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Raising of Stocking Materials of Indian Major Carps in Pen Enclosures in Selected Floodplain Wetlands of Assam, India

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Abstract

Raised stocking materials, fingerling of Indian major carp seeds (*Catla catla, Labeo rohita Cirrhinus mrigala*) in pens, installed in two floodplain wetlands of Assam *viz.* Goruchora (Golaghat district) and 46-Morakollang (Morigaon district). The pens were stocked at 30,000 fry•ha^{-1}, in a ratio of 3:2:1 of *C. catla*, *L. rohita* and *C. mrigala* fry, respectively. The average initial length and weight of fry at the time of stocking for *C. catla*, *L. rohita* and *C. mrigala* were 5.45 cm (1.80 g), 4.51 cm (1.15 g) and 4.65 cm (1.12 g), respectively. The fish stocks inside the pens were given supplementary feeds, mustard oil cake and rice polish (1:1) at 5% body weight. The pens were harvested after a rearing period of 145 days with an average growth of *C. catla* (19.0 cm, 85.1 g), *L. rohita* (15.8 cm, 52.8 g) and *C. mrigala* (15.8 cm, 42.9 g) in Goruchora wetland, while in 46-Morakollang wetland it was recorded as 17.0 cm (63.8 g) for *C. catla*, 15.4 cm (55.9 g) for *L. rohita* and 14.0 cm (41.5 g) for *C. mrigala* for further grow-out in the lakes proper. During the period of experimentation, the fluctuations in water quality parameters like water temperature (17.6-29.0^{o}C), transparency (72-102 cm), dissolved oxygen (3.60-16.50 mg•l^{-1}), pH (7.12-9.53), total dissolved solids (46.6-111.3 mg•l^{-1}) and specific conductance (102-232 µS•cm^{-1}) were monitored, too. The production in terms of fish biomass (fingerlings) was estimated at 2106 and 1780 kg•ha^{-1} in Goruchora and 46-

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Morakollang wetlands, respectively. The cost-benefit ratio was calculated as 1.40 (Goruchora) and 1.77 (46-Morakollang), which can be considered as significant, economically.

Introduction

Floodplain wetlands, locally known as *beels*, have been the highly potential fisheries resources in the state of Assam, India supporting a large number of fishers in earning their livelihoods. The state of Assam has the distinction of possessing a large number of floodplain wetlands (Numbers = 3513, Area = 0.1 01 million ha) (ARSAC 1997), which accounts for nearly 50% of the total floodplain wetland area (0.2 05 ha) available in the country. These natural lakes of Assam are highly fragile but productive ecosystems with an estimated fish production potential of 1000-1500 $kg{\bullet}ha^{-1}$ (Anon 2000). In addition to this, they also support very high and diverse aquatic biodiversity including the avian fauna, both resident and migratory. Currently however, the average fish yield is very low (179 $kg{\bullet}ha^{-1}$), which may be attributed to poor recruitment of fish seeds from natural sources like rivers, as most of these water bodies have lost their riverine connections owing to changed land use patterns (Anon 2000). It is prudent therefore, that these lakes are rationally stocked with fish seeds of desirable size (advanced fingerlings) and in adequate quantity to increase the production and productivity of fish. Data available at the Central Inland Fisheries Research Institute (CIFRI) suggest that the fish yield from these wetlands can be enhanced up to 1000 $kg{\bullet}ha^{-1}{\bullet}yr^{-1}$ without much environmental manipulations.

Over the years, however, many of such wetlands have been turned into derelict water bodies due to increasing levels of eutrophication, siltation and heavy infestation of macrophytes in the absence of suitable management measures, which in turn has eroded the livelihood support of the traditional fishers, to a large extent (Gorai 2004). Effective management of prevailing aquatic weeds and rational stocking of selected fast growing fish species in these water bodies have emerged as the two most important core issues towards fisheries enhancement of these water bodies. The floodplain wetlands of Assam can be considered as the ideal systems for converting them into culture-based fisheries resources. To stock the wetlands rationally, fingerlings of desired size (>80 mm) are essential so as to minimize the rate of mortality and input cost in achieving the desired growth. The constraints, however, are the locally available fingerlings in desired quantity to avoid the risk of transportation from distant places. Despite these constraints, the raising of fingerlings in pens within the same system can be a lucrative option. The pen-cultures, especially for raising stocking materials, offer a great scope for the effective utilization of the available floodplain wetland resources for fisheries enhancement leading to significant improvement in the socio-economic status of fishers (Ayyappan and Venkateswarlu 2002).

