Gudusia chapra (Hamilton, 1822)	Indian river shad	Chapila	107	102	91	300	NO
	Engraulidae	*Setipinna phasa* (Hamilton, 1822)	Gangetic hairfin anchovy	Phaisa	89	109	48	246	NO
		Thryssa purava (Hamilton, 1822)	Oblique-jaw thryssa	Ramchos	91	98	104	293	NO
Cypriniformes	Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)	Guntea loach	Gutum	31	35	40	106	NO
	Cyprinidae	*Puntius sophore* (Hamilton, 1822)	Spot fin swamp barb	Jatpunti	0	69	153	222	NO
		Puntius ticto (Hamilton, 1822)	Ticto barb	Tit punti	158	172	163	493	VU
		Salmostoma bacaila (Hamilton, 1822)	Large razorbelly minnow	Chela	57	56	41	154	NO
		Esomus danricus (Hamilton, 1822)	Flying barb	Darkina	0	9	19	28	NO
		Labeo rohita (Hamilton, 1822)	Rohu	Rui	0	7	11	18	NA
		Gibelion catla (Hamilton, 1822)	Catla	Catla	0	8	4	12	NO
		Devario devario (Hamilton, 1822)	Sind danio	Baspata	62	44	59	165	NO
		Amblypharyngodon microlepis (Bleeker, 1853)	Indian carplet	Mola	127	98	102	327	NO
Osteoglossiformes	Notopteridae	*Chitala chitala* (Hamilton, 1822)	Clown knife fish	Chitol	0	5	9	14	EN
Perciformes	Ambassidae	*Chanda nama* (Hamilton, 1822)	Elongate glassy perchlet	Lamba chanda	0	63	76	139	VU
		Chanda ranga (Hamilton, 1822)	Indian glassy fish	Lal chanda	29	46	33	108	VU
	Anabantidae	*Anabas testudineus* (Bloch, 1792)	Climbing perch	Koi	7	0	12	19	NO
	Channidae	*Channa punctatus* (Bloch, 1793)	Spotted snakehead	Taki	0	18	32	50	NO
		Channa marulius (Hamilton, 1822)	Giant snakehead	Gozar	5	7	11	23	EN
		Channa striatus (Bloch, 1793)	Striped snaked	Shol	0	17	34	51	NO
	Gobiidae	*Glossogobius giuris* (Hamilton, 1822)	Tank goby	Bele	107	109	106	322	NO
		Pseudapocryptes elongatus (Cuvier, 1816)	Lanceolate goby	Cheua	0	98	67	165	NA
		Odontamblyopus rubicundus (Hamilton, 1822)	Rubicusdus eelgoby	Lal cheua	90	76	137	303	NO
		Taenioides cirratus (Blyth, 1860)	Whiskered eel goby	Dogri	91	41	0	132	NO
	Latidae	*Lates calcarifer* (Bloch, 1790)	Giant perch	Koral	8	13	8	29	NA
	Nandidae	*Nandus nandus* (Hamilton, 1822)	Mottled nandus	Vheda	51	48	63	162	VU
	Osphronemidae	*Trichogaster fasciata* (Bloch and Schneider, 1801)	Banded gourami	Khailsa	67	0	44	111	NO
	Polynemidae	*Polynemus paradiseus* (Linnaeus, 1758)	Paradise thread fin	Tapasi	201	239	105	545	NO
	Sciaenidae	*Nibea soldado* (Lacepède, 1802)	Silver jew	Sada poa	89	103	179	371	NA
	Sillaginidae	*Sillaginopsis panijus* (Hamilton, 1822)	Flathead sillago	Tular dandi	106	137	207	450	NA

