



Observation of fish production and availability of aquatic inhabitants under pen culture in *Chatol beel* floodplain

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Abstract

Present study concerned about the growth and production of fishes and availability of aquatic inhabitants in *Chatol beel* floodplain under pen culture technology for a period of 135 days. The pen enclosure was made by bamboo-split fence which covering an area about 2.43 ha. A combination of seven fish species—*Labeo rohita*, *Catla*, *Cirrhinus cirrhosus*, *Ctenopharyngodon idella*, *Puntius gonionotus*, *Aristichthys nobilis* and *Labeo gonius* were stocked in the pen at the ratio of 30:20:25:5:10:5:5 with the stocking density of 6250 fingerings/ha. The gross fish production of pen was 5282.9 kg, which included 4684.9 kg from stocked fish and 598 kg from non-stocked fish. The small indigenous species of fish (SIS) was dominant in the catches of non-stocked fish and total 20 different SIS species belonged to 12 families were being found with varying abundance. A total 9 species of phytoplankton, 5 species of zooplankton, 21 aquatic weeds and 9 taxa of benthic fauna were observed during study period. The net profit was US \$ 3532 and cost-benefit ratio was 1:1.8, which delineate that composite fish culture through pen culture technology in floodplain area has immense possibilities for increasing fish production and financial gains.

Keywords: aquatic inhabitants, *Chatol beel*, floodplain, fish production, pen culture

1. Introduction

Floodplains in Bangladesh are low-lying lands, compared to the adjacent area of land, which situate near river or any other running water sources and remain as flooded by water for several months of a year. However, the floodplain is one of the major sources of fish production in Bangladesh and plays indispensable role by providing food, income and employment for huge number of people. Therefore, in 2015-16, the total area of floodplains in Bangladesh was 2,838,960 ha which included 2,704,084 ha area of capture fisheries and 134,876 ha area of culture fisheries. The total captured fish from the floodplains was 747,872 tones and the amount of cultured fish was 207,658 tones. But, the floodplain productivity from capture fisheries was 277 kg/ha, while the culture fisheries was 1,539 kg/ha (DoF, 2017) ^[1]. So, there are immense possibilities of culturing fish in floodplain to increase fish production and productivity. Pen is an enclosure with bottom and sides of netting or bamboo etc., whether floating at the surface or totally submerged. The pen culture system has lots of advantages including- intensive utilization of space, safety from predators, suitability for culturing many varied species, ease of harvest, the flexibility of size and economy, availability of natural food and exchange of materials with the bottom (FAO, 1987) ^[2]. In 2015-16, total seasonal floodplain area was 1.35 lakh ha, only 7553 ha area of Bangladesh was utilized by pen culture system and the total production was 13364 tones, which was 294 tons higher than the previous year (DoF, 2017) ^[1]. As, the fish production and productivity from pen is increasing day by day, therefore pen culture

system can be an effective way to use the unused seasonal floodplains e.g. *Chatol beel* floodplain and make the fish production higher in relation with the demand. In fact, the pen culture technology was completely unknown to the fishers' community related to *Chatol beel* floodplain. By considering the present situation the objectives of this study were- to assess the growth and production of different commercially valuable stocked fish and production of non-stocked fish in *Chatol beel* floodplain by pen culture system, to identify the availability of other aquatic flora and fauna of the selected floodplain and to introduce the local community with the pen culture system and financial benefits compared to the natural dependency.

2. Materials and methods

2.1 Study area and study period

The experiment was conducted in a floodplain of *Chatol beel* situated in Amura Union, Golapganj Upazilla, Sylhet and necessary laboratory work was done inside the post-graduate laboratory of the Department of Fish Biology and Genetics, Faculty of Fisheries, Sylhet Agricultural University, Sylhet. The study was carried out for a period of 135 days, 1 July to 12 November 2017.

2.2 Pen site and pen preparation

The name of selected seasonal floodplain was "*Kiamor ghat*" covering an area of 2.43 ha. The water availability in this floodplain is about 5-6 months generally from July to December. During dry season, this floodplain turned into dry

lands and local people used this chunk of land to cultivate paddies and vegetables. However, in wet season of past years, the local people occupied in this area had left this site fallow and generally depended on the local fish production. The average depth of water during July to December ranges from 1.3-2.5 m. The selected floodplain for pen site was connected to the *Chatol beel* through a channel of 30 m² (10 m × 3 m). The enclosure- bamboo-split fence (locally called *bana*) was made with easily available materials such as- Bamboo split, bamboo poles and posts, nylon rope, GI wire, jute rope etc. The diameter of bamboo-split fence was 60 m² (15 m × 6 m) and installed at the mouth of the channel. The distance between two thin bamboo splits was maintained (≤ 1 cm) to permit the entry of larvae and hatchling of other small indigenous species but prevented the stocked fish from being escaped. Fertilization was necessary to increase the phytoplankton production of the pen. That's why organic fertilizer cowdung @ 5000 kg/ha and lime @ 250 kg/ha were being applied to the pen 10 days before stocking of fish.