Description of the study site

The Goruchora floodplain wetland (93°51'11" East longitude and 26°34'00" North latitude), a cut-off meander of river Dhansiri, a tributary of river Brahmaputra, came into existence during the early sixties. The water area of the wetland fluctuates between 28 ha (monsoon, June-July) and 23 ha (January-February). The average depth of the lake ranged from 3 m to >5.0 m (monsoon). Presently, it is a closed system without any connection to the river. However, during high floods, waters from river Dhansiri do enter the system.

The 46-Morakollang floodplain wetland (92°51'22" East longitude and 26°14'36" North latitude) with a water spread area of 53 ha gets connected partially to the river Kapili, a tribntary of river Brahmaputra, during monsoon. The water depth ranged between 1.5-3.5 m (Fig. 1).

The Goruchora wetland has thick stands of macrophytes, especially floating (*Eichhornia crassipes*, *Pistia*, *Salvinia*, *Trapa* and *Azolla*) followed by submerged (*Ceratophylum*, *Hydrilla*, *Najas* and *Vallisneria*) and marginal (*Ipomoea*), while the 46-Morakollang wetland is relatively free from weeds, barring certain submerged macrophytes like *Najas, Hydrilla, Lemna* and *ceratophylum*.

Materials and Methods

Sampling

To assess the growth, length and weight of stocked fish, fish samples were drawn randomly from one among the five pens and measured. Simultaneously, water, soil and plankton samples were also collected and analyzed following standard methods (Jhingran et. al. 1988 and APHA, AWWA and WPCF 1992).

Pen materials and construction of pens

Pen material

Locally available *Jati bah* (*Bambusa tulda* Roxb.), bamboo was selected for the mats/screens (split bamboo tied by two-ply coconut coir rope), locally called as *bana*, while *Bholuka bah* (*Bambusa balcooa* Roxb.) was used for the external frame-work. Both varieties of bamboo were available easily at reasonable costs. The former had an effective total length of 6.0-8.0 m with a diameter of 6.0-8.0 cm at the base and 4.0-5.0 cm at the tapering end. The latter had an effective length of 7.0-9.0 m and a diameter of 8.0-12.0 cm at the base and 6.0-8.0 cm at the tapering ends.

Construction of pen

Matured bamboos of *jati* variety were split into small strips, 0.5-0.7 cm in thickness (*kathi*) for knitting the screens (*bana*). The screens were weaved using split-bamboo strips tied by two-ply coconut coir ropes. The gap between the two adjacent coir rope weavings was kept at 40-45 cm.

