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FISH BIO-DIVERSITY AND LIVELIHOOD OF FISHERS OF DEKAR *HAOR* IN SUNAMGANJ OF BANGLADESH

I.N. SURAVI[1], M.S. ISLAM[2], N. BEGUM[3], M.A. KASHEM[4], F.J. MUNNY[5] AND F. IRIS[6]

[1 &3]*Department of Coastal and Marine Fisheries,* [2] *Department of Coastal and Marine Fisheries,*[4] *Department of Soil Science,* [5] *Department of Aquaculture, Sylhet Agricultural University, Sylhet-3100, Bangladesh* [6] *Teesside University, UK*

Abstract

The study was carried out to assess the present status of fish biodiversity in Dekar *haor* and livelihood of fishermen living around the *haor* under Sunamganj district during 12 months from September 2015 to August 2016. Monthly fish samples were collected from the catches of fishermen and identified based on meristic and morphometric characteristics. A total of 51 fish species belonging to 34 genera along with two prawn species under 19 families was found. Among them catfishes were most abundant. The values of Shannon-Weiner diversity ($H^{'}$), Margalef's richness (d), Pielou's evenness indices ($J^{'}$) and Simpson dominance indices (c) ranged from 3.36-3.78, 6.12-8.40, 0.98-0.99 and 0.97-0.98, respectively. Livelihood data were collected through direct interview from randomly selected 73 fishermen. Main occupation of fishermen is fishing. There were three age groups such as young (18-35 years), middle (36-45 years) and old group (above 46 years) where young group was mostly involved in fishing. Most of the fishermen (72.61%) were Muslims and 63% were able to sign only followed by others. Annual income of fishermen varied from Tk. 10,000-100,000. Majority of them had low savings with poor housing and sanitation facilities. Maximum fishers are interested to live in unit family owing to low income. Results of this study imply that fish diversity status was not satisfactory. Also livelihood condition of fishers was not so good. Therefore, appropriate measures should be taken to improve the livelihood of fishermen and to protect the bio-diversity of the *haor*.

Key words: Fish diversity, *Haor*, Livelihood, Fishermen

Introduction

Bangladesh possesses vast natural waterbodies in the form of canal, *beel*, *haors*, *baors*, lakes, floodplains, rivers and estuaries. *Haors* are located in the north-eastern region of Bangladesh. There are about 373 *haors* located in the districts of Sunamganj, Sylhet, Maulvibazar, Habiganj, Brahmanbaria, Netrokona and Kishoreganj, and covering an area of about 858,000 ha, which is around 43% of total area of the *haor* region (Master Plan of *Haor* Areas 2012). The most prominent *haors* are Shaneer, Hail, Hakaluki, Dekar, Tanguar, Chayer, Maker and Kawadighi *haor*. *Haor* is a marshy wetland ecosystem, which physically is a bowl or saucer shaped floodplain depression that looks like inland sea in monsoon flood. In wet season, *haors* are full of water and each of settlements looks like an isolated island in a vast waterbody but in dry season, these are dried up except deep *beels*. During winter, *haor*s contain little water and are restricted to a small

area, and a large area is filled with paddy and other crops. These natural depressed seasonal-perennial waterbodies are directly/indirectly connected with canal and river and other *haor*. These are naturally rich in fisheries resources. Waterbodies of *haor*s are productive and natural habitats of diversified fauna and flora. These are also famous for natural fish production.

*Haor*s play an important role to develop the fish diversity and maintained the livelihood condition of fishermen. Livelihood status of the *haor* dwelling fishermen mostly depends on the fisheries and other natural resources in the *haor*. On the other hand, fish diversity is also somewhat dependent on livelihood of fishermen. So fishing group is an important community to enrich the fish diversity and economics of Bangladesh. But most of the fishermen are poor and are deprived of many amenities of life. All time they have to struggle to survive. Livelihood condition of fishermen is not satisfactory at all because they do not get free access to the waterbody for catching fish in all seasons.

