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Present status of biodiversity in Punuria beel in northern Bangladesh and prospect for using beel as fish nursery

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ABSTRACT

Present status of aquatic biodiversity and the prospect for raising fish fingerlings in Punuria beel in northern Bangladesh has been presented. A total number of 91 species (79 fish, 04 prawn, 01 crab, 02 snail, 01 bivalve and 04 reptiles' species) were identified in the beel during 2006 and 2008. About ten types of fishing gears and crafts were found to be used by the fishers' of the surveyed beel. Increasing use of current jal (gill net), Kapuri jal (sein net) and FAD (Fish aggregating device) were identified as detrimental gear killing almost all type of species. Over a period of 3 years, total production of fish and allied species in the Punuria beel was found to decrease from 96.65±9.22 to 62.60±4.26 mt respectively indicating 35.0% decline. Due to increasing fishing pressure, deterioration of ecosystem health and biological diversity, 6 aquatic fauna were extinct, 16 species were in high risk, 34 species were endangered, 25 species were more or less at risk of extinction, 6 species were in lower risk and 04 species are not threatened from biodiversity view point. In 2009, strict enforcement of fish Act-1950 in Punuria beel resulted in reduced rate of use of current jal, Kapuri jal (sein net) and FAD (Fish aggregating device). Initiation of new technology for production of carp fingerlings in the beel through community based co-management approach and enforcement of Fish Regulation Act-1950, helped to augment productivity of the beel from 62.60±4.26 to 95.58±5.61 mt exhibiting 52.68% biomass enhancement. Two species of fish was found to have reappeared in the beel and surrounding floodplains.

Beel = Seasonally flooded large water bodies on dry-season cropland

Key words: Aquatic lives, biodiversity, carp nursery, extinct, endangered, illegal fishing

In Bangladesh, the beels and floodplains are also important fishing grounds. Once these beel (wet land) had abundant of native wild fish species, crustaceans' crabs and turtles. Due to over-exploitation and various ecological changes of the rivers and beels (wet land), some important fish species and reptiles have disappeared. The breeding and feeding grounds of aquatic lives in and around the rivers and wetlands have been reducing drastically from various human and natural created problems. The aquatic lives in Bangladesh are under severe threat due to over-exploitation and environmental degradation, which includes human interventions through construction of flood control embankments, drainage structures and sluice gates, conversion of inundated land to cropland thereby reducing water area and indiscriminate use of pesticides (Chakraborty, 2010). Pollution from domestic, industrial and agrochemicals wastes and run off have resulted in extinction of a considerable amount of aquatic biota in same stretches of the open water system (Disaster, 1990).

All the beel receives surface runoff water by rivers and khals, and consequently, a beel becomes very extensive water body in the monsoon and dries up mostly in the post-monsoon period. Punuria beel is tectonic in origin and is connected with the Kongsha River. During monsoon the beel gets inundated and becomes part of seasonal floodplain resources with abundant aquatic vegetation. However, through gradual sedimentation, the basin becomes shallower leading to the formation of reeds and sedges. This results in providing enough food and shelter for fish and other aquatic fauna and added fertilizer to the crop land of the beel which promotes rich growth of phytoplankton and macrophytes thus partly contributing to the process of eutrophication.

The basin of the beel supports a large variety of wetland bio-diversity and works as natural reservoir as it plays a key role in basin water resources by regulating water flows of the different River system. In Bangladesh, there are two flood phases: the early flood phase and the deep flood phase. The early flood phase (April to early June) occurs in the early monsoon when the water level in rivers and basin is relatively low. The water level in the floodplain rises and falls in accordance with the water level in adjacent rivers. The deep flood phase (June to September) begins when the water level in the Kangshow River register rapid rise, causing deep flooding in the area of the surveyed beel. Floodwater in flood plains starts receding in the post-monsoon season (October to December). The water recession starts at shallow areas and water surface area shrinks, fishes and other aquatic organism move with water flow into deep water area of the beel (Chakraborty, 2009).

In the past century or so, when the population pressure was less, most of the rim-lands of the beel remained as cultivable wasteland which was mainly used for extensive grazing in the dry season. As population increased, boro cultivation expanded on these marginal lands leading to a large area being drained. Thus, the existence of these wetlands of the beel is now threatened (Chakraborty, 2010).

Owing to massive loss in aquatic biodiversity, a well planned and systematic study was required to assess the present status of biodiversity in the beel with a view to take an appropriate action to preserve and manage the aquatic fauna. The present

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study focuses on the abundance, species combination, catch statistics and related aspects of different beels (wet land). Based on present physiographic conditions of the beels, cost-effective fish fingerlings production technique was developed through co-management community approach which led to enhanced biological productivity of the concerned beels.

MATERIALS AND METHODS

Location and area of the beel

The average area of Punuria beel is 92.0 ha with an average depth 1.69±0.02 m. The location of the beel is Fulpore Upazilla under Mymensingh district in Bangladesh.

Experimental procedure

Detail survey on flora and fauna of the Punuria beel in Mymensingh district was conducted during 2006-2009 with particular emphasis on soil and water quality, biological productivity and biotic communities and status of fishery exploitation. The research was operationalzed through collection of both primary and secondary data, comprehensive literature review and extracts of local knowledge and information. Collection of primary data was made by field observation and different experimentations which comprised of experimental fishing in the beel, survey of different fishing methods, survey of fish markets adjacent to beel, monitoring of hydrological, meteorological, physico-chemical and biological characteristics of beel and fishers' perception as well. Secondary data were collected from Department of Fisheries (DoF) and from the local fishers.

Formation of committee and awareness meeting

Local management committee was formed with the community people living in the vicinity of Punuria beel consisting of 67 members from stakeholders through participatory discussion. The members of the management committee formulated necessary rules and regulations for sharing benefits from beel resources. Regular meeting were arranged fortnightly by the implementing team at every site during the period of 2009 where all stakeholders' representative along with Upazilla Fisheries Officer, Department of Fisheries were present and discussed the progress of the management activities of the beel during investigating period. Agriculture Officer, Department of Agricultural Extension (DAE) was also invited to participate in the awareness meeting.

Morphometry and hydrodynamics of experimental beel

Generally, the main sources of water input into the Punuria beel ecosystem was viz. overspill from the river channel, surface flow and regeneration. Water flows were determined by both rainfall and flooded water from the Meghaloya's hilly range, India. This beel is connected with the Kongsha Rriver by a cannel (khal). In the dry season, almost 70% areas of the beel were dried up except the canals, and khata and kua fishing area where water remains during January to mid-April. Flooding in Mymensingh district originated from inflow of water from the Kangshow River causing resumption of connection between beel and river. The accumulation or exchange of water took place during southwest monsoon when floodplains were flooded. The early flood phase (April to early June) occurred in the early monsoon when the water level in basin was relatively low. The water level in the beel rose and fell in accordance with the water level in adjacent floodplain and adjacent river. Floodwater in flood plain started receding in the post-monsoon season (October to December). The deep flood phase (June to September) begins when the water level in the Kongsha River register rapid rise, causing deep flooding in the area of the surveyed beel. Floodwater in floodplains of the Punuria beel started receding in the post-monsoon season (October to December). After recession of flood, water level in the beel decreased snapping the beel connection with the river. When surface area of the beel was shrinked, fishes and other aquatic organism move with water flow into deep water area of the beel. The beel gets almost dried up through evapo-transpiration and seepage. Except deeper portion of the beel, most of the marginal area where brought under rice cultivation by extracting water from the beel. The water lost by various means caused shrinkage of the effective water area and lowering of depth in the beel which affected the status of the aquatic biodiversity of the Punuria beel.