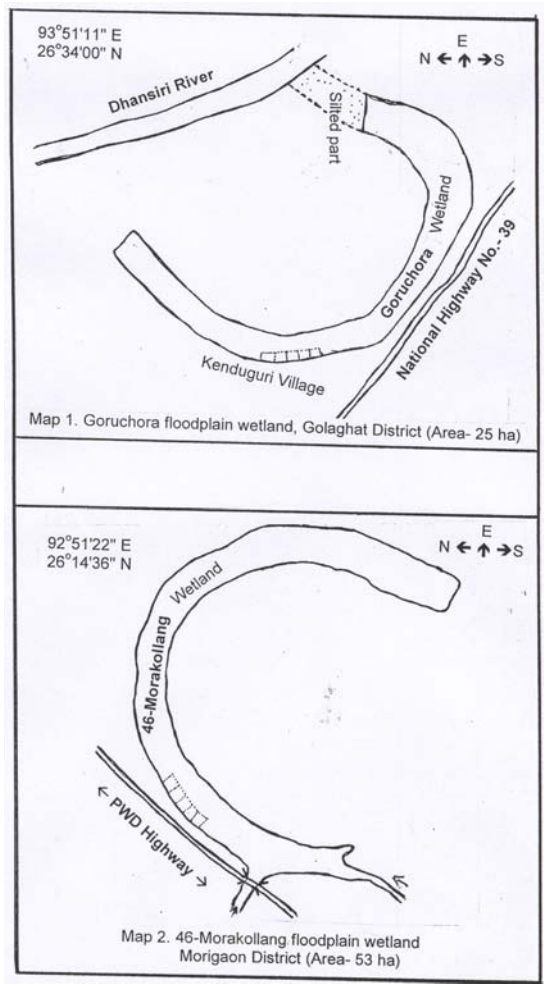

Fig. 1. Maps of Goruchora and 46-

To prevent movement of fish from and into the pens, a layer of commonly available polyethylene net (mesh size 0.1 cm) was stitched over the inner wall of the screens up to the level of the water column.

Pen area was earmarked by fixing bamboo poles at the four corners. The rest of the poles were pushed inside the bottom mud (up to the hard bottom layer) with an interval of 2.5 m for the bamboo screens. Thereafter, relatively longer bamboos (7.0-9.0 m in length) were tied to the poles horizontally below and above the water level at every 1.0 m longitudinal intervals to provide strength to the structures.

The bamboo screens were placed along the long bamboo in such a way that no gaps were left at the lake bottom. Split (1/2) bamboos (locally known as *kami*) were tied to the outer surface of the screens. To provide further strength it was tied with iron wires all along the length (screen, pole and whole bamboo), at every 1.25 m at the junctions of the poles. The heights of the screens were kept at 0.5 to 1.0 m above the water level of the wetlands. A series of five pens were installed at the Goruchora and 46-Morakollang wetlands covering an effective pen area of 750 m^2 and 1875 m^2, respectively (Table 3).

Managements of pens

Prestocking management of pens

Prior to fixing of pen materials, thorough cleaning of pen areas was done by manually removing macrophytes. The unwanted or wild fish stocks, trapped within the pen enclosures, were removed through repeated netting. An application of lime in the pen area, at 300 $kg•ha^{-1}$, was given initially, seven days prior to the stocking of fish fry, followed by a monthly dose of 150 $kg•ha^{-1}$ and 100 $kg•ha^{-1}$ in the second and third months, respectively.

Stocking of pens

Fry of Indian major carps, Catla (*Catla catla*, Cyprinidae), Rohu (*Labeo rohita*, Cyprinidae) and Mrigal (*Cirrhinus mrigala*, Cyprinidae) fry were stocked in the pens in the ratio of 3:2:1 and at a stocking density of 30,000 $fry•ha^{-1}$ (Table 4). The initial average length and weight of each species were recorded to track the pattern of growth during the rearing period.

Poststocking management of pens

Repeated manual removal of aquatic macrophytes was undertaken monthly followed by a subsequent dose of lime (100-150 $kg•ha^{-1}$). The stocked fry were sampled every month to monitor the growth and health conditions. To avoid excessive loss of supplementary feed leading to contamination of water inside the pen area, feeding trays made up of bamboo, were used to supply the supplementary feed.

Supplementary feeding

The stocked fish fry were given supplementary feed made of rice polish (RP) and mustard oil cake (MOC) mixture (1:1) at 5.0% body weight once every day. The required quantity of feed was soaked and given in dough form during the early hours of the day. The dose of supplementary feed remained constant considering the adaptability of fishes to natural fish foods available in the system.

Results

Abiotic and biotic factors inside the pen areas

Soil profile

The soil texture at the Goruchora wetland indicated the greater contribution of sand (40-56%) followed by silt (26-48%) and clay (2-18%). In the 46-Morakollang wetland, silt (46-66%) was dominant followed by sand (20-36%) and clay (10-18%). The soil pH in Goruchora wetland ranged from 5.1 to 7.1 whereas the specific conductivity ranged from 146 to 260 µS•cm^{-1} (av. 199.6). In 46-Morakollang, pH varied in the range of 5.0-6.0 whereas specific conductivity fluctuated between 195 and 650 µS•cm^{-1} with an average of 419.2 µS•cm^{-1} (Table 1).