Dekar *haor* is one of the largest and important *haor* in greater Sylhet, Netrakona, Kishoreganj and Brahmanbaria districts. The area of this *haor* is around 252 km^2. Different sizes of *beel*s are present in the *haor*. All *beel*s are submerged during rainy season. Rivers and *haor*s are directly jointed with each other during this period. Fishes are grazed in the whole *haor*. They enjoy more space and more different types of feed without competition to each other. Growth of fishes increases with passing of time. Small indigenous species and short cycled fishes become marketable size within few months. Fishes of the *haor* are caught using various types of gear by fishermen round the year for accomplishing the expenditure of their family. So this *haor* has a great influence on fish diversity and livelihood of fishermen. But despite its innumerable importance, research has not yet been carried out on fish diversity as well as livelihood of fishermen of the *haor*. In view of the above facts, the study was undertaken to assess the fish diversity and livelihood of fishermen living around the *haor.*

Materials and Methods

Description of the haor and selection of study area: Dekar *haor* is one of the most important and the largest *haor* in Bangladesh. It lies between latitude 24°34´N to 25°12´N and longitude 90°56´E to 91°49´E. The *haor* covers four *upazilas* namely Sunamganj Sadar, Dakshin Sunamganj, Dowarabazar and Chhatak under Sunamganj district (Fig.1). It is located 60 km west away from Sylhet town, which is closed to Sunamganj town. The *haor* is consisted of 36 small, medium and large interconnecting *beels*, canals, rivers and crop lands. This open waterbody was selected as a study area.

Data collection: The data were collected for 12 months (from September 2015 to August 2016). During data collection, both primary and secondary sources were considered to interpret the results. For fish diversity assessment of the *haor*, monthly fish samples were collected directly from the catches of fishermen for identification of the species. Some samples were identified up to species on the spot and recorded the number of specimen

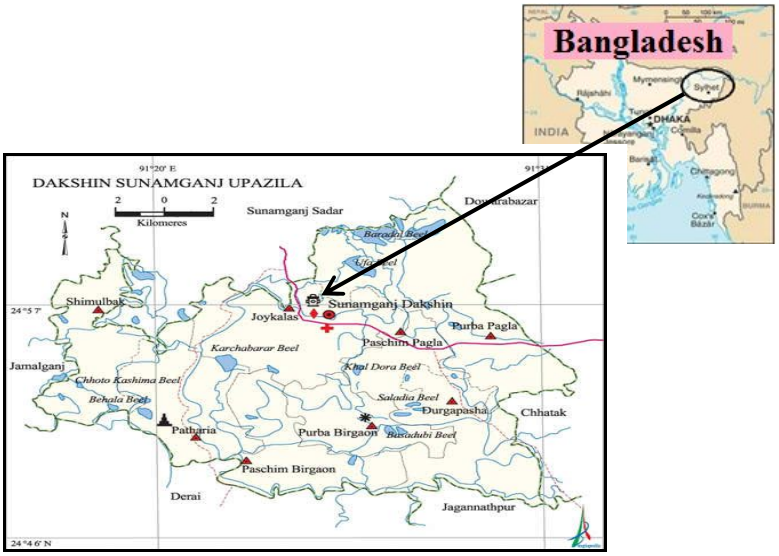

Fig. 1. Map of Dakshin Sunamganj *upazila* showing the study area.

and weighed species wise. Some samples were identified and recorded up to genus or species level following the manual and books of Talwar and Jhingran (1991) Shafi and Quddus (2001) DoF (2014) (2005) and Rahman.

Livelihood information data were collected based on field survey method from fishermen and others 4 different villages namely Noyagoan, Sultanpur, Robbaninagor, Sadarpur surrounding the *haor* under Dakshin Sunamganj *upazila*. Fishermen were randomly selected from both professional and subsistence fishermen groups living around the study area. Livelihood data were collected from 73 randomly selected fishermen and others 17 through questionnaires interviews, focus group discussion, market visit, etc where leaders of the fisher community, fish market leaders, fish traders, fry traders, local leaders, school teachers and community people were also present. Secondary data were collected from Dakshin Sunamganj *Upazila* Fisheries Office, District Fisheries Office of Sunamganj district, books, journals, reports and NGOs.

Fish diversity data analysis: Diversity of species assemblage was analyzed by Shannon-Weiner index (H') (Shannon 1949, Shannon and Weiner 1963, Pielou 1966, Margalef 1968, Ramos *et al.* 2006), species richness was measured by Margalef index (d) evenness was estimated by Pielou's index (J') and dominance was determined by Simpson index (c). Values of Shannon-Weiner diversity index and Margalef richness index, Pielou's evenness index and Simpson dominance index were calculated using the following formula :

Shannon-Weiner diversity index (H′): $\sum_{i=1}^{s} [Pi \times \log (Pi)]$

Where, H' = Shannon-Weiner index

Pi = ni/N

ni = No. of individuals of a species

N = Total number of individual fish

S = Total number of fish species

Margalef species richness (d): *(S-1)/log (N)*

Where, S = Total fish species

N = Total individual fish

Pielou's evenness index (J'): *H (s)/H(max)*

Where, *H* (s) = the Shannon-Weiner information function.