2.3 Fish stocking

Healthy seven fish species- Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus cirrhosus*), Grass carp (*Ctenopharyngodon idella*), Sarpunti (*Puntius gonionotus*), Bighead carp (*Hypophthalmichthys nobilis*) and Gonia (*Labeo gonius*) were stocked in the pen at the ratio of 30:20:25:5:10:5:5 with the stocking density of 6250 fingerings/ha. The initial length of fish ranged from 12 to 17 cm and initial average weight was between 15-75 g.

2.4 Management of the pen

A mixture of rice bran (50%), wheat bran (30%) and oil cake (20%) was applied as supplementary feed in the pen @ 3% body weight daily. In fact, equal amount of feed in the form of wet balls was distributed at the four corner of the pen two times in a day. Fish sampling was done fortnightly for feed adjustment. The whole pen including bamboo screen and net was checked regularly. The water quality parameters were measured twice in a month to understand the aquatic condition. Water quality parameters- water temperature, transparency, dissolved oxygen (DO), pH, total dissolved solid (TDS) and level of ammonia were measured by using thermometer (Hg), Secchi disc, Dissolve Oxygen meter (DO-5509), pH meter (EZDO-6011), TDS meter (EZDO-6031) and Aquasol (AE 307), respectively. In addition, depth of the water body was measured and color of the water was observed carefully. For studying growth and feed management, 10 fishes of each species were sampled randomly twice in a month. The weight was measured by digital balance and length was measured by measuring scale.

The following formulae were used to evaluate the growth of stocked fishes:

1. Length gained = Mean final length-Mean initial length
2. Weight gained = Mean final weight-Mean initial weight

$$3. \text{ \% of length gained} = \frac{\text{Length gained}}{\text{Initial length}} \times 100$$

$$4. \text{ \% of weight gained} = \frac{\text{Weight gained}}{\text{Initial weight}} \times 100$$

$$5. \text{ Specific growth rate (SGR)} = \frac{\{\ln W_2 - \ln W_1\}}{(T_2 - T_1)} \times 100$$

Where, W_1 = Initial body weight at time T_1

W_2 = Final body weight at time T_2

2.5 Observation of aquatic inhabitants

Observation of availability of aquatic inhabitants which include- phytoplankton, zooplankton, benthic fauna and aquatic weeds in different months was necessary as stocked and non-stocked fish feed on them, may use as shelter and others. For observing the availability of plankton, the samples were collected from the surface water through fine-meshed plankton nets once in a month. Less than 25 μ m mesh sized net was used for phytoplankton and less than 40 μ m mesh sized net was used to collect zooplankton samples. The samples were immediately preserved with 10% buffered formalin in glass bottles and brought to post-graduate laboratory of Fish Biology and Genetics department for lab assessment. Samples were taken on glass slide by a micropipette and then covered it by cover slide. Then, the prepared slide was placed under a luminous microscope (XSZ21-05DN) for identification of phytoplankton and zooplankton. The phytoplankton and zooplankton were identified to at least genus level (Thompson, 2012) [3]. For observing availability of benthic fauna, clay samples containing benthic fauna were collected once in each month. Clay samples were immediately preserved in plastic container with 10% buffered formalin and brought back to laboratory for lab assessment. In the lab, clay was sieved using 0.2 mm mesh sized sieve to separate micro benthos and macro benthos. Then, the macro benthos was cleaned with distilled water and the micro benthos sample was taken in glass slide by a dropper. Afterwards, the glass slide was covered with cover slide and was placed under the luminous microscope. The benthic faunas were identified to at least genus level (except larval stage) (Robertson *et al.*, 2012) [4]. Identification of weed species at the pen was done by unaided eye observation. The weed samples were collected and brought to laboratory for further identification and the weed was identified up to species level.

2.6 Qualitative and Quantitative estimation of fish production

The fishes were finally harvested from the pen on 12 November 2017. The total production of stocked fish with their total number caught, final length and final weight, and the number and species of non-stocked fish were recorded. In the catches of non-stocked fish, the amount of small (< 25 cm) indigenous fish (SIS) was observed carefully in every catches by counting the total number of individual species in 100 fishes randomly. The non-stocked fishes were identified up to species level by the help of Encyclopedia of Flora and Fauna of Bangladesh, FAO identification sheet and other online references.