Table 1. Soil quality of Goruchora and 46-Morakollang wetlands

Wetlands	Period/ Date	Sand (%)	Silt (%)	Clay (%)	pH	Specific Conductivity (µS•cm^{-1})
Goruchora	18.11.2001	56	26	18	5.7	228
	18.12.2001	52	30	18	5.1	146
	15.02.2002	40	48	12	7.1	260
	16.03.2002	52	46	02	6.4	216
	18.04.2002	52	32	16	5.4	148
46-Morakollang	19.11.2001	20	66	14	5.0	508
	20.12.2001	36	46	18	5.4	650
	18.02.2002	-	-	-	5.6	367
	20.03.2002	26	64	10	6.0	376
	21.04.2002	31	58	11	5.8	195

Water quality

The physico-chemical parameters at the Goruchora wetland were recorded as water temperature (17.6-27.0^{o}C, av. 23.18), pH (7.12-8.99), dissolved oxygen (3.60-16.50 mg•l^{-1}, av. 7.59), transparency (72- 150 cm, av. 127cm), specific conductivity (102-130 µS•cm^{-1}, av. 119.8) and total dissolved solids (46.6-64.5, mg•l^{-1}, av. 58.5). In the case of 46-Morakollang wetland, however, these parameters fluctuated as, water temperature (23.0-29.0^{o}C, av. 26.5), pH (7.28-9.53), dissolved oxygen (6.49-15.86 mg•l^{-1}, av. 11.60), transparency (90- 98 cm), specific conductivity (135-232 µS•cm^{-1}, av. 201.4) and total dissolved solids (59.9-111.3 mg•l^{-1}, av. 96.0) (Table 2).

Table 2. Physico-chemical parameters of Goruchora and 46-Morakollang wetlands

Wetlands	Date	W. Temp. (^{o}C)	pH	DO (mg•l^{-1})	Trans. (cm)	Sp. Cond. (µS•cm^{-1})	TDS (mg•l^{-1})
Goruchora	18.11.01	22.8	7.12	03.90	115	102	046.6
	18.12.01	17.6	8.38	03.60	156	120	054.4
	15.02.02	23.5	7.80	06.75	142	130	063.5
	16.03.02	27.0	8.99	16.50	150	122	064.5
	18.04.02	25.0	7.84	06.94	072	125	063.6
46-Morakollang	19.11.01	26.7	7.28	06.49	90	135	059.9
	20.12.01	23.0	7.98	09.19	98	232	103.0
	18.02.02	25.8	7.80	15.86	BV*	201	097.8
	20.03.02	29.0	9.53	14.50	BV	218	111.3
	21.04.02	28.2	9.02	12.03	BV	221	107.9

* BV = Bottom Visible (>150 cm).

Table 3. Details of pens constructed at the Goruchora and 46-Morakollang wetlands

Name of wetlands	Length (m)	Width (m)	Size of each pen (m^2)	No. of pens	Total pen area (m^2)
Goruchora	15	10	150	5	750
46-Morakollang	25	15	375	5	1875

Structure and density of plankton

At the Goruchora wetland, the community size of plankton population ranged from 186 to 565 $u \cdot l^{-1}$ (unit per liter), while at the 46-Morakollang wetland it ranged from 18 to 626 $u \cdot l^{-1}$. The Goruchora wetland harboured relatively higher zooplankton population as compared to the 46-Morakollang. The phytoplankton communities at the Goruchora wetland showed the dominance of species like *Navicula, Synedra, Nistzia, Cymbela, Pinnularia* (Bacillariophyceae), *Mougeotia* (Chlorophyceae) and *Oscillatoria* (Cyanophyceae). The zooplankton community showed the greater presence of *Cyclops,* Nauplii, *Lecane, Bosmina* and *Moina*. At the 46-Morakollang wetland, however, members of Cyanophyceae like *Rivularia*, *Microcystis* and *Aphanocapsa* were dominant followed by Chlorophyceae (*Ulothrix* and *Pandorina*), Bacillariophyceae (*Melosira, Synedra* and *Fragillaria*) and Dinophyceae (*Ceratium*). The zooplankton population in this wetland was low in abundance, while species like *Cyclop*s, Nauplii, *Keratella, Monostyla* and *Philidina* were dominant.