H (max.) = The theoretical maximum value for H(s) if all species in the sample were equally abundant.

Simpson dominance index (c): $\sum_{i=1}^{s} (ni/N)^2$

Where, ni = number of individuals in the 'each' species
N = Total number of individual fish
S = Total number of fish species

Socioeconomic and livelihood data analysis: All collected socioeconomic and livelihood data were calculated using the following formula :

$$\text{Mean, } X = \frac{-\sum X_i}{N}$$

Where, $\sum X_i$ = Sum of all of the numbers in a list
N = Total number of items in that list

Range: It is the difference of the higher and lower observation of the distribution.

Percentage: It is the rate/number/amount in each hundred.

Statistical analysis: A one way analysis of variance (ANOVA) was used to test for significant difference in Shannon-Weiner diversity index (H'), Pielou's evenness index (*J'*) and fish abundance among months. All multivariate analyses were performed by software PRIMER V6 (Plymouth Routines Multivariate Ecological Research) (Clark and Warwick 1994). All socioeconomic and livelihood data were stored and processed through computer software and analyzed using Microsoft Excel and STATISTICA software.

Results and Discussion

Fish diversity of Dekar haor: Large number of freshwater fish species are still available in this largest freshwater wetland. During the study period 51 species of fish of which 8 species of carps, 4 snakehead, 8 perches, 3 eels, 11 catfishes, 6 barbs, 1 minnows, 2 clupeids and 8 other fishes including prawn namely *Macrobrachium rosenbergii* and *Macrobrachium malcolmsonii* under 19 families were recorded (Table 1). It was found that 23 fish species were abundant, 10 common and 18 rare out of 51 fish species (according to IUCN, 2015). Of 51 species, 47 were indigenous and the rest four exotics species. Among exotics, carpio (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) were dominant in the *haor*. Pandit *et al*. (2015) reported a total of 56 fish species including prawn species belongs to 21 families from the *haor* Soma Nadi *Jalmohal* of Derai *upazila*, Sunamganj. Among 56 species, 26 were commonly available (47%), 18 moderately available (32%) and 12 rarely available (21%). Out of 56 species, 8 were carps, 12 catfish, 9 barbs and minnows, 4 snakehead, 4 eel, 10 perches, 3 loaches and 6 miscellaneous including 3 prawn species. Sayeed *et al*. (2015) reported a total of 82 fish species belongs to 50 genera of 22 families under 9 orders, of which 75 were indigenous and 7 exotic in Hakaluki *haor*.

Fishermen in this *haor* were classified according to their fishing gear used. Nine types of gear were considered during the experimental period (Table 2). Most of the fishermen (31.51 and 16.4%) used gill net and seine net, and only 2.74% used fish trap-b (*gui*) and c (*polo*), respectively for catching fish. Fisheries resources are now under great threat due to man-made obstacles (fishing by dewatering of *beels,* use of gill net, harvesting of undersized fishes and brood fishes, use of insecticides, embankment, exploitation of aquatic vegetation, etc) and various environmental degradations (siltation of the *beels*, lack of water around the year, lack of natural food for fishes, water quality degradation, climate/seasonal changes, etc). For these reasons, fish diversity of the *haor* has been reducing day by day.

Fish species diversity indices : Shannon-Weiner diversity index (H'): The highest (3.3556) Shannon-Weiner index was recorded in February and the lowest (3.7799) in September. Kanon (2014) reported the highest value (3.12) in June and the lowest (2.9) in January of Shannon-Weiner index of Konoskhai *haor*, Sunamganj, which was lower than the findings of the present study.

Margalef richness index (d): The lowest (6.1185) and the highest (8.4023) values of Margalef index were recorded in February and September, respectively. Kanon (2014) reported the Margalef's index ranging from 2.7 (December) to 3.02 (July) in Konoskhai *haor*, which was less than the findings of this study.