The production of fish was evaluated by following formulae

$$1. \text{ Survival rate (\%)} = \frac{\text{No.of fish caught}}{\text{No.of fish released}} \times 100$$

- Total gross production of fish (kg) = gross production of stocked fish (kg) + gross production of non-stocked fish (kg)
- Gross production = No. of fish caught × average final weight
- Net production = No. of fish caught × average weight gained

2.7 Economic return

The benefit-cost analysis was done and net profit was calculated to identify the suitability and viability of culturing fish in floodplain area covering 2.43 ha through pen culture.

- Net profit = Total output (income) - total input (cost)
- Benefit- cost ratio = $\frac{\text{Total output (income)}}{\text{Total input (cost)}}$

2.8 Statistical analysis

Growth and production parameters were analyzed by using one way analysis of variance (ANOVA) to compare mean

values. The ANOVA was followed by Duncan’s Multiple Range Test (DMRT) at 5% level of significance. The statistical analysis was done by using SPSS version 22 and Microsoft Excel 2010.

3. Results and discussion

3.1 Growth of stocked fish

The growth analysis of fish was done by one way analysis of variance (ANOVA) test to determine whether the growth pattern (i.e. growth of different stocked fish species at different time) and growth of stocked fishes were significantly different or not (Table 1). The growth pattern was analyzed by assessing average growth on the basis of mean weight differences and we were failed to reject null hypothesis. It delineated that the average growth pattern by weight of all stocked fish species was not significantly different from each other. However, from the result of one way ANOVA for the average total length and average weight, we were able to reject null hypothesis and it can be assumed that there were significant differences in growth of different stocked fish.

Table 1: One way ANOVA test to analyze the growth in pen

Variable	Sources of variation	Sum of Squares	degree of freedom	Mean Square	F-value	Level of significance	Remarks
Growth pattern	Between samples	67008.53	6	11168.09	1.47	0.212	F _t > F _c
	Within samples	319112.31	42	7597.91			
	Total	386120.84	48				
Average weight	Between samples	1195429.90	7	170775.70	3.23	.007	F _c > F _t
	Within samples	2538292.11	48	52881.09			
	Total	3733722.01	55				
Average length	Between samples	827.29	7	118.18	3.33	.006	F _c > F _t
	Within samples	1704.83	48	35.52			
	Total	2532.12	55				

The final length (cm), length gained (cm), weight gained (g), and specific growth rate was the highest for Grass Carp (*C. idella*) due to presence of higher amount of aquatic weeds in the pen site. However, the length gain (cm), length gained (%), weight gained (g), weight gained (%) and specific growth rate of Mrigal (*C. cirrhosus*) and Catla (*C. catla*) was

comparatively lower because lower availability of planktons and these fishes could not compete with other fishes in feeding on supplemental diet. However, the specific growth rate of Rohu (*L. rohita*), Sarpunti (*P. gonionotus*) and Gonias (*L. gonius*) were almost similar with slight variation (Table 2).

Table 2: Growth study of released fish species (Mean ± Standard Deviation)

Fish species	Average initial length (cm)	Average final length (cm)	Length gained (cm)	% of length gained	Average initial weight (g)	Average final weight (g)	Weight gained (g)	% of weight gained	SGR
Rohu	13.0± 0.3	23.4± 0.8	10.4± 0.8	79.7± 6.9	17.7± 3.3	283.0± 15.5	265.3±14.4	1501.9 267.9	2.64±0.6
Catla	16.3± 0.4	24.5± 1.3	8.24± 1.5	50.52± 9.9	71.5± 5.1	524.6± 20.6	453.2±24.2	633.8± 72.5	1.90±0.4
Mrigal	15.2± 0.2	20.2± 1.0	5.13± 1.1	34.0± 7.7	24.5± 1.9	172.8± 13.2	148.3±14.1	605.4± 92.1	1.86±0.3
Grass Carp	16.1±0.9	45.7± 1.2	29.6± 1.2	183.88±18.6	68.5± 3.8	1573.8±10.3	1505.0±13	2197.1± 127.6	2.98±0.3
Sharpunti	13.7±0.4	21.2± 0.7	7.5± 1.0	54.70± 8.9	16.9± 2.2	253.3± 13.0	236.4±13.9	1397.5±243.8	2.58±0.3
Bighead carp	16.8± 0.4	22.8± 0.4	6.1± 0.5	36.1± 3.5	69± 7.2	257.2± 4.3	193.2± 9.7	301.8± 45.2	1.25±0.2
Gonia	13.2± 0.8	24.3± 0.3	11.0± 1.0	82.5± 12.7	20.5± 1.9	312.6± 7.5	292.2± 9.0	1425.2± 171.9	2.59±0.4

