Pen Fish Culture in Reservoirs – an Alternative to Land Based Nurseries

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Abstract

An experiment to rear carp seed was conducted in Tamil Nadu, India during October 2001 to April 2002 as a part of an ambitious programme aimed at standardization of pen fish rearing technology for production of stocking material of desired size at a lower cost. The experiment used six pens erected using locally available materials in the exposed marginal area of an existing reservoir. The high survival rate of carps (67.2-94.7%) and reasonable returns on investment (26.2%) obtained in the experiment indicated that fish seed rearing in pens erected in suitable areas of existing reservoirs could serve as a cheaper alternative to the expensive land-based nursery ponds.

Introduction

Pens are used for various aquaculture activities in countries such as the Philippines, Indonesia, Thailand, Malaysia, China and USA (Beveridge 1984; Chua and Teng 1977; Shang and Tisdell 1997). In India, experiments have been carried out to raise carp seed using pen culture in oxbow lakes, swampy tanks, *beels* and reservoirs (Abraham 1980; Banerjee and Pandey 1978; Swaminathan and Singit 1982; Yadava et al. 1983), but the technology has not yet been standardized.

Natarajan (1976) and Selvaraj et al. (1990) recommended stocking of advanced fingerlings (more than 100 mm long) in reservoirs for achieving higher survival and fish production. However, the development agencies continue to stock smaller fish seed (15-40 mm) because of inadequate rearing space in land-based ponds as construction of new ponds is capital intensive. In this situation, fish culture in pens becomes desirable as the pens can be erected even by unskilled labour, and the materials required for the fabrication of pens is inexpensively and readily available in the local markets. This experiment was conducted to standardize carp seed rearing practices in pens erected in suitable areas of existing reservoirs and to develop the technology suited to Indian conditions for raising advanced fingerlings to be used as stocking material of the desired size.

Materials and Methods

A marginal area of the Odathurai reservoir in the Erode district of Tamil Nadu, India was selected for erecting six pens, each with an area of 200 sq. m (20 m x 10 m). A trench (30 cm x 30 cm) was excavated at the boundary of the proposed pen structure during the first week of October 2001. Casuarina poles were erected vertically in the center of the trench at an interval of 1.5 m. Bamboo poles were tied horizontally across the casuarina poles at intervals of 30 cm using coir ropes to strengthen the frame structure. High density polyethylene (HDPE) woven fabric (12 x 12 meshes cm) was used as netting material for the pen. The bottom of the net was wrapped around a bamboo pole, stitched and then placed in the trench. The trench was filled with soil removed at the time of the excavation. With the onset of the northeast monsoon in the second fortnight of October 2001, the water level in the reservoir increased and entered the pens. The pens were fertilized with cow dung at the rate of 10 000 kg/ha and lime at the rate of 100 kg/ha to accelerate plankton production. After 10 days, seeds of catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idellus*) were transported under oxygen packing, acclimatized to the local conditions and then released into the pens (Table 1). A mixture of rice bran (60%), groundnut oil cake (30%) and soya meal (10%) was given as supplemental feed twice daily *ad libitum* in the form of wet balls served in plastic trays hung in the four corners of the pens. The feeding trays were examined daily and the quantity of the feed to be provided the next day was decided according to the consumption. In a few days, it was observed that *C. idellus* were consuming the major portion of the supplementary feed, leaving little for the other carps. To overcome this problem, aquatic weeds collected from the reservoir were spread on a floating bamboo frame placed inside each pen. The mixed feed balls were given two hours later so that the gorged *C. idellus* did not compete with other carps for the feed. Water quality, plankton abundance and primary production in the pens as well as in the open reservoir were studied following standard methods (APHA 1989; Vollenweider 1971; Ward and Whipple 1959). The growth of different species of fish was monitored by periodic sampling using a dragnet. Final harvesting

Table 1. Details of stocking in the pens.

Date of stocking	Species	Average initial length (mm)	Average initial weight (g)	Number stocked per pen
13 November 2001	*C. catla*	32.6	0.83	300
13 November 2001	*L. rohita*	32.1	0.29	2000
13 November 2001	*C. mrigala*	36.3	0.38	1080
20 November 2001	*C. carpio*	15.0	0.08	3000
22 November 2001	*C. idellus*	50.0	4.50	100

of fingerlings exceeding 100 mm in length was carried out using seine nets till the entire stock was exploited. The harvested fingerlings were stocked in the open reservoir for further growth and enhancement of fish production.