Table 1. List of indigenous and exotic fishes recorded in Dekar *haor* during study period.

Sl. No.	Family name	Local name	English name	Scientific name	Remarks (IUCN, 2015)
1.	Cyprinidae	Rui	Indian major carp	*Labeo rohita*	Rare
2.	Cyprinidae	Catla	Indian major carp	*Jubilant catla*	Common
3.	Cyprinidae	Kali baush	Black rohu	*Labeo calbasu*	Abundant
4.	Cyprinidae	Mrigal	Indian major carp	*Cirrhinus cirrhosus*	Rare
5.	Cyprinidae	Gonia	Kuria labio	*Labeo gonius*	Abundant
6.	Cyprinidae	Silver carp	Silver carp	*Hypophthalmychthys molitrix*	Common
7.	Cyprinidae	Grass carp	Grass carp	*Ctenopharyngodon idella*	Common
8.	Cyprinidae	Carpio	Common carp	*Cyprinus carpio*	Abundant
9.	Channidae	Shol	Snakehead murrel	*Channa striatus*	Abundant
10.	Channidae	Taki	Spotted snakehead	*Channa punctatus*	Abundant
11.	Channidae	Chang	Asiatic snakehead	*Channa orientalis*	Rare
12.	Channidae	Gajar	Giant snakehead	*Channa marulius*	Rare
13.	Anabantidae	Khalisha	Striped gourami	*Colisa fasciatus*	Rare
14.	Anabantidae	Chuna khalisha	Honey gourami	*Colisa chuna*	Rare
15.	Anabantidae	Lal khalisha	Red gourami	*Colisa lalia*	Rare
16.	Anabantidae	Koi	Climbing perch	*Anabus testudineus*	Common
17.	Centropomiodae	Kata chanda	Round glass perchlet	*Chanda baculis*	Abundant
18.	Centropomidae	Lal chanda	Indian glass perch	*Chanda ranga*	Rare
19.	Centropomidae	Nama chanda	Elongated glass perchlet	*Chanda nama*	Abundant
20.	Nandidae	Meni	Mud Perch	*Nandus nandus*	Abundant
21.	Mastacembelidae	Guchi baim	Striped spiny eel	*Mastacembelus pancalus*	Abundant
22.	Mastacembelidae	Tara baim	One striped spiny eel	*Macrognathus aculeatus*	Abundant
23.	Mastacembelidae	Lal baim	Tire-track spiny eel	*Mastacembelus armatus*	Abundant
24.	Bagridae	Gulsha	Long whiskered catfish	*Mystus gulio*	Common
25.	Bagridae	Bujuri	Long bled catfish	*Mystus tengra*	Abundant
26.	Bagridae	Tengra	Striped dwarf catfish	*Mystus vittatus*	Abundant
27.	Bagridae	Air	Long whiskered catfish	*Sperata aor*	Rare
28.	Claridae	Magur	Walking catfish	*Clarius batrachus*	Abundant
29.	Heteropneustidae	Shing	Stinging catfish	*Heteropneustes fossilis*	Abundant
30.	Schilbeidae	Batashi	River catfish	*Pseudeutropius atherinoides*	Common
31.	Schilbeidae	Bashpata	Gangetic ailia	*Ailia coila*	Common
32.	Schilbeidae	Bacha	River catfish	*Eutropiichthys vacha*	Rare
33.	Siluridae	Modhu pabda	Butter catfish	*Ompok pabda*	Common
34.	Siluridae	Boal	Freshwater shark	*Wallago attu*	Abundant
35.	Cyprinidae	Phul chela	Barb	*Chela phulo*	Rare
36.	Cyprinidae	Lamba chela	Barb	*Chela bacaila*	Rare
37.	Cyprinidae	Mola	Barb	*Amblypharyngodon mola*	Common
38.	Cyprinidae	Dhela	Barb	*Rohtee cotio*	Rare
39.	Cyprinidae	Jatpunti	Spot fin swamp barb	*Puntius sophore*	Abundant
40.	Cyprinidae	Tit punti	Fire fin barb	*Puntius ticto*	Abundant
41.	Cyprinidae	Darkina	Top minnow	*Esomus dandricus*	Rare
42.	Clupeidae	Chapila	Indian river shad	*Gudusia chapra*	Abundant
43.	Clupeidae	-	Indian river shad	*Gudusia minminna*	Abundant
44.	Belonidae	Kakila	Freshwater gar fish	*Xenentodon cancila*	Abundant
45.	Cobitidae	Gutum	Guntea loach	*Lepidocephalus guntea*	Rare
46.	Gobiidae	Baila/bele	Bar-eyed goby	*Glossogobius giuris*	Common
47.	Notopteridae	Chitol	Humped feather back	*Notopterus chitala*	Rare
48.	Palaemonidae	Golda	River prawn	*Macrobrachium rosenbergii*	Rare
49.	Palaemonidae	Gura chingri	Monsoon river prawn	*Macrobrachium malcolmsonii*	Abundant
50.	Tetraodontidae	Choto tepa	Oscillated puffer fish	*Tetraodon cutcutia*	Abundant
51.	Cichlidae	Tilapia	Tilapia	*Oreochromis mossambicus*	Rare