Gorai *et al.* (2006) [5] carried out an experiment by stocking fingerling of Indian major carp seeds (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) in two pens. The specific growth rate (SGR) of *C. catla* was 2.657 followed by *L. rohita* (2.639) and *C. mrigala* (2.515) at the Goruchora wetland, whereas at the 46- Morakollang wetland a better SGR was observed, *L. rohita* (2.678) followed by *C. mrigala* (2.492) and *C. catla* (2.458). In the present study, the exotic carp *C.*

idella had the highest growth because of the presence of higher amount of aquatic weeds. As a result, the total number of aquatic species found was positively correlated with the SGR of *C. idella* at different time, the Pearson correlation value was 0.797 (correlation significant at 0.05 level). However, the specific growth rate of Catla, Mrigal and Bighead carp was lower as they could not compete for supplied feed with other fishes.

3.2 Production, productivity and survival of fish

The highest survival rate was for Grass carp (89.5%) while the survival rate for Rohu (80.9%) and Sharpunti (80.7%) have comparatively lower. However, the highest number of Rohu (3687) was harvested from the pen because of higher stocking density. On the contrary, the lowest number of Sarpunti was recovered from the pen due to the higher mortality during and after stocking. The gross production of fish from the pen was

5282.9 kg which consisted of gross production 4684.9 kg of stocked fish (1927.94 kg/ha/135days) and 598 kg of non-stocked fish (246.09 kg/ha/135days) (Table 3). Therefore, the total production of fish from the *Chatol beel* pen was 2174 kg/ha. Gorai *et al.* (2006) [5] documented the production in terms of fish biomass was estimated at 2106 kg/ha and 1780 kg/ha in Goruchora and 46- Morakollang wetlands of Assam, India respectively. These findings support to the present study.

Table 3: Estimation of harvested fish and fish biomass production from pen (2.43 ha)

Fish species	Harvested fish (nos.)	Survival rate (%)	Species wise Net Production (kg)	Total Net Production of stocked (kg)	Sp. Wise Gross Production (kg)	Gross Production of stocked fis (kg)	Gross Production of non-stocked fish (kg)
Rohu	3687	80.9	978.2		1043.4		
Katla	2583	85.0	1170.4		1355.0		
Mrigal	3130	82.4	464.2		540.9		
Grass Carp	679	89.5	1022.1	4232.8	1068.6	4684.9	598
Sharpunti	1224	80.7	289.4	310.0			
Bighead carp	656	86.3	123.5	168.7			
Gonia	634	83.4	185.2	198.2			

3.3 Production of non-stocked fish within pen

The total amount of non-stocked fish production was 598 kg (246.09 kg/ha/crop). This production consisted of 497 kg (204.5 kg/ha/crop) of SIS and 101 kg (41.6 kg/ha/crop) of other indigenous fish species where Freshwater shark (*Wallago attu*) were contributed- 70.0 kg. In the last year (2016), the natural production of fish (data obtained from the fishers' community) from the 2.43 ha floodplain was 350 kg

(119.3 kg/ha/crop) (Figure 1), which was comprised of 290 kg of SIS and 60 kg of other indigenous fishes. Therefore, there was a massive increase in natural fish production and productivity of SIS in the *Kiamor Ghat* compared to the last year (2016) due to construction of pen which facilitated the entrance of larvae and hatchlings of other fish (Figure 1). SIS was observed at a lion proportion (83.1%) in the total amount of harvested non-stocked fish.