Table 2: Continue

Order	Family	Scientific name	Common english name	Local name	Individual encountered				IUCN red list status
					S_1	S_2	S_3	Sub-total	
Pleuronectiformes	Cynoglossidae	*Cynoglossus cynoglossus* (Hamilton, 1822)	Bengal tongue sole	Kukur jeeb	17	6	0	23	NO
Siluriformes	Bagridae	*Mystus vittatus* (Bloch, 1794)	Striped river catfish	Rani Tengra	67	0	77	144	NO
		Sperata aor (Hamilton, 1822)	Long-whiskered catfish	Ayr	32	28	47	107	VU
		Mystus tengara (Hamilton, 1822)	Tengra catfish	Kalo bujuri	43	0	53	96	NO
		Rita rita (Hamilton, 1822)	Rita	Rita	5	6	7	18	CR
	Heteropneustidae	*Heteropneustes fossilis* (Bloch, 1794)	Stinging catfish	Shing	0	12	17	29	NO
	Pangasiidae	*Pangasius pangasius* (Hamilton, 1822)	Yellowtail catfish	Pangas	8	17	21	46	CR
	Sisoridae	*Wallago attu* (Bloch and Schneider, 1801)	Freshwater shark	Boal	39	37	36	112	NO
	Schilbeidae	*Silonia silondia* (Hamilton, 1822)	Silond catfish	Silon Tengra	44	54	0	98	EN
		Clupisoma garua (Hamilton, 1822)	Garua bachcha	Garua	78	27	89	194	CR
		Ailia coila (Hamilton, 1822)	Gangetic ailia	Kajuli	30	0	46	76	VU
Synbranchiformes	Mastacembelidae	*Macrognathus aculeatus* (Bloch, 1786)	Lesser spiny eel	Tara baim	102	107	66	275	VU
	Synbranchidae	*Monopterus cuchia* (Hamilton, 1822)	Swamp eel	Cuchia	8	3	8	19	VU
Tetraodontiformes	Teraodontidae	*Tetraodon fluviatilis* (Hamilton, 1822)	Green puffer fish	Potka	11	7	0	18	NO
Total				48	2526	2509	2840	7875	

LC: Least concern, DD: Data deficient, NO: Not threatened, CR: Critically endangered, EN: Endangered, VU: Vulnerable and NA: Not assessed

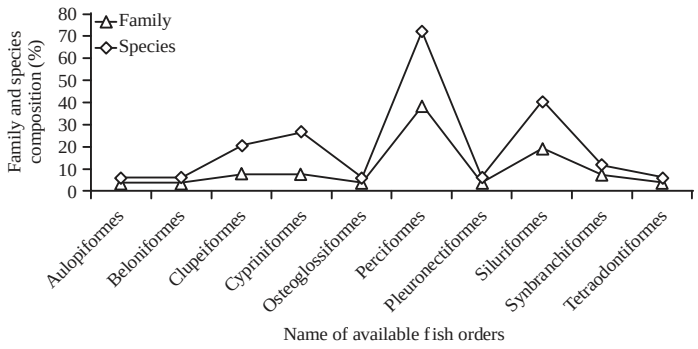

Fig. 2: Family and fish species composition under different orders

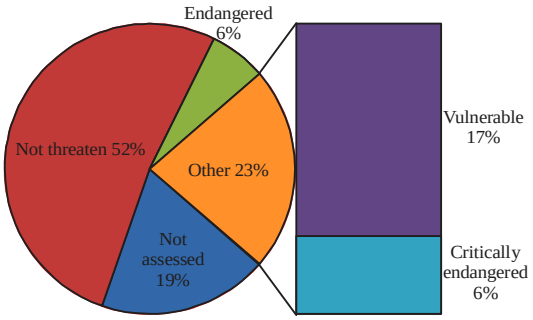

Fig. 3: Red list status of available fishes recorded from Andharmanik river

Table 3: Diversity indexes used to understand species status

Sampling stations	S_1	S_2	S_3
Taxa S	38	42	42
Individuals	2526	2509	2840
Variable			
Shannon-wiener index (H)	3.33	3.33	3.42
Gibson's evenness (E)	0.73	0.67	0.73
Simpson's dominance index (D)	0.042	0.044	0.048
Simpson's index of diversity (1-D)	0.958	0.956	0.952
Margalef's index (d)	4.72	5.24	5.16

analysis of the fish species showed the highest occurrence belongs to the order Perciformes (33.33%), which was followed by 20.83, 18.75, 12.50 and 4.17% for Siluriformes, Cypriniformes, Clupeiformes and Synbranchiformes, respectively. In addition, five orders viz., Aulopiformes, Beloniformes, Osteoglossiformes, Pleuronectiformes and Tetraodontiformes were found in the percentage as 2.08% (for each) of the total number of fish species (Fig. 2). Earlier study reported higher number of fishes total 53 from Andharmanik river[3]. But lower number of fishes as 40 species was identified from Chanda beel[21].