Pielou's evenness index (J'): The highest evenness value (0.9965) was observed in February and the lowest (0.9885) in November. Alam *et al*. (2015) recorded Pielou's index as 0.67, 0.59 and 0.67, respectively in three *beel*s (Patasinghra, Shalkatua and Hawagulia of Kawadighi *haor*), Moulvibazar, which were lower than the present findings.

Table 2. Fishing gears used in Dekar *haor* during study period.

Groups	Types of gear	
Fish net	Gill net	*Current jal*
	Seine net	*Ber jal*
	Lift net	a. *Vassal/Khorajal* b. *Dharma jal*
	Cast net	*Jhaki jal*
	Push net	*Thela jal*
Fish trap		a. *Tengra chai* b. *Gui* c. *Polo* • *Dori* • *Kon* • *Ronga*
Hooks and line		a. *Borshi* b. *Hand borshi*

Simpson dominance index (c): The uppermost dominance value (0.9819) was determined in June and the lowest (0.9747) in February. Kanon (2014) demonstrated Simpson index ranging from 0.91 (January) to 0.94 (June) in Konoskhai *haor*, which was coincided with the findings of the present study. It is noted that water area of the *haor* is gradually/drastically increased after first/mid/last April in a year due to heavy shower and upstream run-off/flash flood. Fishes are dispersed in the whole *haor*. Fishermen freely catch fishes from the non-restricted water using different types of gear for their livelihood. Fishermen catch gradually increase with the increases of time up to a certain period, while water of the *haor* gradually recedes, comparatively a good amount of fishes are caught by fishermen. Peak season of fishing is started from June/July and continue up to October/November in a year. After that water is limited to certain areas and fishermen are not allowed for catching fish from restricted/leased water-bodies. For these causes, monthly catch by fishermen varied with season and water availability.

Livelihood status of fishermen

Age structure: Age structure of fishermen was divided into three age groups such as young (18-35 years), middle (36-45 years) and old age (above 46 years). It was observed that young group was the highest (59%) and old was the lowest (19%) among all gear users. Within fishing gears, young group was the highest (100%) in trap-c (*polo*) users and in the middle group the highest percentage (66.67%) was observed for push net whereas the highest value (50%) was estimated for old group in case of trap-b (*gui*) users. Rabbani (2007) reported that age group of 25-50 years was the highest (46.67%) and more than 50 years were the lowest (25%) of fishermen in the Karatua river, Bogra. Roy (2010) stated that young group was the highest (42%) and old group was the lowest (34%) among all gear users, these were consistent with the findings of the present study.

Family size: About 48% fishermen had medium family, 31% small and 21% large. Within the fishermen according to gear types, the highest percentage (100%) of medium family belonged to cast net, push net and trap-c (*polo*) users, and the lowest of small family was recorded in long line users. The highest value (50%) of large family was observed in trap-b (*gui*) users. Roy (2010) reported the largest value (83.33%) of medium family belongs to trap-b (*gui*) users and the lowest of large family among all gear users.

Religion: Sampled fishermen were distributed as 72.61% the Muslims and 27.39% the Sonatans, respectively in the *haor*, which was in agreement with the findings of Mahmud (2007) and Roy (2010), who stated that the highest 74 and 71% fishermen were the Muslim whereas only 26 and 29% the Hindus (Sonatans). Himu (2014) mentioned that majority (95.14%) of fishermen was the Muslims and minority (4.85%) the Hindus in study area of Hakaluki *haor*, which was higher than the findings of the present study.