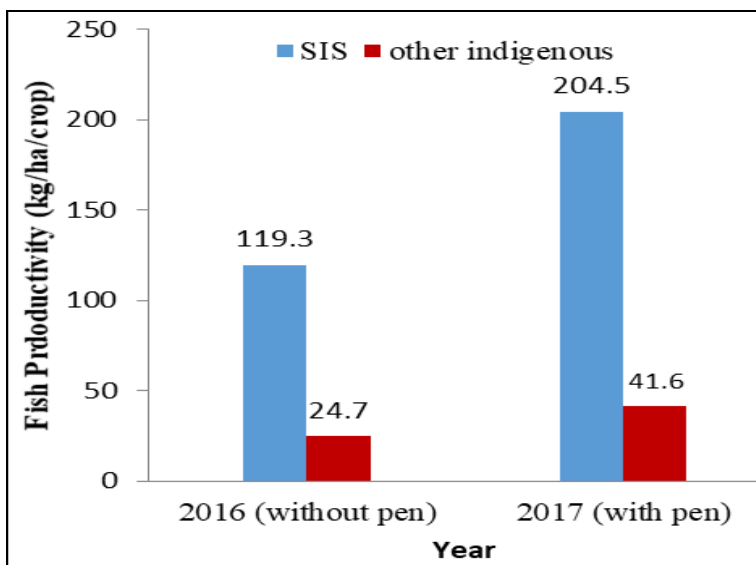


Fig 1: Comparison of productivity of non-stocked fish with the last year

3.4 Fish production from *Chatol Beel* floodplain outside the pen

The natural production (without any technological

intervention) of fish harvested by fishers' community of Amura Union, Golapgonj in 2017 was 6132 kg from 52.5 ha area (116.8 kg/ha) of *Chatol Beel* floodplain (Table 4).

Table 4: Estimation of captured fish outside the pen

Captured fish (kg) in different months												Total production (kg)	Fish Productivity (kg/ha/crop)
July		August		September		October		November		December			
SIS	Other	SIS	Other	SIS	Other	SIS	Other	SIS	Other	SIS	Other		
42	13	68	21	115	34	368	62	1311	210	2986	902	6132	116.8

In the captured fishes from *Chatol Beel* outside the pen, the production of 4890 kg (93.14 kg ha/crop) of SIS and 1242 kg (23.66 kg/ha/crop) (Figure 2) of other indigenous fish species-

Freshwater shark (*Wallago attu*), Shol (*Channa striata*), Ayer (*Sperata aor*), Rohu (*Labeo rohita*), Catla (*Catla catla*), and Mrigal (*Cirrhinus cirrhosus*) etc. were observed. The natural fish productivity was higher within pen than outside of the pen site.

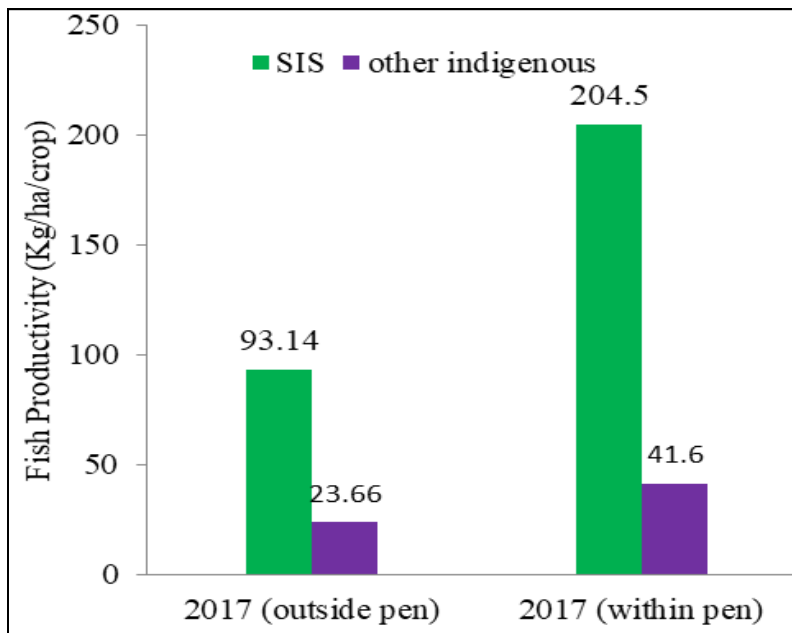


Fig 2: Comparison of productivity of non-stocked fish between outside pen and within pen

Hanif *et al.* (2016) [6] reported 40 species from 19 families of SIS in Gorai River, Bangladesh. However, in the catches of SIS from this pen, 20 different SIS species from 12 families were being found with varying abundance (Table 5). The total species found was lower because of water instability in seasonal floodplains. In the catches of SIS from the pen, abundance of 4 fish species was comparatively higher, 4 species were normal and 2 species were found in moderate

amount. However, the maximum number of 10 fish species was found very low in amount. On the other hand, 31 species from 14 families were found outside the pen in *Chatol Beel* floodplain (Table 5). In the catches of SIS outside the pen, abundance of 7 fish species was comparatively higher, 3 species were normal, 9 species were found in moderate amount and 12 species in very low amount.