Study of physico-chemical parameters and plankton

Physico-chemical parameters were followed by the standard method of APHA (1998). A bamboo made meter scale was used to measure water depth. Water temperature was measured using a Celsius thermometer and transparency was recorded by using a Secchi disc of 20 cm diameter. Dissolved oxygen and pH were calculated directly using a digital electronic oxygen meter (YSI Model 58) and an electronic pH meter (Jenway Model 3020). Alkalinity was recorded by titrimetric method (Clesceri *et al.*, 1989). The plankton sample was collected fortnightly from the euphotic zone using 0.55 blotting silk plankton net and later analyzed numerically with the help of Sedgewick-Rafter counting cell (SR-cell) under a compound microscope (Clesceri et al., 1989). Calculation of the abundance of plankton was done by Stirling 1985.

Fishing method

Detail survey on fishing method of the Punuria beel was conducted with particular emphasis on number of different gear and traps. Fishers' used boat for transport of nets and related materials and used seine net or ber jal, komor jal, thela jal, bua jal, lift net, cast net, current jal and various type fish traps, hook and lines; and fishing by dewatering FAD (Fish aggregating device) according to season and availability of different species of fish. During monsoon and post monsoon, fisher's used lift net, current jal, cast net, traps, hook and lines to catch fishes. Fisher's also operated kata fishing by sein net (Ber jal and Komor jal) in winter and spring season.

Data collection

An organized sampling program was run for a long time to get a true picture of the catch and catch composition of experimental beel. The experimental beel were sampled during winter (mid November to mid February), pre monsoon (mid February to April), monsoon (May to August) and post monsoon (September to mid November) for assessment of aquatic lives' abundance and availability. The current study, being a rapid survey, gives only a broad picture of a stock of fishes, crabs, snail and reptiles that was recorded through fish landing centers and different market survey, collection of different species directly from fishers' catch, fishing through enclosure with bana fence (made by bamboo), khata fishing and interaction with fishers'. Resident fish species was recorded through fishing in the deep pool areas (man-made kuas) where water remains during dry season (January to mid April). Shannon index was followed to compare the status of the aquatic lives among different years and the number of six code of IUCN was followed only to categorize the aquatic lives

Shannon diversity index

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

Where:

H = the Shannon diversity index; P_i = fraction of the entire population made up of species I;S = numbers of species encountered; Σ = sum from species 1 to species S.

Note: The power to which the base e (e = 2.7182183) must be raised to obtain a number is called the natural logarithm (ln) of the number.

Nursery development

In 2009, on the basis of status and physical conditions of beel, nursery ground for native carp (Catla, Rui and mrigal) were constructed inside the Punuria beel in Mymensingh district of Bangladesh. The experiment was planned with 3 treatments (locations) designated as, designated as, T_1, T_2 and T_3. The area and average depth of each earthen nursery pond was 0.50 ha and 0.88 m, respectively. The ponds were dewatered, freed from aquatic vegetation and limed (250 kg.ha^{-1}). After liming, the nursery ponds were allowed to dry for about seven days. Then the ponds were filled up with water up to 0.75 m depth. Cowdung (2500 kg.ha^{-1}) was added in the water. Five days after manuring both Urea and TSP were applied to the ponds at the rate of 24.7 kg.ha^{-1} each to stimulate the primary productivity of the ponds. Dipterex (0.5 ppm) was applied to the ponds to control predatory zooplankton and harmful insects 24 hrs before stocking the spawn. The ponds were stocked at the rate of 2.5 kg.ha^{-1} with 4 days old hatchlings Catla, (*Catla catla*), Rui, (*Labeo rohita*) and Mrigal (*Cirrhinus cirrhosus*) having an initial length of 1.01 cm and weight of 0.012 g, respectively.

Supplementary feeding

In order to meet the increasing dietary demand, supplementary feed consisting of a mixture of mustard oilcake, rice bran, wheat bran and fish meal in 30:25:25:20 proportions was supplied at the rate of 9-12% of their total biomass twice daily commencing from the first day of stocking. The rate of feeding was 20 kg.million hatchling^{-1}.day^{-1} for the first one week, 24 kg for the second 2 weeks, 28 kg for the third 2 weeks, 32 kg for the fourth 2 weeks and 36 kg for the fifth 2 weeks. Proximate composition of the feeds was analyzed according to Howritz (1995) method, nitrogen free extract (NFE) by subtraction (Castell and Tiews 1980). Proximate composition (% dry matter) of the supplementary feeds (crude protein, crude lipid, Crude fiber, ash and Nitrogen-free extract) of experimental feeds was 32.80%, 7.84%, 11.15%, 17.84% and 30.37%, respectively.

Water quality parameters and plankton monitoring

Physico-chemical parameters and quantitative and qualitative estimates of plankton in the nursery ponds were monitored at every 10 days interval between 9.00 and 10.00 h. Analysis of physico-chemical parameters and primary productivity was followed according to the procedures described in materials and methods, paragraph 4.

Estimation of growth, survival, production and feed utilization

Fifty individuals from in each pond were sampled at 10 days interval until they attained the fingerlings stage. Growth in terms of length and weight, average daily gain (ADG), specific growth rate (SGR) and food conversion rate (FCR) was estimated. SGR and FCR were calculated according to Brown (1957); Castell and Tiews (1980) and Gangadhara et al. 1997, respectively. After 60 days, the fingerlings were counted and weighed. The fish fingerlings were allowed to move out of the nursery ground in each beel after commencement of early monsoon flood. The fishes were sampled at every 10 days interval to determine the change in their length and weight to adjust daily ration of the fry and fingerlings. Survival rate of fish as well as fish production (kg.ha^{-1}) were also determined as per conventional method.

Analysis of experimental data

The data were analyzed through one way ANOVA using MSTAT followed by Duncan's Multiple Range Test to find out whether any significant difference existed among treatment means (Duncan 1955; Zar 1984).

RESULTS AND DISCUSSION

Physical characteristics of Punuria beel

Soil texture of Punuria beel bed varied from clay to sandy sand. In the deeper bed, structure of soil texture of the bed appeared to have predominantly clay and in the wet land bed the soil was found to be sandy to loam sand (Table 1). Highest percentage of loam sand was recorded in the deeper bed of the beel (69.4±2.47%) respectively.