Fish diversity indexes: Species richness, evenness and diversity indices as Shannon-Weiner, Simpson's index and Margalef's index were calculated to evaluate the fish species diversity from the study areas (Table 3). Shannon-Weiner index (H) affects both number of species and evenness of a community of population, diversity increases as both increases. From the study area, the H values found to be higher in S_3 (3.42) followed by S_2 (3.33) and S_1 (3.33). The value of evenness (E) varied between 1 and 0. However, evenness (E) was shown as 0.73, 0.67 and 0.73 for S_1, S_2 and S_3, respectively. The bigger the Simpson's dominance index (D) value usually ranges from 0-1, the smaller the biodiversity. The value of D was found 0.042, 0.044 and 0.048 for S_1, S_2 and S_3, respectively. The Simpson's index of diversity (1-D) value also ranges between 0 and 1, the greater the value the greater the sample diversity, where the 1-D value occurred maximum in S_1 (0.958) followed by S_2 (0.956) and minimum in S_3 (0.952). The Margalef's index (d) was happen maximum in S_2 (5.24) followed by S_3 (5.16) and minimum in S_1 (4.72).

Shukla and Singh[22] also studied on three stations of Aami river and showed Shannon-Weiner index (H) in site-1 was 0.0213 followed by site-2 (0.0088) and lowest in site-3 (0.00422). The Simpson's dominance index (D) value showed high at site-1 (0.064) and site-2 (0.0280) and low at site-3 (0.0133). Simpson's index of diversity (1-D) for site-1 was 0.936, site-2 was 0.72 and site-3 is 0.986. Galib *et al.*[23] found about 63 species from Choto Jamuna river and calculated values of Shannon-Weiner index (H), Margalef's index and evenness (E) were 3.717, 6.954 and 0.897, respectively.

Fish conservation status: Out of 48 species 3, 3 and 8 species belonged to endanger, critically endanger and vulnerable, respectively (Fig. 3). But Mohsin *et al.*[3] identified 2 critically endangered, 3 endangered and 5 vulnerable fish species from Andharmanik river, which was lower than present finding. Galib *et al.*[23] also recorded 10 vulnerable, 10 endangered and 6 critically endangered species from river Choto Jamuna higher than present result.

The comparison between earlier and present study suggested that the fish fauna of Andharmanik river are declining day by day. These are due to excess fishing pressure by non-selective, illegal and restricted fishing gears. One of the major causes of declining of fishes from the river is the indiscriminate killing of small fishes in the early stage by various small size fishing gears like moia jal and badha jal under the group of push net and seine net respectively. Stationary gears like gill nets have significance contribution for reduction of fish species. The majors group of net like cast nets and hook and line are not destructive and could be allowed to operate round the year to catch fish in the river. The findings were supported by Rahman *et al*.[24].

Besides, it was observed that a number of drains have been fallen into the river from the banks. As a result various chemical wastages from agro-industrial sources fall through the drainage and sewerage systems and polluted the water quality consequently destroying the spawning, nursing and grazing grounds of fish species of the river. The construction of diversion canal and sluice gates causes siltation in the river bed, which influences the water flow consequently affecting the entire ecosystem of the Andharmanik river. Agricultural runoff and discharge of oil from mechanical trawlers also affects the water quality, therefore destroying habitat of many commercially important fish species. Some of these problems are also shown in other water body of Bangladesh by Sayeed *et al*.[7]. So government as well as fisheries related organizations should take a conservation manner to guide the fishes in the river from extinction as conservation of fish diversity is essential to maintain ecological/nutritional and socio-economic equilibrium[25]. If the fishing effort decreased, then the density of fish biodiversity and the Shannon-Weiner diversity index will be increased.

CONCLUSION

The study is a preliminary attempt to understand the selectivity of fishing gears as well as fish diversity and its decline causes on a particular point of Andharmanik river, Bangladesh. The ecosystem of Andharmanik river still supports good number of fish species. But increased fishing pressure by the artisanal and subsistence fishermen as for livelihood and food, fish diversity from the river is declining gradually. Some recommendations like banned illegal fishing gears, preventing water pollution, ensuring water flow, fishermen's awareness, implementation of fisheries laws and declaration of fish sanctuary have been coming out to save the fish fauna from extinction. Government and Fisheries Research Institution along with different agencies must take immediate action through public awareness and education to protect the ecosystem of these valuable fish species and to develop more feasible strategy as conservation measures.

ACKNOWLEDGMENT

The authors would like to express sincere appreciation to (i) Local fishers (Kalapara upazila under Patuakhali district, Bangladesh), (ii) Upazila Fisheries Officer (Kalapara) for providing valuable information and (ii) Department of Fisheries Technology, Patuakhali Science and Technology University (Bangladesh) for adequate laboratory facilities to complete this research successfully.

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