Educational status: Sixty three percent (63%) fishermen had ability to sign, 26% no education and 7% primary. On the other hand, only 3% and 1% fishermen had JSC (Junior School Certificate) and SSC (Secondary School Certificate). Rabbani (2007) reported 20% riverine fishermen illiterate, 71.67% primary and only 8.33% secondary level. It might be due to the majority of the fishermen had no education. Roy (2010) stated that 73% fishermen of Pagnar *haor* in Sunamganj had no education, 21% primary and only 6% secondary. Most of sampled fishermen were compelled to engage in fishing profession at their early stage due to poor economic condition of their parents and lack of awareness about education.

Annual income: A 51% fishermen had moderate income and 11% low income whereas 38% high income. Annual income varied within different types of gear used by fishermen (Fig. 2). Majority of the cast net (100%) and gill net (82.61%) users had moderate income and most of the push net and multiple gear users (66.66%) were fell in low income group. Maximum multiple gear users (73.34%) had high income. Fishermen opine that their income depend on the availability of fishes in the *haor*. The quantity of fishes in the *haor* has been decreasing in every year owing to natural and man-made

causes. On the whole life, fishermen are at risk and they have no refreshment and no different taste of life. So many fishermen are switching over fishing profession to other

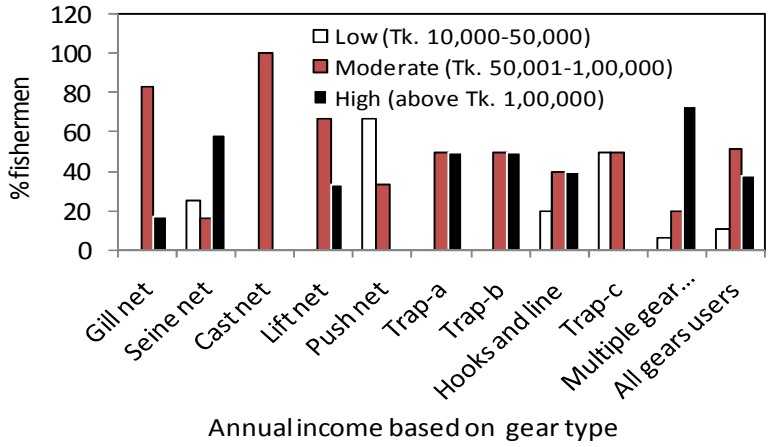

Fig. 2. Annual income of fishermen of Dekar *haor*.

activities to enjoy better life. Roy (2010) stated that the highest (7.14%) annual income was in long line fishermen under high annual income category. Comparatively maximum income (85.72%) was recorded in long line users under moderate income and the highest (50%) income was found in trap-b (*gui*) users under low income. He also concluded that long line fishermen earned comparatively higher income than other two categories. Holder (2002) reported annual income from fishing of all gear users as Tk. 89,199.96 and 96,199.92 in Doba *beel* and Chara *beel*, respectively. Himu (2014) observed that only 21.37% fishermen continued their livelihood generation through fishing. Majority (78.63%) of them took other occupations due to low income from fishing. He concluded that livelihood of fishermen were not satisfactory.

Savings: Savings of *haor* fishermen are presented in Fig. 3. About 38% respondents had medium savings, 41% low, 11% no savings and 10% high savings. Within fishing gear categories, majority (75%) of trap-a (*chai*) users had medium savings and 66.67% push net users had no savings at all, whereas about 50% trap-b (*gui*) users had high savings. It was also found that maximum of trap-b (*gui*) and multiple gear users were saved from their income. Roy (2010) reported that low savings group was the highest (55%) and high savings group was the lowest among all gear users. He also added that within fishing gear users no savings group was the highest (35.72%) in cast net and long line users, low savings group was the highest (83.33%) in trap-b (*gui*) users and medium savings group (46.66%) was in gill net users.