Table 1: Physical features (sediment) of the surveyed Punuria beel

Name of the beel	Location	Soil texture (%)		
		Clay	Loam sand	Sandy
Punuria beel	Deeper bed	69.4±2.47[a]	29.1±1.64[b]	1.5±0.17[c]
	Wet land bed	18.5±2.28[b]	78.3±3.15[a]	3.2±0.45[c]

Note: Figures with different superscripts in the same row varied significantly (P>0.05)

On the other hand, highest percentage of loam sand in the wet land bed of surveyed beel (78.3±3.15%) was identified. The soil structure of the deeper bed appeared to have predominantly clay and in the surrounding area of the wet land was loamy to clay. Water depth of the beel was recorded 1.82±0.17, 1.81±0.18, 1.80±0.24 and 1.79±0.38 m during the year 2006, 2007, 2008 and 2009, respectively. The highest depth of the beel was recorded in the year 2006 and lowest depth was found in the year 2009. There was a tendency to decrease the depth of the beel bed shallow to shallower between 2006 and 2009 due to siltation and sedimentation. The results of the physico-chemical parameters of the Punuria beel have been furnished in Table 2, which includes temperature, transparency, pH, dissolve oxygen and alkalinity of water were found to be more and less in a normal range.

Table 2: Physico-chemical parameters of Punuria beel

Parameters	Study years			
	2006	2007	2008	2009
Temperature (°C)	24.95±6.06 (14.08-32.92)	25.16±6.15 (14.11-32.84)	24.88±7.26 (14.23-32.68)	25.02±5.12 (14.18-32.85)
Transparency (cm)	29.24±7.24[a] (24.22-42.32)	40.34±6.42[d] (30.32-51.45)	33.52±5.58[b] (26.18-44.34)	37.28±6.88[c] (30.33-47.68)
pH	7.48± 2.17 (6.50-8.64)	7.67±3.06 (6.75-8.75)	7.85±2.24 (6.45-8.85)	7.55±2.12 (6.60-8.78)
Dissolve oxygen (mg L^{-1})	5.24±1.54 (4.22-7.34)	5.15±1.17 (4.14-7.28)	5.04±1.48 (3.88-7.62)	4.95±1.32 (4.01-8.22)
Alkalinity (mg L^{-1})	130.24±9.44[b] (101.23-140.52)	117.22±10.01[d] (105.28-138.18)	123.22±9.28[c] (108.55-139.22)	135.32±9.71[a] (118.80-150.33)

Note: Figures with different superscripts in the same row varied significantly (P>0.05). Figures in the parentheses indicate the range.

It is evident from the Table 2 that the mean water temperatures of the aquatic environment was not statistically significant (P>0.05). Mean Secchi disk transparency differed significantly (P<0.05), during the year 2006-2009. Higher values occurred during post monsoon and summer months due to reduced flow and relatively stable conditions of water. pH of the experimental beel did not differ significantly (P>0.05). A significant rise in pH during pre-monsoon; followed by a drop in winter was noted in the experimental beel. The mean dissolved oxygen (DO) of the experimental beel did not differ significantly (P>0.05). But total alkalinity of the experimental beel differed significantly (P<0.05).

Plankton population

Increased plankton abundance in the Punuria beel was observed particularly in the month of June and July; and lowest count was obtained in December and January (Table 3) in the survey period. The phytoplankton consisted of 27 genera in the Punuria beel in four broad groups' *viz.*, Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae. Chlorophyceae contributed the genera were *Protococcus, Mougeotia, Microspora, Mesotenium, Clasterium, Eremesphaera, Chlorococcum, Ophiocytium, Penium, Spyrogyra, Zygnema, Kirchneriella, Gonotozygon, Pediastrum, Oocystis, Tetraedron, Volvox.* Bacillariophyceae included various species belonging to genera

Melosira, *Diatoma*, *Fragilaria* and *Navicula*. Cyanophyceae included the genera of *Anabaena Chroococcus*, *Gomphospheria*, *Merismopedia*, *Mycrocystis* and *Oscillatoria*. Chlorophyceae was the dominant group which was significantly higher ($P<0.05$) during four years study. The abundance of Bacillariophyceae differ significantly ($P<0.05$) in different years. The mean abundance of total phytoplankton differed significantly ($P<0.05$) during investigation period. The phytoplankton consisted of 12 genera in the Punuria beel in four broad groups' Rotifera and Crustacea. Rotifera included *Brachionus calyciflorus*, *Filinia longiseta*, *Keratella cochlearis* and *Trichocera sp.*and Crustacea included *Bosmina sp*, *Cyclops americanus,Daphnia longispina*, *Diaptomus oregonensis*, *Lecane sp.*, *Moina sp.*, *Oicomonas sp*, and Nauplius. Rotifera and Crustacea e significantly differed ($P<0.05$) in the beel during investigation period. The mean abundance of total zooplankton differed significantly ($P<0.05$) during different years.

Table 3: Mean variation of phytoplankton (individual.ml^{-1}) and zooplankton (organism.ml^{-1}) population in the Punuria beel

Plankton group ($\times10^3$ cells L^{-1})	Years			
	2006	2007	2008	2009
Chlorophyceae	20.15±4.44^b	18.52±5.01^c	17.74±4.32^d	21.18±4.12^a
	(18.25-24.24)	(16.11-22.47)	(15.57-22.32)	(18.04-24.02)
Bacillariophyceae	13.84±3.54^c	14.21±4.34^b	16.04±3.54^a	12.88±2.16^d
	(11.03-16.48)	(12.68-17.14)	(12.33-18.92)	(10.14-16.64)
Cyanophyceae	6.18±1.08^d	8.06±2.32^a	6.92±2.18^c	7.68±2.05^b
	(5.15-9.48)	(7.01-10.52)	(5.05-9.44)	(5.52-10.42)
Euglenophyceae	0.08±0.00^b	0.07±0.02^c	0.10±0.02^a	0.06±0.02^d
	(0.04-0.10)	(0.03-0.09)	(0.05-0.32)	(0.04-0.50)
Total Phytoplankton	40.25±8.77^c	40.86±8.01^b	40.80±8.24^b	41.80±8.88^a
Rotifera	7.04±1.82^a	5.66±1.22^c	5.28±1.35^d	6.34±1.42^b
	(5.10-8.96)	(4.61-6.78)	(4.10-6.26)	(4.82-7.90)
Crustaceae	4.88±1.66^c	4.24±1.12^b	3.82±1.22^d	4.42±1.22^a
	(3.62-6.27)	(3.51-6.72)	(3.01-5.58)	(3.05-5.62)
Others	1.18±0.50^d	1.22±0.62^c	1.55±0.42^a	1.38±0.86^b
	(1.02-2.01)	(1.11-2.58)	(1.18-2.22)	(0.99-2.02)
Total Zooplankton	13.10±2.93^a	11.12±2.27^c	10.65±1.881^d	12.14±2.50^b

Note: Figure in the same row having different superscripts varied significantly ($P>0.05$). Figures in the parentheses indicate the range.

