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Cage culture of commercially important fish species in a flood plain wetland of barak valley, Assam

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Abstract
The wet lands in Assam are highly productive aquatic ecosystems covering over one lakh hectare water spread area. The wetlands are amenable for practicing various forms of fisheries enhancements options including culture based fisheries. Cage aquaculture offers a great scope especially for raising stocking material and effective utilization of available floodplain wetland resources for fisheries enhancement that will lead to significant improvement in the socio-economic status of fishermen. Results of a cage aquaculture experiment conducted in Khelma village of Cachar district Assam to determine the highest growth of fish species in cages are discussed. The cages were rectangular in shape and size of each cage is 4.0 m x 2.5 m x 2.0 m having an effective rearing area of 15 cubic meters. The low cost floating cages were constructed with locally available materials such as PVC drum (220 L), HDPE net, bamboo, rope; nails, etc. Fish fry (length: 1.5-4.0cm; weight: 1.4-4.0g) were stocked in cages at a stocking density of 250fry/m ^{3} in different species composition. After 60 days of rearing, the highest recovery and survival percentage was recorded in rohu (*Labeo rohita*) and highest growth rate was recorded in grass carp (*Ctenopharyngodon idella*) that attained an average weight of 98.00 ± 6.42 g. Economics of the cage culture operation was analyzed taking into consideration the costs involved in construction of the cage units and operational costs. A total of Rs. 35,337.00 was earned by the fishers as net income from one battery (*i.e.* 10 cages) in one batch.

Keywords: Cage, *Labeo rohita*, Khelma, BCR, feeding, fry

Introduction
Assam is the most resourceful state as fisheries is concerned. The state has vast water resources suitable for aquaculture, covering an area of 4.77 hectares of beels, ponds and tanks which form about 2.85 lakh hectares [3]. In addition, two major river systems viz., the Brahmaputra and Barak with their tributaries play a major role in the socio-economic development of Assam. With its vast aquatic resources covering about 3.9 lakh hectares, the Fisheries Sector is one of the most promising sectors for alleviating poverty and providing livelihoods in Assam [1]. Cachar is a district situated in the Barak valley of state Assam. The Cachar district is blessed with immense fishery resources in the form of *beels*, low-lying area, derelict water bodies, forest fishery, ponds& tanks etc. including one major river system - the Barak and their tributaries [1]. But, the district produces deficit fish production in spite of having available fisheries resources. Lack of awareness about scientific fish farming among farmers, lack of fish feed and quality fish seed locally at proper time are the major constrains in fish production. Therefore, the adoption of proper scientific technologies to utilize the resources is the need of the hour to minimize the gap between demand and supply of fish seed and fish production of the district. The wetlands in Assam are highly productive ecosystems and if properly managed, can contribute to an increase in fish production [2].
Cage aquaculture, offers a great scope for effective utilization of available floodplain wetland resources for fisheries enhancement that will lead to significant improvement in the socio-economic status of fishermen [3]. Cage aquaculture is especially effective in raising carp seed in seasonally open beels of the region where practicing pen aquaculture is a difficult proposition during the south–west monsoon season in Khelma village of Cachar district. Therefore in the present study an attempt has been made to increase the fish production from the flood affected open water bodies of Khelma village through stock enhancement at proper time with quality fish seed of proper size.

Materials and Methods

Cage culture site

The cage aquaculture site is situated at the Khelma village under Kalain development block is a flood affected area of the Cachar district of Assam. Almost 90% populations of the village are fishers under scheduled caste category and completely depend on their livelihood on culture and capture fisheries. The Barak is the main river of the district and apart from these; there are numerous small rivers that harbor rich pristine fisheries resources of India. In-spite of having lots of fisheries resources in the area; the fishers were unable to culture fish in ponds due to erratic flood problems which occurs during July to August. The water depth of the ponds during March–April ranges between 1.0–2.2 m, which usually increases by another3 m during high floods (July–August) having an average water depth of three meters. Keeping all these problems of the area in mind, a community management approach for increasing fish production through stock enhancement in flood affected open water bodies (*beels)* was proposed to implement in the above mentioned village. Fish stock enhancement (i.e., augmenting the stock of desirable fish species) is one of the most common and effective management measures followed in the beels of Assam [4].