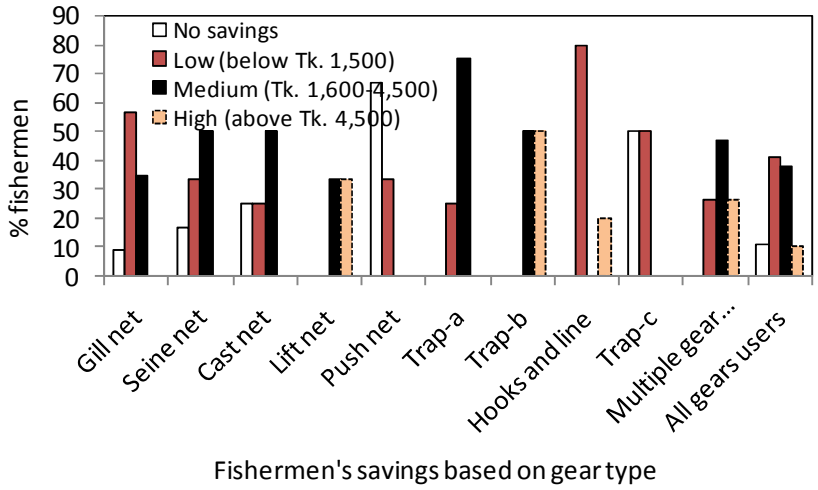

Fig. 3. Savings status of fishermen of Dekar *haor*.

Housing and health condition: There were two types of house in the study area namely thatched house and half building (brick walls with tin roof). Data of the present study revealed that 83.56% fishermen had thatched houses and 16.44% half building. Ahmed (2002) found that 62% fishermen had thatched houses in Mymensingh. Roy (2010) observed that majority of fishermen (83%) had thatched house and 17% half building in the Pagnar *haor*, Sunamganj. Himu (2014) noted that about 66.66% fishermen had thatched house, while 26.66% half building and only 6.66% building surrounding the Hakaluki *haor*. Health facilities of fishermen in studied area were very poor and found that 54.79% fishermen households dependent on village doctors who do not have any knowledge regarding medical science, 23.28 and 19.18% on quack doctor and municipal hospital, respectively while only 2.74% received health service from MBBS doctor. Roy (2010) mentioned 85% fishermen in Pagnar *haor*, Sunamganj dependent on village doctors and 15% received health service from *upazila* hospital. Alam (2006) reported only 42% farmers received the medical facilities from MBBS doctor and *upazila* health complex while the rest 58% dependent on village doctor and others in Mithapuqur *upazila*, Rangpur.

Sanitation facilities: Sanitation facilities of fishermen living around the *haor* were not good. Data showed that 79.45% had open toilets surrounded by temporary fencing while 20.55% sanitary. Alam (2006) reported that only 24% had good sanitation. Roy (2010) observed that 40% had open toilets, only 8% sanitary and 52% had no toilets. Himu (2014) found that most of the fishermen had the worth toilet facilities, 58.33% had open toilet, whereas 3.66% no toilet facility.

Land area: Majority (49%) of fishermen had small land whereas only 14% large. On the other hand, 37% respondents had medium land. According to gear types the largest value (66.66%) of small land holder in lift net users and in case of long line users about 40% had large whereas 66.66% push net users had medium land.

Family type: There were two types of family in the study area such as joint family and unit family. Approximate 16.44% fishermen lived in joint family and 83.56% in unit family. Roy (2010) noted that 56% fishermen lived in joint family and 44% in nuclear (small) family. Himu (2014) observed that most of fishermen had nuclear family (90%) while few (10%) joint family, which was coincided with the findings of the present study. Joint/large family is splitting owing to majority respondents are interested to live separately due to lack of income.

Results of the study indicate that indiscriminate fishing activities using different types of gears by fishermen caused great loss of all varieties of fishes and the status of fish bio-diversity is now moderate to poor. Most of the fishermen's income is much lower than the national per capita income. Fishermen's savings are very poor. Their livelihood condition is not good. Majority of the fishers are changing their livelihood as fish diversity and fish production of the *haor* are decreasing in every year due to man-made and natural causes. Government and other organizations should come forward for taking urgent actions to protect the biodiversity of the *haor*, which will help to improve fishermen's livelihood and fish diversity will be saved.

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References

Ahmed, N. 2002. Socio-economic aspects of freshwater prawn culture development in Mymensingh. Bangladesh. A report prepared for ICLARM, Dhaka. 25 p.

Alam, M. J. 2006. Status of fish farming and livelihood of the fish farmers in Mithapukur, Rangpur. M. S. Thesis (unpublished), Department of Fisheries Management, Bangladesh Agricultural University (BAU), Mymensingh. 81 p.