Macrophytes

A total number of 14 species belonging to 14 genera and 12 families of aquatic weeds were identified from four surveyed beel (Table 4). The Macrophytes consisted of 11 families in the experimental beel *viz.*, Lemnaceae, Pontederiaceae, Gramineae, Marsiliaceae, Najadaceae, Compositaceae, Commelinaceae, Convolvulaceae, Nymphaceae, Menyanthaceae and Myrtaesae. A total number of 14 species of marginal and submerged aquatic macrophytes were recorded from the beel. These macrophytes provide shelter to the periphyton and other aquatic insects, and act as a source of nutrition to the aquatic animals. *Najas najas* species was dominant among the identified weeds. The eggs of prawn and different fish species were identified into the *N. najas* and water hyacinth (*Eichhornia crassipes*) during summer to winter. Water hyacinth usually covered a layer on the surface of Khua in the deep. However, due to changing ecosystem health, using pressure of human consumption and cattle food, the percentage (%) of the population of aquatic weeds was reduced day by day.

Uses of fishing craft and gears

Generally fishers' used boat for transport of nets and related materials and used seine net or ber jal, komor jal, thela jal, bua jal, lift net, cast net, current jal and various type fish traps, hook and lines; and fishing by dewatering FAD (Fish aggregating device) according to season and availability of different species of fishes. During monsoon and post monsoon, fisher's used lift net, current jal, cast net, traps, hook and lines to catch fishes. Fisher's also operated kata fishing by sein net (Ber jal and Komor jal) in winter and spring season. Many fish trap (vair, dugair, ghuni and pholo etc.) and hook and line (barshi, fulkuichi, Jhupi aikra etc.) were used to capture different groups of aquatic lives. The percentage of catch statistics of Punuria beel by using prohibited current jal, ber jal (kaperi jal) and FAD were 27.50%, 14.20% and 9.20% in 2006; 30.10%, 16.40% and 10.10% in 2007; 33.76%, 19.30% and 11.80% in 2008, respectively (Fig. 1). There were significant differences in the extent of use of different categories of fishing gears among different years. A significant trend in fish catches was observed with thela jal, dharma jal, bua jal, lift net, cast net, fish trap, and hook and line during thereporting period. A significant decline in the abundances of fish population could be accounted for due to indiscriminate use of the illegal fishing gears as mentioned above. Increased abundance of aquatic lives was presumed to be resulted with loss of use of destructive fishing gears. In 2009, community based co-management approach in Punuria beel also resulted in reduced uses of current jal (33.76-10.80)%, ber jal (19.30-11.20)% and FAD (11.80-9.70)% which consequently lead to higher productivity of the beel.

Table 4: The percent decrease of aquatic weeds of Punuria beel between 2006 and 2009

Type	Local & Scientific name	Decrease of aquatic weeds between 2006 and 2009 (%)		
		2006-07	2007-08	2008-09
Floating	Edurkanipana, *Wolffia arrhiza* and Kachuripana, *Eichhornia crasssipes*	11.22	14.04	17.11
Emergent	Dal, *Hudroryza aristota* and Shusnishak, *Marsilea quadrifolia*	10.11	12.58	16.25
Submerged	Najas, *Najas najas*	11.15	13.22	15.55
Spreading	Helencha, *Enhydra flucktuans*; Arail, *Leersia hexandra*; Kanaibashi, *Commelina bengalensis* and Kalmilata, *Ipomoea aquatica*	10.11	13.58	16.25
Rooted plants with floating leaves	Shapla, *Numphaea nouchali*, Padma, *Nelumbo nucifera*; Amazan lili, *Victoria amazonica* and Chandmala, *Nymphoides cristata*	9.44	11.17	14.85
Rooted plants	Hizal, *Barringotonia acutangula*	10.14	16.44	23.12

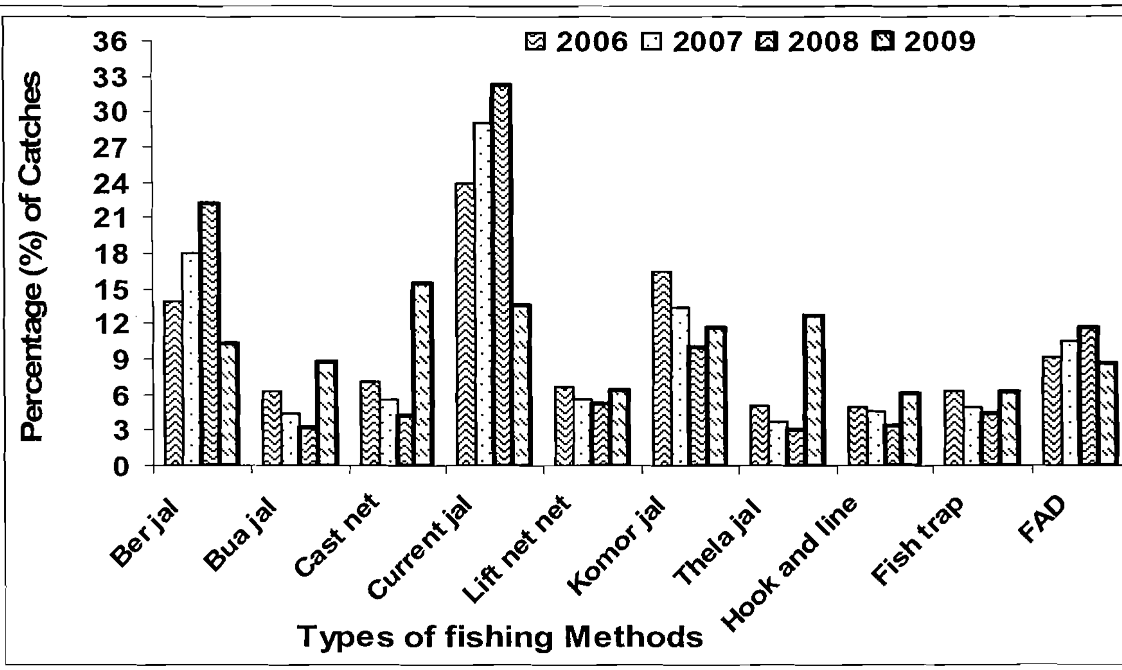

Fig. 1. Percent of catch composition by different types of fishing gear between 2006 and 2009 in Punuria beel

Catch and catch composition of the beels

Present status of available position of fish species and related organisms is furnished in Table 6. Fishing activity in the Punuria beel indicated the presence of 91 aquatic wild lives (80 species of wild fishes, 04 species of prawn, 01 species of crabs, 02 species of snail, 01 species of bivalve and 03 species of turtles) belonging to 51 genera and 24 families. The annual catch estimation of the Punria beel was around 96.65±5.41; 74.88±4.07, 62.6±3.67 and 95.58±5.44 mt in the year 2006, 2007, 2008 and 2009, respectively; represented by 10 groups of aquatic fauna (Fig. 2). From the catch statistics it was found that fishing pressure had been escalating between the year 2006 and 2008 with consequence of reduced level of fish. Production declined from 22.0% to 35.0% during the year 2007 to 2008; but the total production went up to 99.6% in 2009 due to the practice of a beel nursery and implementation of community based co-management policy (Table 5).