Cage structure and design

The cages were rectangular in shape and size of each cage is 4.0 m x 2.5 m x 2.0 m having an effective rearing area of 15 cubic meters. The low cost floating cageswere constructed with locally available materials such as PVC drum (220 L), HDPE net, bamboo, rope, nails, *etc*.Ten batteries comprisinga total of 100 cages were installed in Khelma village of Cachar. Onebattery (a set of 10 cages) was allotted to three fishers and thus, the 10 batteries (100 cages) were allotted to a total of 30 fishers. The cage platforms were fixed at the suitable site in the wetlandwith the help of bamboo poles inserted through the fourcorners of the frame.

Experimental fish

Fish fry (length: 1.5-4.0cm; weight: 1.4-4.0g) of nine different species *v.i.z.* Catla (*Catla catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*), Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*), Common carp (*Cyprinus carpio*), *Kurhi* (*Labeo gonius*), *Mali* (*Labeo calbasu*) and *Java Puthi* (*Puntius sarana*) were procured from *Nilam Bazar* (Fish seed market) of Karimganj district. On reaching the cage site, the fish were stocked in cages @ 250 nos. fry per cubic meter in different species composition. As the effective rearing area of each cage was 15.0 cubic meters considering 1.5 meter water depth in cage, 3750 numbers of fish fry were stocked per cage. Stocking of fish fry was done in the morning after proper acclimatization to avoid mortality. The water quality parameters in the experimental site during the culture period has been mentioned in Table No. 2.

Formulation and preparation of experimental diets

Fish seed were fed with locally available feed ingredients such as mustard oil cake and rice bran at 1: 1 ratio and vitaminmineral mixture were used for formulationof the mash feed. Weighed quantities of different ingredients were mixed thoroughly and fed to the fishes @ 5% of total body weight of fish stocked. Feed was given twice daily in bamboo trays suspended in the cages for better utilization. The feed formulation and proximate composition of the feed has been mentioned in Table No. 1.

Economics of Cage Culture Operation

Economics of the cage culture operation was analyzed taking into consideration the costs involved in construction of the cage units and operational costs (including cost of fish fry, cost of feed and feeding and labour costs). The following realistic assumptions were made based on past experiments/experiences. After 60 days of fish seed rearing in cage, a total of Rs. 35,337.00 (Thirty five thousand three hundred thirty seven) only was earned by the fishers as net income from one battery (*i.e.* 10 cages) in one batch. As the fish seed rearing can be practiced for six months, three batches can be completed in a season. Thus, Rs. 1, 37,723.00 (one lakh thirty seven thousand seven hundred twenty three) only can be earned as net income from one cage battery in a season selling 81591nos. of fingerling @ Rs. 2.5 per number. The calculated BCR was 2.08 as mentioned in Table No. 4.

Results and Discussion

The study was carried out with thirty beneficiaries selected from Khelma village of Cachar district. Beneficiaries were selected on the basis of their common interest and divided into ten groups. Each group consisting of three beneficiaries was given one cage battery having ten numbersof net cages. It has been observed that while raising fish seed with a different species composition in cages for 60 days in the openwater bodies, the fish fry stocked with average weight of 2g - 4g and average length of 2cm - 4cm showed highest growth in case of grasscarp that attained an average weight of 98.00 ± 6.42 g (Table No. 3). After 60 days of rearing, the highest recovery and survival percentage was recorded in rohu (*Labeo rohita*). The results of the research study conform to the findings that cage culture of fingerlings of rohu (*Labeo rohita*) could be done successfully in open water bodies such as reservoirs and wetlands [5]. The loss may be due to stress during transportation of fry from itssource to project site and crab attack at later stage of rearing. No disease incidence was recorded during demonstration period. An inverse correlation between growth rate and stocking density was also reported in *Oreochromis niloticus* [6]. High stocking density may create group effects resulting in high mortality, as reported in estuary grouper *Epinephelus salmoides* [7]. Similar results were obtained for carp species which corroborate with our findings [8]. Maximum depth of the flood plain wetland in Khelma village was recorded 9m and its range varies from 7-9 m at cage site. As reported, the depth is suitable for proper water exchange in the cages [9]. Water of the cage culture site was found to be alkaline in nature during summer months. Dissolved oxygen in water is of great significance to all aquatic organisms and is considered to be an important factor which reflects physical and biological process taking place in a water body [10]. This may be due to increased photosynthetic activity and can be used as an index of net production [3]. In the present study the dissolved oxygen concentration range varied from 5.0-7.2 mg/l (Table No. 2). The free carbon-di-oxide and BOD levels were in the adequate range that initiates increase in fish production. In view of the above limnological parameters the wetland was found to be suitable for cage culture operation. The capital cost and operational costs incurred in the construction and operation of cages at Khelma village was similar in all treatment groups and the calculated BCR (Benefit Cost Ratio) was found to be 2.08. Therefore, considering the economics of cage aquaculture system the stocking density of 250 fry/m^3 of different species combination of carps were found to be adequate.