Fish diversity

Predatory fish species like *Channa marulius*, C. *striatus, Notopterus notopterus* and *Wallago attu* were dominant at the Goruchora wetland, where no management practices were followed since the year 2000. *Anabas testudineus, Puntius sarana sarana* and *Xananthodon cancila* were also common wild varieties. Indian major carps, *C. catla*, *L. rohita* and *C. mrigala,* were also recorded at times.

The fish species spectrum at the 46-Morakollang wetland, which get auto-stocked to some extent, annually, during monsoon as connected with river Kapili had the sizeable presence of Indian major carps followed by species like *Gudusia chapra*, *Labeo gonius,* L. *calbasu, L. bata, Cirrhinus reba*, *Colisa lalia, C. fasciatus*, *Channa marulius, C. punctatus, Mystus vittatus, M. tengra*, *Puntius ticto* and *P. sophore.*

Harvesting of pens

Growth of fish

The stocked fish were sampled every month to monitor the growth and health condition. The average growth of *C. catla*, *L. rohita* and *C. mrigala* was recorded as 85.1 g (19.0 cm), 52.8 g (15.8 cm) and 42.9 g

(15.8 cm), respectively at the Goruchora wetland, after 145 days of rearing. At the 46-Marakollang wetland, growth was relatively low, such as *C. catla*, *L. rohita* and *C. mrigala* 63.8 g (17.0 cm), 55.9 g (15.4 cm) and 41.5 g (14.0 cm), respectively (Table 4).

Fish growth measurement

Based on the data of fish growth as calculated in terms of length and weight, during the rearing period (Table 4), the Specific Growth Rate (SGR), Proportion of Weight Gain (PWG) and Average Condition Factor (ACF) were calculated using the following formulae (Hardy and Barrows 2002; Venkateshwarlu *et. al*. 2002):

SGR: The 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).

$$\text{SGR (\% day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$$

Where, W_1 = Weight of the fish at time T_1 and W_2 = Weight of the fish at time T_2

PWG: The PWG at the Goruchora wetland found for *C. catla* was 46.06 followed by *L. rohita*, 44.87 and *C. mrigala*, 37.33; while at the 46-Morakollang wetland it was calculated as *L. rohita*, 47.56 followed by *C. mrigala*, 36.08 and *C. catla*, 34.30.

$$\text{PWG} = \frac{FW - IW}{IW}$$

Where, FW= Final weight of the fish and IW= Initial weight of the fish

ACF: The ACF was relatively better for *L. rohita* (1.340) followed by *C. catla* (1.243) and *C. mrigala* (1.088) at the Goruchora wetland, while at the 46-Morakollang wetland ACF was also better for *L. rohita* (1.538) followed by *C. mrigala* (1.503) and *C. catla* (1.294).

$$\text{ACF} = \frac{W}{(l)^3} \times 100$$

Where, W= Final weight of the fish and l= Final length of the fish

The increase condition factor values as obtained during pen culture experiments have indicated the well-being of the stocked fish.

Table 4. Fish stock, yield and growth at the Goruchora and 46-Morakollang wetlands

Parameter	Goruchora			46-Morakollang		
	C. catla	*L. rohita*	*C. mrigala*	*C. catla*	*L. rohita*	*C. mrigala*
No. of fish released	250	150	100	625	375	250
Days of rearing	145	145	145	145	145	145
Av. initial weight (gm)	1.81	1.15	1.12	1.81	1.15	1.12
Av. final weight (gm)	85.05	52.80	42.93	63.80	55.90	41.53
Av. initial length (cm)	5.46	4.51	4.65	5.46	4.51	4.65
Av Final length (cm)	18.99	15.80	15.80	17.02	15.38	14.03
SGR (%•day^{-1})	2.66	2.64	2.52	2.46	2.68	2.49
PWG	46.06	44.87	37.33	34.30	47.56	36.08
ACF	1.24	1.34	1.09	1.29	1.54	1.50
Net wt. Gain (gm)	83.24	51.65	41.81	62.00	54.75	40.41
Production kg•ha-1		2106			1780	