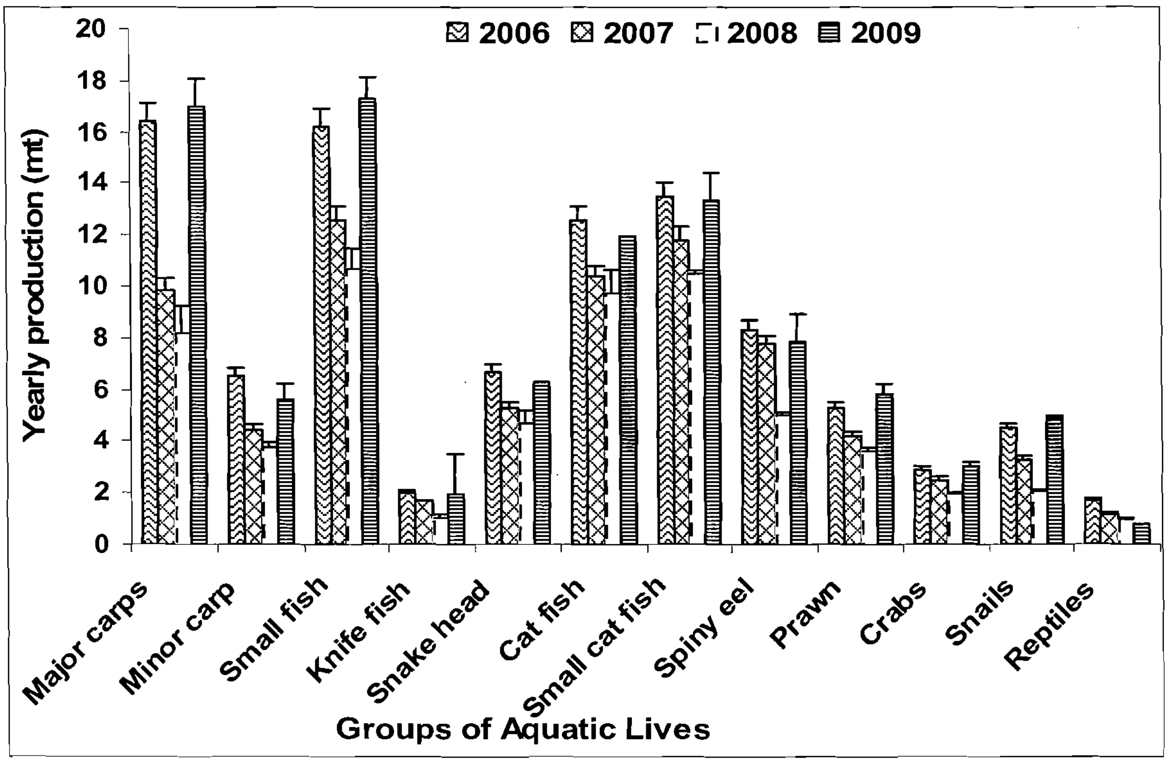

Fig. 2. The production of different groups of aquatic fauna in the Punuria beel was decreasing between 2006 and 2008, and increasing in 2009

Table 5: Change inproduction percentage of aquatic fauna in the Punuria beel

Groups of aquatic lives	Decreasing production (%)		Increasing production (%)
	2006-07	**2007-08**	**2008-09**
Major carp	41.19	51.07	103.16
Minor carp	32.21	42.6	85.04
Small fish	22.5	34.28	106.35
Knife fish	17.33	45.05	97.52
Snake head	20.96	29.79	94.01
Cat fish	17.41	22.1	94.75
Small cat fish	12.44	21.85	98.59
Spiny eel	6.96	39.26	96.88
Prawn	21.06	30.36	110.44
Crabs	13.79	54.44	103.79
Snails	27.46	53.57	109.38
Reptiles	30.36	41.67	54.16

Commercially important aquatic lives nandina, (*Labeo nandina*) and local sarpunti (*Puntius sarana*), Gagot (*Gagata nangra*), Gojar (*Channa marulius*) and Reptiles (*Kachuga tecta* and *Morenia petersi*) were rarely found in the year of 2006. However, these species were extinct (E) between 2007 and 2008. Sixteen commercially important aquatic species was Critically endangered (CR), thirty four major commercial importance aquatic wild species of the beel was Endangered (EN), twenty five species was Vulnerable status (VL), six species were identified as Lower Risk (LR) and only four species was Not threatened (NO) position, respectively (Table 6). The status of the 91 aquatic wild lives of the Punuria beel was 7% (E), 18% (CR), 37% (EN), 27% (VU), 7% (LR) and 5% (NO), respectively (Fig. 3). Community based co-management policy, a technology of beel nursery and enforcement of Fish Regulation Act-1950 helped to upgrade the habitat of the surveyed beel. As a result, a remarkable production was recorded and Bata (*Labeo bata*) and Along (*Rasbora elanga*) reappeared in the beel and the total production percentage (%) also increased in 2009. During investigation periods, fresh water pearl bearing mussels (Bivalve, *Lamellidens marginalis*) were recorded in the surveyed beel. Shells of bivalve were utilized by rural people for production of lime which was utilized in aquaculture and agriculture land, and consumed with betel leaves and nuts. Wildlife includes, amphibians (*Buffo melanostictus*, *Rana tigerina*, *Rana limnocharis*, *Rana cyanophyctis* and *Salamandra salamondra*) aves (whistling duck, great crested grebe, great cormorant, red crested pochard, water cock, swamphen, great black headed gull, gray-headed fish eagle, curlew, spotted redshank) and mammals (musk shrew, fishing cat, small Indian jackle, flying fox) were identified.