Table 1: Feed formulation and proximate composition (% DM basis) of the experimental diet fed to the fishes reared for 60 days in cages installed in Khelma village of Cachar district.

Ingredients	Inclusion level (%)
Mustard oil cake	20
Animal viscera meal	30
Rice bran	40
Fish oil	8
Vitamin & mineral mix [a]	2
Proximate composition [b]	**Percentage (%)**
Dry matter	83.74 ± 1.25
Moisture	9.68 ± 0.89
Ash	11.27 ± 0.33
Crude Protein (CP)	35.67 ± 1.84
Total carbohydrate (TC)	40.63 ± 1.28
Ether Extract (EE)	6.74 ± 0.99
Digestible energy (DE)[c]	365.73± 2.87

[a]Vitamin-mineral mix (Minerex Forte) (quantity/1 kg): Vitamin A-20,00,000 IU; Vitamin D3-4,00,000 IU; Vitamin E-300 I.U.; Vitamin B12- 2.4 mg; Vitamin B2-0.8 g; Vitamin K3-0.4 g; Calcium D panthothenate-1 g; Choline chloride-60 g; Ca- 300 g; Mn- 11 g; Fe- 3 g; Cu-0.8 g; Co- 180 mg; Se-40 ppm; Niacinamide-4 g; Zn2128 mg; Tri-sodium citrate as chelating agent; Approximate overages and antioxidants added

[b] Data presented are mean ± S.E. (n = 3)

[c] Digestible energy (kcal/100 g) = (CP % × 4) + (EE % × 9) + (TC % × 4)

Table 2: Limnological study of cage culture site at Khelma village of Cachar district, Assam. The water quality was analyzed based on the standard methods.

Parameters	Range of value
Water depth (cage site)	7-9 m
Transparency	30-60 cm
Dissolved oxygen	5.0-7.2 mg/l
pH	6.5-8.5
Free CO_2	Nil – 3.57mg/l
Total Alkalinity	75-260 mg/l
Total Hardness	80-150 mg/l
BOD (Biological oxygen demand)	2.8-4.6 mg/l
Plankton density	1.4-2.7ml/50l

Table 3: Growth rate of different fish species cultured in cages at Khelma village, Cachar district.

Sl. No.	Fish species	Growth (in gms)
1.	Grass carp	98.00^{d} ± 6.42
2	Silver carp	83.00^{d} ± 5.50
3	Catla	66.50^{c} ± 3.80
4	Rohu	58.00^{bc} ± 1.33
5	Mrigal	47.00^{b} ± 5.58
6	Javaputhi	9.50^{a} ± 1.95
7	Calbasu	26.50^{a} ± 7.26
8	Gonius	24.50^{a} ± 8.28

Table 4: Economic analysis of demonstration of one cage battery (10 cages)