Table 5: SIS found with their abundance in catches

Family	Scientific name	Local name	Abundance in Catches (within pen)	Abundance in Catches (outside pen)
Anabantidae	<i>Anabus testudineus</i>	Koi	+	++
	<i>Badis badis</i>	Napit koi	NF	+
Ambassidae	<i>Chanda nama</i>	Shada Chanda	+++	++++
	<i>Chanda ranga</i>	Lal Chanda	NF	++
Bagridae	<i>Mystus tengra</i>	Bujiuri Tengra	+	+
	<i>Mystus vitatus</i>	Tengra	+	+
	<i>Mystus bleekeri</i>	Tengra	NF	+
	<i>Mystus cavasius</i>	Gulsha tengra	NF	+
Belonidae	<i>Xenodon cancala</i>	Kakila	+	++
Channidae	<i>Channa orientalis</i>	Cheng	+	+
	<i>Channa punctatus</i>	Taki	+	++
Clupeidae	<i>Gudusia chapra</i>	Chapila	+++	++++
	<i>Corica soborna</i>	Kechki	++++	++++
Cobitidae	<i>Lepidocephalus guntea</i>	Gutum	+++	+++
	<i>Botia dario</i>	Rani	+	++
Cyprinidae	<i>Esomus danricus</i>	Darkina	++++	++++
	<i>Osteo brama cotio</i>	Dhela	++	+++
	<i>Puntius sophore</i>	Jatpunti	++++	++++
	<i>Amblypharyngodon mola</i>	Mola	++++	++++
	<i>Puntius ticto</i>	Titpunti	+	+
	<i>Labeo bata</i>	Bata	NF	+
	<i>Labeo boga</i>	Bhangon	NF	+

Gobiidae	<i>Glossogobius giuris</i>	Bele	NF	+
Nandidae	<i>Nandus nandus</i>	Bheda	+	++
Osphronemidae	<i>Colisa fasciatus</i>	Kholisa	+	+
Schilbeidae	<i>Pseudeutropius atherinoides</i>	Batashi	+++	+++
	<i>Ailia coila</i>	Baspata	NF	++
	<i>Eutropiichthys vacha</i>	Bacha	NF	++
Siluridae	<i>Ompok pabo</i>	Madhupabda	++	++++
	<i>Ompok bimaculatus</i>	Boalipabda	NF	+
Tetradontidae	<i>Tetraodon cutcutia</i>	Potka	NF	++

NF= Not found; +: Very low; ++: Moderate; +++: Normal; ++++: Higher

From the Figure 3, it is apparent that the family Cyprinidae contributed the maximum proportion of fish species in SIS composition within pen which accounted for 25%. Then, the second highest contributions of 10% each were from 4 families- Bagridae, Channidae, Clupeidae and Cobitidae. However, seven families contributed the least (5% each) in the

species composition. On the contrary, 14 families contributed for the composition of SIS outside the pen. Among them, Cyprinidae contributed the highest proportion with 23%, while Belonidae, Gobiidae, Nandidae and Tetradontidae contributed the least of 3% each.