Table 6: Status and distribution of aquatic lives of Punaria beel

Status Indicator	Bengali and Scientific name
E	Nandina, (*Labeo nandina*), Puda/sarpunti (*Puntius sarana*), Gajar (*Channa marulius*), Gang tengra (*Gagata nangra*), Reptiles (*Kachuga tecta* and *Morenia petersi*)=06
CR	Bata (*Labeo bata*), Along (*Rasbora elanga*), Laubuca (*Chela laubuca*), Bhagna (*Cirrhinus reba*), Dhela (Rohtee *cotio*), Batasi (*Pseudeutropius atherinoides*), Baghair (*Bagarius yarrellii*), Gulsa (*Mystus cavasius*), , Modhu pabda (*Ompok pabda*), Naptani (*Ctenops nobiilis*), Pabda, (*Ompok pabo*), Ghura chela (*Securicola gora*), Vul (*Barilius bola*), Korsula (*Rhinomugil corsula*) and Reptile (*Chiitra indica* and *Lissemys punctata*)=16
EN	Khoksa (*Barilius vagra*) Calbaus (*Labeo calbasu*), Ghonia (*Labeo gonius*), Jili punti (*Puntius gelius*), Mola (*Amblypharyngodon mola*), Phutani punti (*Puntius phutunio*), Jat punti (*Puntius Sophore*), Fulchela (*Salmostoma phulo*), Khalisha (*Colisa fasciata*), Lal khailsha (*Colisa lalia*), Chuna Khalisha (*Colisa sota*), Kanpona (*Oryzias melastigma*), Mini (*Nundas nandus*), Rani/Botya (*Botia Dario*), Kakila (*Xenentodon cancila*), Potka (*Tetrodon cutcutia*), Rani (*Botia dayi*), Gang tengra (*Gagata nangra*) Chitol (*Notopterus chitala*), Shol (*Channa striatus*), Koi (*Anabas testudineus*), Ayre (*Aorichthys aor*), Guzia (*Aorichthys seenghala*), Rita (*Rita rita*), Kani papda (*Ompok bimaculatus*), Kajuli (*Ailia coila*), Bacha (*Eutropiichthys vacha*), Napit (*Badis badis*), Gharua (*Clupisoma garua*), Magur (*Clarius batrachus*), Baim (*Mastacembalus armatus*), Kuicha (*Monopterus cuchia*) Tara Baim (*Macrognathus aral*) and Galda isa (*Machrobrachium* rosenbergii)=34
VU	Catla, (*Catla catla*), Rui, (*Labeo rohita*), Mrigal (*Cirrhinus cirrhosus*), Taka punti (*Puntius conchonius*), Tit punti (*Puntius ticto*), Teri punti (*Puntius terio*), Darkina (*Esomus danricus*), Chapila (*Gadusia chapra*), Batasi (*Pseudontropius atheronoides*), Nama chanda (*Chanda nama*), Kata chanda (*Pseudambasis bacuculis*), Kachi (*Corica soborna*), Ranga chanda (*Pseudambasis ranga*), Gachua (*Channa gachua*), Taki (*Channa punctatus*), Boal (*Wallago attu*), Tengra (*Mystus vitttus*), Singi (*Heteropneustes fossilis*), Guchi baim (*Macrognathus pancalus*), Gura chingri (*Machrobrachium birmanicum*) Shotka chingri (*Machrobrachium malcolmsnii*), Bivalvia (*Lamellidens marginalis*), Snail (*Cyclophorus involvulus* and *Pila globosa*) and *Kakra* (*Stylla serrata*)=25
LR	Common carp (*Cyprinus carpio*), Silver carp (*Hypophthalmicichthys molitrix*), Bujuri (*Mystus tengra*), Grass carp (*Ctenopharyngodon idellus*), Gutum (*Lepidocephalus gontea*) and Foli (*Notopterus notopterus*)=06
NO	Thai sarpunti (*Puntius gonionotus*), Gkatakia chingri (*Machrobrachium villosimanus*), Bala (*Glossogobus giuris*) and Kakra (*Stylla serrata*)=04.

Note: E-Extinct, CR- Critically Endangered, EN- Endangered, VU-Vulnerable, LR-Lower risk, NO- Not threatened; followed as per Shannon Diversity Index

Beel nursery

Water quality parameters of the beel nursery

The physico-chemical parameters of the nursery ponds are furnished in table-7. The physico-chemical parameters, which included temperature, transparency, pH, oxygen and alkalinity of water, were found to be in suitable range for warm water fish culture. It is evident from data in table- 7 that phytoplankton and zooplankton were found to be in abundantly present for fingerlings culture of nursery ponds. Growth and production parameters of fingerlings are shown in table- 8 and fig.- 4. The initial length and weight of spawns, stocked in all the nursery ponds of the beel were similar. The fish (spawn) in all treatments showed the more or less similar gain in both of length and weight, where stocking density of spawn was 2.5 kg ha^{-1}. However, the mean final length and weight of fingerlings in different treatments were not significantly different (P>0.05).

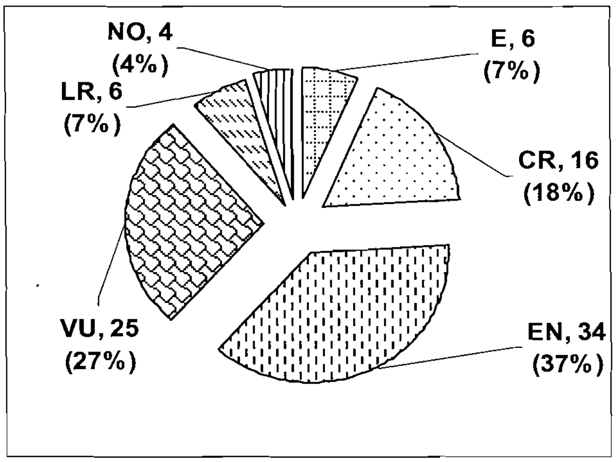

Fig. 3. Status and position of different species of aquatic lives in the Punuria beel during 2006-09

Table 7: Mean variation of phytoplankton (individual.ml^{-1}) and zooplankton (organism.ml^{-1}) population in the experimental beel nursery ponds under different treatments

Plankton group	Treatment		
	T_1	T_2	T_3
Chlorophyceae	100.52±6.08[c]	105.38±6.08[a]	104.43±8.00[b]
	(94.33-108.33)	(94.00-111.33)	(88.33-111.00)
Bacillariophyceae	84.24±1.37[c]	90.81±0.54[b]	96.0±1.12[a]
	(77.33-80.67)	(90.00-91.67)	(94.67-97.33)
Cyanophyceae	58.00±0.77[c]	57.52±1.48[b]	61.24±0.83[a]
	(50.00-52.50)	(53.33-57.00)	60.00-62.33)
Euglenophyceae	4.09±0.31[a]	3.14±0.38[b]	2.38±0.30[c]
	(3.67-4.33)	(2.67-3.67)	(2.00-2.67)
Total Phytoplankton	246.85±41.02[c]	256.85±45.48[b]	264.05±46.36[a]
Rotifera	10.62±1.42[c]	11.81±1.53[b]	12.28±0.80[a]
	(8.33-12.67)	(9.67-13.67)	(11.67-15.33)
Crustaceae	5.55±0.29[b]	5.10±0.19[c]	6.42±0.39[a]
	(3.09-3.88)	(4.29-4.75)	(5.82-6.80)
Others	2.19±0.12[b]	2.67±0.02[a]	1.74±0.02[c]
	(2.01-2.33)	(1.55-1.78)	(2.60-2.79)
Total Zooplankton	18.36±4.52 [c]	19.58±4.84 [b]	20.44±5.28 [a]

Note: Figure in the same row having different superscripts varied significantly (P>0.05). Figures in parentheses indicate the range.