Capital cost	Rupees (Rs.)
Construction of 1no. battery (10 cages)	43,956.00
Aluminum *Hundi*	2600.00
Total cost	46,556.00
A. Considering 2 years shelf life for net cage & frame	10908.00
B. Considering 5 years shelf life for PVC drum	4428.00
C. Considering 5 years shelf life for *Hundi*	520.00
Capital cost for cage battery for one year i)	15,856.00
Recurring cost:	Rupees (Rs.)
A. Cost of 37,500 nos. of fry @ Rs. 0.2 per fry	7,500.00
B. Cost of fish feed	9,300.00
ii)	16,800.00
Total cost (i + ii)	Rs. 32,656.00
In one season, three batches can be reared: Gross income from one batch of fish seed rearing Fish fingerling sold @ Rs. 2.5 per number (27,197 X 2.5) :	 67,993.00
a) Net Income from 1st batch	35,337.00
b) Net Income from 2nd & third batch	51,193.00 X 2 = 1,02,386.00
Total net income from one battery in a season (a + b):	Rs. 1,37,723.00
Income per fisher (3 fishers in one battery) per season	Rs. 45,907.67 ~ 45,908.00
BCR	2.08

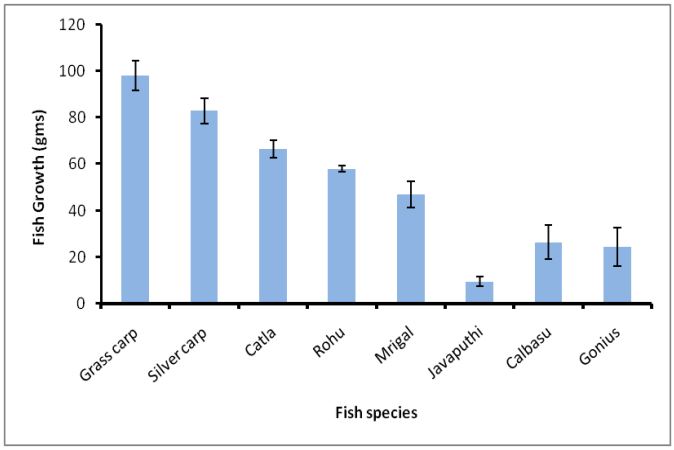

Fig 1: Growth rate of fish species cultured in cages. (Values differ significantly (p<0.05) and expressed as mean ± SE) (n=6).

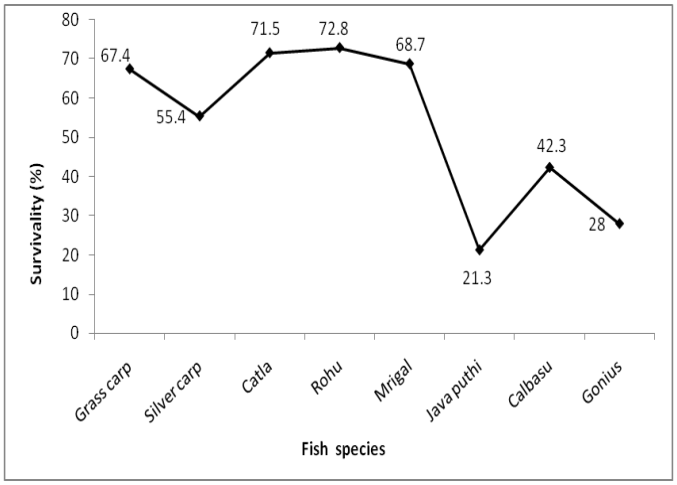

Fig 2: Survival percentage of different fish species in cages reared for a period of 60 days. Values differ significantly (p<0.05) and expressed as mean ± SE) (n=6).

Conclusion

Fish stock enhancement through adoption of cage culture practice is one of the most common and effective management measures to strengthen *Beel* fisheries of Assam. Keeping this in view, the cage culture operation was carried out at a flood plain wetland of Cachar district, Assam with a primary focus on rearing of commercially important fish species in low cost cages. The finding of the research study draws conclusions on the profitability of cage culture operation for socio economic development of rural flood affected people in Assam. To substantiate further, seed rearing in cages in seasonally flooded open water bodies prove to be sustainable which could produce sufficient numbers of fish fingerlings for income generation and to make the area self sufficient in fish production.

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