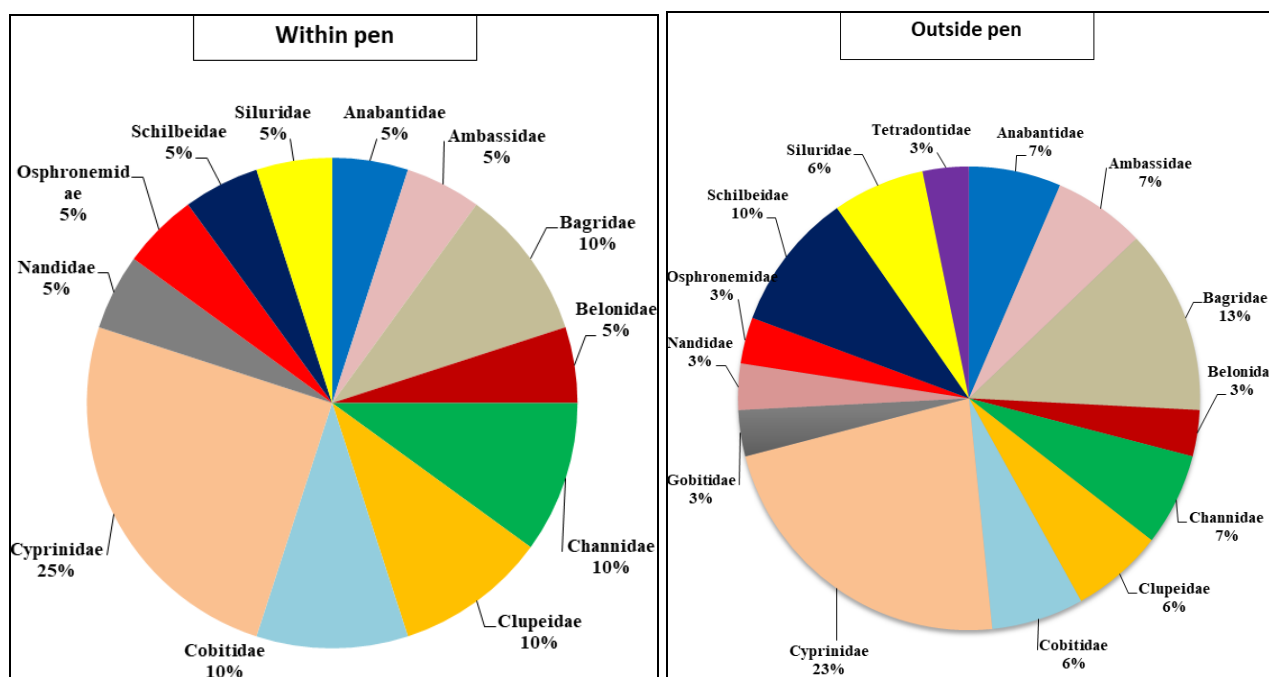


Fig 3: Contribution of different families (%) in composition of Small Indigenous Species (SIS) within pen and outside pen

3.5 Water quality parameters

The water quality parameters (water temperature, DO, pH, TDS, transparency and level of ammonia) of the pen was suitable for culturing fish, though the transparency was quite

higher which indicated lower proportion of natural production (Table 6). So, the supplemental diet was a must to ensure proper growth of stocked fishes.

Table 6: Water quality parameters of different months

Date	Water temperature (°c)	DO (ppm)	pH	TDS	Transparency (cm)	Ammonia (mg/l)
Aug	27	7.3	6.9	30	64	< 0.02
Sep	26	6.9	7.1	35	60	< 0.01
Oct	26	6.2	7.2	30	59	< 0.01
Nov	25	7.2	7.8	38	50	< 0.01
Average	26 ± 0.82	6.9 ± 0.50	7.3 ± 0.39	33.3 ± 3.95	58.3 ± 5.91	<0.013

3.6 Availability of phytoplankton, zooplankton and benthic fauna

Total 9 genera of phytoplankton, 5 genera of zooplankton and 9 taxa of benthic fauna were observed in the study period (Table 7). However, in a study Meghna river estuary 22

different genera of phytoplankton, 32 major taxa of zooplankton and 11 major taxa of macro benthos were observed (Muhammed Sharif, 2017) [7]. The availability of phytoplankton, zooplankton and benthic fauna were lower due to the instability of water in seasonal floodplain.

Table 7: Availability of aquatic inhabitants in different months (August- November)

Inhabitant	Species/ taxa/genera	Availability of individual			
		August	September	October	November
Phytoplankton	<i>Pseudoanabaena mucloi</i>	√	√		
	<i>Chlorella sp.</i>	√	√	√	
	<i>Gyrosigma fasciola</i>	√	√		
	<i>Gyrosigma balticum</i>			√	√
	<i>Stephanopyxis sp.</i>	√		√	
	<i>Skeletonema sp.</i>	√	√		√
	<i>Ceratium sp.</i>	√	√		
	<i>Triceratium sp.</i>			√	√
	<i>Gyrodinium sp.</i>	√			√
Zooplankton	<i>Euglena sp.</i>	√	√	√	
	<i>Brachionus sp.</i>	√		√	√
	<i>Moina sp.</i>	√	√		
	<i>Cyclops sp.</i>	√	√	√	√
	<i>Sida sp.</i>	√	√		
Benthic fauna	<i>Nauplius sp.</i>			√	√
	<i>Hirudo sp.</i>	√	√	√	√
	<i>Tubifex sp.</i>		√	√	√
	<i>Chironomous sp.</i>	√	√	√	√
	Dipteran pupae			√	√
	<i>Sartoriana sp.</i>	√	√	√	√
	<i>Planorbella sp.</i>	√	√	√	√
	<i>Melonia sp.</i>	√	√	√	√
	<i>Viviparus sp.</i>	√	√	√	√
<i>Lamillidens sp.</i>	√	√	√	√	

3.7 Availability of aquatic weeds

The aquatic weeds can be divided into three broad groups- floating, emergent and submerged. Total 21 species of aquatic weeds from 3 groups were found in the pen (Table 8). Among the 3 groups, emergent weeds were the highest in number with 14 weed species, which followed by floating group (5 species)

and the lowest submerged group (2 species). The number of aquatic weed species found in the pen site is not very low compared to other regions. According to investigation of the aquatic weeds diversity and abundance at Noakhali Sadar, Bangladesh, total 22 species of aquatic weeds were observed (Kaisar *et al.*, 2016)^[8].