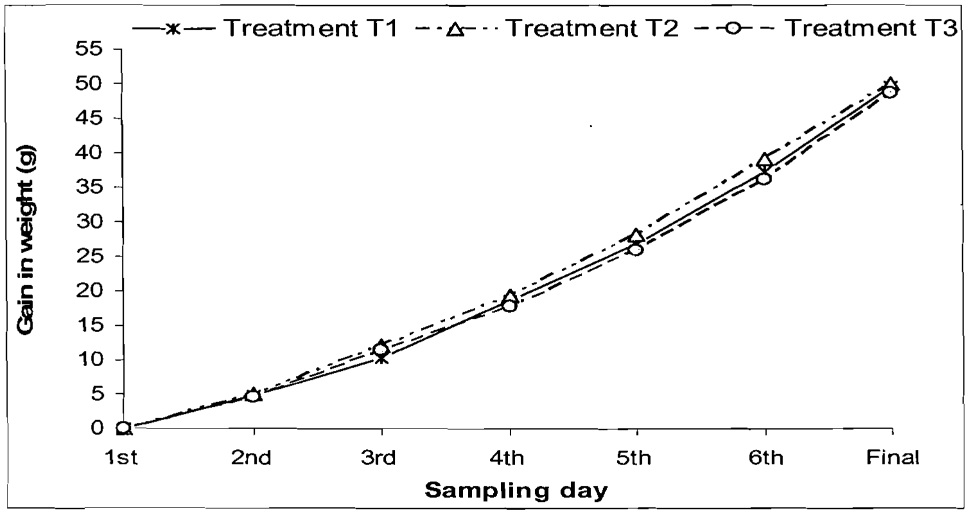

Fig. 4. Gain in weight (g) of carps fry and fingerlings in different treatments at every 10 day interval

The highest weight gain was also more or less similar. Therefore, SGR, FCR and survival rate were more or less similar in all the beel nurseries. There was no significant variation (P>0.05) in the value of SGR, FCR and survival rate in Catla, (*Catla catla*), Rui, (*Labeo rohita*) and Mrigal (*Cirrhinus cirrhosus*) fry and fingerlings among different beel nurseries. The initial length and weight of fish spawn were almost identical. It is evident from the data that the fry attained an average size of 10.66 cm in length and 47.57±3.94 g in weight in treatment T_1, 10.48 cm in length, 50.02±4.07 g in weight in treatment T_2 and 10.62±1.85 cm in length, 48.33±4.11 g in weight in treatment T_3, where same feed with mustard oil cake (30%), rice bran (25%), wheat bran (25%) and fish meal (20%) were maintained. It is clearly indicated that the growth in weight was exhibited by the fry and fingerlings when they were supplied same quality/amount of feed stuff, showing a direct correlation between feed stuff and growth of fish. The mean productions (number.ha^{-1}) of fingerlings were 420,955, 435,574 and 428,049 in treatment T_1, T_2 and T_3, respectively (Table 8 & Fig. 4)). Production was very much similar in all the treatments and production of fingerlings was not differed significantly (P<0.05) among the different treatments.

Table 8: Growth, survival and production of carp fry and fingerlings after sixty days of rearing (Mean ± SD)

Parameters	Treatments		
	T_1	T_2	T_3
Initial length (cm)	1.01±0.05	1.01±0.05	1.01±0.05
	(0.92-1.06)	(0.92-1.06)	(0.92-1.06)
Final length (cm)	10.66±2.12^a	10.48±2.02^b	10.62±1.85^c
	(7.44-13.81)	(7.48-14.11)	(7.28-13.90)
Initial weight (g)	0.013±0.002	0.013±0.002	0.013±0.002
	(0.010-0.015)	(0.010-0.015)	(0.010-0.015)
Final weight (g)	47.57±3.94^a	50.02±4.07^b	48.33±4.11^c
	(45.30-54.27)	(44.88-53.84)	(44.77-53.55)
Net weight gain (g)	47.56±3.58^a	50.01±3.61^b	48.32±3.34^b
	(44.58-54.22)	(44.11-54.58)	(44.18-54.22)
Average daily gain(g)	0.79±0.02^a	0.83±0.02^b	0.81±0.02^c
	(0.73-0.85)	(0.77-0.84)	(0.74-0.81)
Specific growth rate	13.82±0.42^a	13.89±0.62^b	13.33±0.66^c
	(13.35-14.05)	(12.94-14.76)	(12.52-13.8 4)
Survival rate (%)	70.05±0.85^a	72.60±0.71^b	69.88±0.66^c
	(69.6-74.80)	(70.24-75.55)	(68.80-75.24)
FCR	1.32±0.01^a	1.43± 0.01^b	1.73±0.01^c
	(1.02-1.42)	(1.10-1.58)	(1.12-1.96)
Production ha^{-1} #	420955±21.22	435574±52.45	428049±44.18

Note: Figure in the same row having different superscripts varied significantly (P>0.05). Figures in parentheses indicate the range. # Total number of fingerlings harvested after 60 days.

The physico-chemical factors and plankton were found to be more or less in normal range in the surveyed beel which is agreed by APHA (1998). Water temperature of the beel showed increasing trend in monsoon and post monsoon season and decreasing trend in winter which is supported by Mathew (1975). The temperature of the nursery ponds was within the acceptable range that agrees well with the findings of Haque et al. (1993). Transparency was consistently higher in deeper portion of the beel, possibly due to stagnancy of water. Rahman (1992) stated that the transparency of productive water bodies should be 40 cm or less. The uniformly average value of oxygen range (4.05-7.65mg L^{-1}) as noted in the beel agrees well with the findings of APHA (1998) and fluctuation of dissolve oxygen concentration in the beel nursery might be attributed to photosynthetic activity and variation in the rate of oxygen consumption by fish and other aquatic organisms (Boyd, 1982). pH (6.45-8.86) values of the beel was more or less similar with the findings of Chakraborty et al. (2003). An alkalinity level of the beel was medium to high (Clesceri *et al.,* 1989). Alkalinity levels indicate medium to higher level of productivity. Higher total alkalinity values in the nursery ponds might be due to higher amount of lime used during beel nursery preparation (Boyd 1982).

The phytoplankton consisted of 27 genera and the zooplankton population consisted of 12 genera, which was more or less similar to the observation of Sugunan and Bhattacherjya, 2000. In the nursery ponds, the phytoplankton abundances were consistently higher than that of zooplankton. Similar results were also recorded in various food fish, and fry and fingerling rearing ponds (Chakraborty *et al.*, 2003). Higher phytoplankton concentrations in water normally indicate higher productivity. The higher abundance of phytoplankton compared to zooplankton might be due to fertilization and excess uneaten feed (Sugunan and Bhattacharyya, 2000; Keshavanath *et al.*, 2002).

A total number of 14 species of marginal and submerged vegetation was observed in the floodplain and beel, which are comparable with the finding of Sugunan and Bhattacharyya (2000) in case of floodplain of Brahmaputra basin. The swamp forests, mainly represented by hijal tree (*Barringtonia acutangula*) have been reduced to a few small patches in the surveyed area.