Discussion

Reports on pen culture of Indian major carps (IMC) for raising stocking materials from Indian waters are not many. Rai and Singh (1990) while experimenting to produce table fish of IMC from pens in ox-bow lakes of Bihar have reported a yield of 3362-3962 kg.ha^{-1} in six month of rearing of advanced fingerlings. Abraham (1990) and Giresha et al. (2003) have also attempted to rear fry in pens for raising stocking materials for reservoirs with moderate success. Fish yield of table fish @ 5545 kg•ha^{-1} in six months with a stocking density of 1600•ha^{-1} advanced fingerlings has also been reported from pens of ox-bow lakes in Bihar, India (Anon 1983).

It has been increasingly realized, in recent times, that rational stocking in open waters like wetlands and reservoirs holds the key for increasing inland fish production on a sustainable basis (Beveridge 1984; Kutty and Campbell 1987; Baluyut 1989). The moot point of animated discussion, however, is from where the desired quality and quantity of fingerlings may come?

Rearing or raising of fingerlings for effective stocking from land nursery and their transport to respective sites has not been found viable economically, especially in regions like the Northeastern part of India, where the terrain is difficult for quick transportation of stocking materials from one place to another. In the backdrop of this scenario the present project was conceived and conducted. It is evident from the results, obtained from both wetlands, that the raising of required quantity of stocking materials within the same system by installing pens can be a viable option to address the cause of rational stocking in floodplain wetlands so as to convert them into culture based systems for better economic returns. Moreover, since small sized fish, of all categories, are being treated as a delicacy by the people of Northeastern region of India, the demand for such fish can be met to a larger extent through pen-culture in wetlands. People of the region often resort to wanton killing of fish juveniles of prized species like IMC from natural waters like rivers affecting the recruitment process in these waters, adversely. Short-term rearing of Indian major carps (IMC) or even minor carps in pens as food fish can therefore be an alternative source of income to the fishers besides preventing the killing of juveniles from the natural stock of rivers.

During the present experiments an average biomass of 1943 $kg{\bullet}ha^{-1}$ (1780 and 2106 $kg{\bullet}ha^{-1}$) was obtained from a rearing period of 145 days, which can be considered significant. The present findings, therefore, offer tremendous scope in view of large available area under floodplain wetland resources in Assam, which require rational stocking to build the fish stocks for commercial harvesting. This is all the more essential as most of such water bodies have lost their riverine connection thereby auto-stocking of fish seeds of commercially important species.

Economics of pen culture operation

The capital cost for making the pens inclusive of the bamboo screens, poles, polyethylene nets etc. could be used at least for three crops. During the second (10%) and third (20%) croppings, operation capital cost will be more towards repairing cost. The cost-benefit ratio for a single crop for the present experiments at the Goruchora and 46-Morakollang wetlands were calculated as 1.40 and 1.77, respectively, which indicate relatively higher profitability than any other entrepreneurships (Table 5).

Table 5. Economics of pen culture at the Goruchora and 46-Morakollang wetlands (Cost in US $)

Cost and return	Goruchora		46-Morakollang	
	Quantity	Cost (US $)	Quantity	Cost (US $)
A. Capital cost				
Total area (m^2)	750		1875	
Area of each pen (m^2)	150		375	
With partition (bamboo screen) m^2	400	267.6	500	444.4
Cost of pen per crop		66.7		111.1
Total capital cost		66.7		111.1
B. Operational cost (1 crop)				
Fish seed (nos)	2500		6250	
Cost		33.3		83.3
Weed clearance (labour cost)		35.6		53.3
Lime		24.9		24.9
Feed (MOC+RP)		10.7		16.0
Harvest (labour cost)		4.4		4.4
Total operational cost		108.9		182.0
Total cost (A+B)		175.6		292.8
C. Gross income				
Fish yield (kg)	158		334	
Return (1.56 US$/kg of fish)		245.5		519.5
Profit (US $)		70.2		226.4
B/C ratio		1.40		1.77

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