Table 8: Availability of aquatic weeds in different months

Group	Scientific name	Availability of weed species			
		August	September	October	November
Floating	<i>Eichhornia crassipes</i>	√	√	√	√
	<i>Pistia stratiotes</i>	√	√	√	
	<i>Lemna minor</i>	√	√		
	<i>Wolffia arhiza</i>	√	√	√	
	<i>Azolla pinnata</i>	√	√		
Emergent	<i>Nymphaea pubescens</i>	√	√		
	<i>Nelumbo nucifera</i>	√	√		
	<i>Hygroryza aristata</i>	√	√	√	√
	<i>Trapa natans</i>	√	√	√	√
	<i>Enhydra fluctuans</i>	√	√	√	√
	<i>Polygonum glabrum</i>	√	√	√	√
	<i>Colocasia esculenta</i>	√	√	√	√
	<i>Ipomea aquatica</i>	√	√	√	√
	<i>Cyperus rotundus</i>	√	√	√	√
	<i>Scirpus actus</i>	√	√	√	√
	<i>Ludwigia adscendens</i>		√	√	√
	<i>Commerlina bengalensis</i>	√	√	√	√
	<i>Commelina appendiculata</i>	√	√	√	√
	<i>Sagittaria sp.</i>	√	√	√	√
Submerged	<i>Cartophyllum demersum</i>	√	√		
	<i>Najas minor</i>	√	√	√	

3.8 Economic estimation of pen

The total expenditure of pen included the cost of pen construction (US\$ 275), fish fry (US\$ 735), fertilization and liming (US\$ 301), fish feed (US\$ 2881), transportation (US\$ 181) and other maintenance (US\$ 72). Therefore, the total cost of input was US\$ 4445. On the other hand, the harvested fish (5283 kg) was sold on an average of 1.51 US\$/kg and the total output was the income of US\$ 7977. Therefore, the net profit from the pen was US\$ 3532 (1 US\$ = 83 BDT) and the cost-benefit ratio was 1:1.8, which was comparatively higher due to the deliberate cooperation of local fishers' community which minimized labor cost.

4. Conclusion

The present experiment revealed that utilization of seasonal floodplains through pen culture technology can be considered very significant in different aspects, mainly for increasing fish production of seasonal floodplains, financial profits and creating employment opportunities. In fact, the composite culture of other indigenous and exotic carp by the help of such a pen can facilitate the increased natural fish production. The natural production was higher compared to the previous year. In respect of growth of fishes, *Ctenopharyngodon idella*, which is an exotic carp, had the highest weight gain, length gain and specific growth rate than other stocked fishes due to presence of higher amount of aquatic weeds. However, the availability of phytoplankton, zooplankton and weeds were the lowest in the month November, while the number of species of benthic invertebrate was the lowest in October. From the economic estimation, the net profit from the pen and benefit-cost ratio was outstanding, which worth the practice of pen culture technology in unused floodplains. Further study should be carried out by changing stocking density of fish and use of commercial fish feed or quantification of plankton and weed abundance with their relationship to fish growth.

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6. References

1. DoF (Department of Fisheries). Yearbook of Fisheries Statistical of Bangladesh 2016-17. Fisheries Resources Survey System (FRSS), Department of fisheries, Dhaka, Bangladesh. 2017; 34:129.
2. FAO (Food and Agriculture Organization). Pen culture (enclosure culture) as an aquaculture system, 1987. <http://www.fao.org/docrep/field/003/AC181E/AC181E00.htm>. 14 February, 2018.
3. Thompson PA. Plankton. A Guide to Their Ecology and Monitoring for Water Quality. Austral Ecology, 2012, 273.
4. Robertson T, Sargeant B, Urgelles R, Easton JA, Huselid L, Abreu A. Invertebrate identification guide. Aquatic ecology lab, Florida International University, Florida, United States, 2012, 53.
5. Gorai BK, Sugunan VV, Jha BC. Raising of stocking materials of Indian major carps in pen enclosures in selected floodplain wetlands of Assam, India. Journal of Asian Fisheries Science. 2006; 19(3-4):185-197.

6. Hanif MA, Siddik MA, Nahar A, Chaklader MR, Rumpa RJ. The Current Status of Small Indigenous Fish Species (SIS) of River Gorai, a Tributary of the River Ganges. Bangladesh. Journal of Biodiversity and Endangered Species. 2016; 4(2):162-166.
7. Muhammed Sharif AS. A comparative study on plankton and benthos of the lower Meghna River estuary, Bangladesh. Journal of Aquatic Sciences. 2017; 68(3):338-354.
8. Kaisar I, Adhikary RK, Dutta M, Bhowmik S. Diversity of Aquatic Weeds at Noakhali Sadar in Bangladesh. American Journal Scientific and Industrial Research. 2016; 7(5):117-128.