Alam, M. T., M. A. H. M. Kamal, M. A. Sayeed and M. A. Kabir. 2015. Impact of Aquaculture on Fish Biodiversity in Kawadighi*Haor* of North- East Region of Bangladesh. SAU Res. Prog. Rep. No. **02**, Sylhet Agricultural University, Sylhet, Bangladesh, pp. 51-56.

Clarke and Warwick, 1994. Change in Marine Communities: An Approach to Statistical Analysis & Interpretation. Natural Environment Research Council, UK, 144 p.

DoF (Department of Fisheries). 2014. Freshwater Fishes of Bangladesh. Department of Fisheries, Bangladesh. 213 p.

Himu, M. H. 2014. Impact of fish biodiversity on fishers livelihood of Hakaluki *haor* in Bangladesh. M. S. Thesis (unpublished), Department of Fisheries Technology and Quality Control, Sylhet Agricultural University, Sylhet. 60 p.

Holder, D. K. 2002. Studies on the availability of small indigenous species (SIS) of fishes and socioeconomic condition of fishers in two beels of rice fields. M. S. Thesis (unpublished), Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 136 p.

IUCN (International Union for Conservation of Nature) Bangladesh. 2015. Red List of Bangladesh, Vol. 5: Freshwater Fishes, Bangladesh Country Office, Dhaka, Bangladesh. pp. xvi+360p.

Kanon, M. H. 2014. Diversiity of Indigenous Fish Species in Konoskhai *Haor*. M.S. Thesis (unpublished) submitted to the Department of Fish Biology and Genetics, Sylhet Agricultural University (SAU), Sylhet. 49 p.

Mahmud, T. A. 2007. Fish biodiversity and socio-economic conditions of the fishing community in some selected areas of Chalan *beel*. M. S. Thesis (unpublished) submitted to the Department of Aquaculture, BAU, Mymensingh. pp. 27-53.

Margalef, R. 1968. Perspectives in Ecological Theory. Chicago Illinois University. Chicago Press. 111 p.

Master Plan of Haor Areas. 2012. Draft Final Report, Vol. II, Ministry of Water Resources, Bangladesh *Haor* and Wetland Development Board, Government of the People's Republic of Bangladesh, pp. 1-18.

Pandit, D., M. Kunda, M. J. Islam, M. A. Islam and P. P. Barman. 2015. Assessment of present status of fish diversity in Soma Nadi*Jalmohal* of Sonamganj in Bangladesh. *J. Sylhet Agril. Univ.*, **2** (1): 127-135.

Pielou. 1966. The measurement of Diversity in Different Types of Biological Collections. *Theort. Biology*, **13**:131-144.

Rabbani, M. G. 2007. Study on the fisheries and socio-economic condition of fishermen of Karatua river. M. S. Thesis (unpublished), Department of Fisheries Management, BAU, Mymensingh. 85 p.

Rahman, A. K. M. 2005. Freshwater Fishes of Bangladesh. 2nd ed. Zoo. Soc. of Bangladesh, Dhaka, Bangladesh. 394 p.

Ramos, S., R. K. Cowen, P. Re´ andA. A. Bordalo. 2006. Temporal and patial distribution of larval fish assemblages in the Lima estuary (Portugal). Estuarine, Coastal and Shelf Science, **66**: 303-314.

Roy, K. C. 2010. Fish biodiversity and the livelihoods of the fishing community in Pagnar*haor* under Jamalgonjupzila in Sunamgonj district. M.S. Thesis (unpublished), Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Sayeed, M. A., R. C. Deb, D. Bhattarcharjee, M. H. Himuand and M. T. Alam. 2015. Fish biodiversity of Hakaluki*haor* in north-east region of Bangladesh. SAU Res. Prog. Rep. No. **02**, Sylhet Agricultural University, Sylhet, Bangladesh, pp. 71-78.

Shafi, M. and M. M. A. Quddus. 2001. *Bangladesher Matshaw Sampad (Bangla)*. Kabir Publications, Dhaka. 485 p.

Shannon, C. E. 1949. Communities in the presence of noise proceeding of the Institute of Radio Engineers, **37** (1): 10-21.

Shannon, C. E. and W. Weiner. 1963. The mathematical Theory of communications. University of Illinois Press, Urbana, **II**, 125 p.

Talwar, P. K. and A. G. Jhingran. 1991. *Inland fishes of India and adjacent countries*. Volume 1 and 2. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta. 1158 p.

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