In this experiment, crude protein levels (32.88 % dry weight) in supplementary feeds was very near the dietary protein of 31% for the optimal growth of *Labeo rohita* (De silva and Gunasekera, 1991). Growth in terms of length, weight, weight gain and SGR of fingerlings of carp fry and fingerlings was more or less similar in the surveyed beel where the stocking density was the same. According to Chakraborty et al., 2006, higher density of fish causes competition for food and habitat. De Silva and Davy (1992) stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. Digestibility, in turn, depends on daily feeding rate, frequency of feeding, and type of food used (Chiu *et al.*, 1987). However the FCR value in the present study indicates better food utilization efficiency, despite the values increased with applied stocking densities.

Thripathi *et al.* (1979) and Chakraborty *et al.* (2003) found higher stocking density of fry and fingerlings of carp as well as competition for food and space reduces survival rate. But there was no competition for food and space in the experimental nursery ponds due to same stocking density (2.5 kg ha^{-1}). Saha *et al.* (1988) and Chakraborty *et al.* (2003; 2006) stated that low growth at higher stocking densities could be due to less availability of natural food and some variations in environmental parameters. In this experiment, same stocking density was maintained and the amount of supplementary feeds given in different treatments was based on the number of hatchlings stocked and amount of feed provided per fry was kept at the same level.

Finally, it is concluded that the survival, growth, production of carp fingerlings were more or less similar due to the same stocking densities of hatchlings. Stocking density of 2.5 kg hatchlings.ha^{-1} is a standard density of stocking for rearing of carp fingerlings for 60 days in single-stage nursing. Production of requisite quantity of higher quality fish fingerlings within the beel premises may be helpful towards the protection of Catla, (*Catla catla*), Rui, (*Labeo rohita*) and Mrigal (*Cirrhinus cirrhosus*) from extinction as well as ensuring its conservation and rehabilitation.

The fishing effort with various types of fishing gears such as seine net (kaperi jal), gill net (current jal) and FAD had been increasing between the year 2006 and 2008 but use of current jal was increased rapidly during same period. As a result, an average size and number of aquatic lives declined in those beels and floodplains. Haroon *et al.* (2002) reported eighteen types of fishing gears recorded from the Sylhet sub-basin and thirteen types from Mymensingh sub-basin which were very similar to this study. Sugunan and Bhattacharyya (2000) found a wide variety of fishing methods employed in the beels of Assam, India which were very similar to the present study. Cast net (Jaki jal) was used whole year in the beel. It is a very popular fishing method and used in all over the Bangladesh (Ahmed, 1962).

The catch statistics indicate that fishing pressure of the beel increased in the year 2006 to 2008. As a result, a decreasing trend in production percentage of the beel was clearly pronounced within three years which is very similar to the report of Moyle and Leidy (1992). They found that worldwide 20% of all freshwater species are extinct, endangered or vulnerable. The total catch statistics of aquatic lives in the surveyed beel indicated that percentage of different group of aquatic lives sharply decreased within three years which are very similar to the study of Chakraborty (2009); Chakraborty and Mirza, (2007). Shannon Diversity Index was used to identify the present status and indicators of IUCN (2000) were used to categorize the present status of the Punuria beel.

In the Punuria beel, commercially important aquatic fauna Nandina, (*Labeo nandina*), Puda/sarpunti (*Puntius sarana*), Gajar (*Channa marulius*), Gang tengra (*Gagata nangra*), Reptiles (*Kachuga tecta* and *Morenia petersi*) were rarely found in the year of 2006 in the surveyed beel. However, these species were extinct between 2007 and 2008. Sixteen commercially important aquatic species in Punuria beel was facing as extremely higher risk of extinction (Critically endangered, CR) day-by-day. Thirty four commercially important aquatic wild species was facing as extremely high risk of extinction (Endangered, EN), 25 aquatic wild species was Vulnerable status (VL), six species was identified as Lower Risk (LR) and only four species of the surveyed beel was Not threatened (NO) position, respectively. According to IUCN 1998, Bangladesh about 56 freshwater fish species is critically or somewhat endangered. Due to over-exploitation and various ecological changes in natural aquatic ecosystem health such as beel (wetland) and its floodplain, commercially important aquatic lives are in the verge of extinction which is in agreement with the findings of Sarker (1993).

During winter season, turtles (*Morenia petersi* and *Kachuga tecta*) were caught in the beel and its flood plain. Khan (1982) reported that *K. tecta* are mainly distributed between the stretches of Ganges River and the Brahmaputra River. Bengal Eyed turtle, *Morenia petersi* was found in the beel and its floodplain. Das (1991) mentioned its occurrence in Assam of India. Turtles of the surveyed beel and its floodplain declined because of dewaterization of its habitat for irrigation and destruction of its breeding ground and nesting sites. Over exploitation for local consumption and foreign trade indiscriminately posses a threat to all species of turtles as well. The population of bivalve, *Lamellidens marginalis* as found in the beel and its floodplain, has also been decreasing which is consistent with the observation of Ali (1991).

The study clearly indicated that the aquatic lives of the beel were subjected to over fishing resulting in gradual decline in aquatic population. In addition, aquatic ecosystem health is changing due to construction of flood control barrage, soil erosion, siltation and drainage structures and agro-chemicals. Domestic organic wastes (sewage) directly or indirectly passing through canals or drains to the rivers or canals polluted the aquatic ecosystem health. The genetic stock structure of aquatic populations was reduced due to pollution and destructive fishing practices (Mazid and Hussain, 1995). Indiscriminate killing of fish occurred due to the use of pesticides in improper doses, use of forbidden chemicals, and aerial spray of chemicals as used in paddy field which was very much similar to the observation of Mazid (2002) and Chakraborty (2010).

Indiscriminate destructive fishing practices caused havoc to the aquatic biodiversity of the surveyed beel. As a result, the ecosystem health and biological diversity of the beel deteriorated at an unprecedented rate (Noss 1990; Cairns and Lackey 1992). Intervention to control floods, adoption of new agricultural technologies and construction of road networks altered the ecology of beel significantly which supported the views of Khan (1993) and Ali (1991). Stock of the wildlife brood fishes in their breeding ground also suffered significant damages resulting in a reduction of biodiversity as noted by Nishat (1993), Zaman (1993) and Chakraborty (2010).

A team of the local beel management committee was organized who developed a working frame work on sharing of benefits, developing rules and regulations for beel resource management. Fortnightly meeting was regularly held by the beel management committee to monitor and progress of the beel; nursery practices. Participation of local communities and their active involvement played an important role in overall management of beel fishery resources.

It is extremely important to apply community based co-management approach to harness aquatic resources and conserve biodiversity of the beel. In order to promote biodiversity the deep area of the beel must be declared as sanctuaries to protect the aquatic lives in all season, strict enforcement of fish Act-1950, forbidding unplanned digging and sedimentation; avoiding unplanned construction of flood control, embankments, drainage system and sluice gates, conversion of inundated land to cropland (reducing water area); and controlling use of pesticides and agrochemicals in the beel and floodplain area. Successfully implementing the above issues will lead to ensure the food security of the people of Bangladesh.

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