Observations

The water depth in the pens varied from 2.00-2.25 m at full reservoir level but gradually diminished over the post-monsoon period as water was released from the reservoir for irrigation purposes. Application of cow dung and lime in the pens prior to stocking improved the water quality in terms of pH, electrical conductivity, total dissolved solids, hardness, Ca, Mg, P_2O_5, NO_3 and primary production. However, the dissolved oxygen diminished, probably because of its consumption in the process of mineralization. The suspended particles from the fertilization and subsequent growth of plankton reduced the transparency of the water (Table 2). The fish fry, stocked in the pens at the rate of 324 000/ha, consumed the plankton leading to a drastic reduction in their population. The total plankton count in the pens after 10 weeks of fish seed stocking was 1 347/l compared to that of the reservoir (76 900/l). Similarly, the benthos in the pens was much less (50-202/m^2) than in the reservoir (432-606/m^2) indicating that bottom feeders like *C. mrigala* and *C. carpio* consumed the bottom fauna produced in the pens. On the other hand, the values of gross and net primary production in the pens were slightly more than that of the reservoir, probably due to the adequate supply of nutrients from the periodic fertilization of the former with cow dung and lime. Fixing of old gill nets above the pens controlled the predation of fish seed by birds. Manual cleaning of the pen screen net with a brush every 15 days facilitated thorough mixing of the water between the reservoir and the pens.

Periodic sampling of fish seed in the pens indicated fast growth of *C. idellus*, followed by *C. catla, L. rohita*, *C. mrigala* and *C. carpio* in that order. *C.idellus* attained the targeted size of more than 100 mm within a month, whereas *C. catla* exceeded this size only after 38 days. The growth of *L. rohita* and *C. mrigala* was relatively slow and they grew to 100 mm after 75 days. The growth of *C. carpio* was poor and they measured only 60-90 mm on termination of the experiment after 120 days.

Statistical analysis (ANOVA) of the results of the experiment indicated that there was a significant difference in growth in terms of length and weight between the species and that there was no significant variation in the growth of fish species with respect to different pens.

Among the different species of fish used in the experiment, the growth of *C.idellus* was the highest, followed by *C. catla* and *L. rohita*. The performance of *C. carpio* was very poor. Harvesting of the surface moving fishes like *C. idellus* and *C. catla* was easy and the entire stock of the pens could be hauled in a few drag net operations. The collection of the fast moving *L. rohita* with an escaping tendency and the bottom dwelling *C. mrigala* and *C. carpio* posed a problem. It was interesting to note that the fingerlings did not die due to heat even when the water level in the pens was very low, probably due to the mixing of reservoir water into the water in the pens. The growth of aquatic weeds inside the pens was kept under control by *C. idellus*. Table 3 gives the number recovered and the survival percentages, by species and by pen. The average survival was the highest for *C. idellus* (94.7%), followed by *L. rohita* (92.2%), *C. carpio* (74.8%), *C. mrigala* (74.4%) and *C. catla* (67.2%). Table 4 gives the recurring and non-recurring expenditures, estimated sale proceeds, profits and the rates of return. The return on investment (26.2%) obtained in this experiment indicated the economic viability of the seed rearing in pens.

Discussion

Erection of pens did not interfere with the fisheries and other uses of the reservoir. The advanced fingerlings raised through pen culture were useful for stocking the reservoir and increasing fish production.

Supplementary feeding was essential in pens as the natural food (plankton) production was not sufficient to meet the demand of the seed at high stocking density. A mixture of soya meal, groundnut oil cake and rice polish used in this experiment served as a cheap supplementary feed, leading to fast growth in all the species. The growth of carp seed in the pens in this experiment was higher than the growth observed elsewhere in cages. A growth rate of 25 mm/per month in *C. catla*, 20 mm in *L. rohita* and 17 mm in *C. mrigala* was recorded in fry rearing in cages installed at the Getalsud reservoir (Banerjee and Govind 1979). Natarajan et al. (1979) observed a growth ranging between 30.2-45.6 mm in 21-28 days of rearing of hatchlings and between 103.6-121.6 mm in 90 days of rearing of fry in cages with supplementary feeds of the same ingredients used in the present experiment. Menon (1983) raised 10-day-old fry (10 mm) to 50-60 mm in 40 days. While Banerjee and Govind (1979) followed a stocking rate of 300-700 fry (10-31 mm/m^2), Natarajan et al. (1979)

Table 2. The abiotic and biotic characteristics in the pens and reservoir.

Parameters		Pen			Reservoir		
		6.12.01	20.12.01	29.1.02	6.12.01	20.12.01	29.01.02
Atmospheric temp.	(°C)	31.1	28.2	30.4	31.1	28.2	30.2
Water temp.	(°C)	29.7	28.1	29.1	30.2	26.7	29.1
pH	(units)	8.27	8.83	7.9	8.01	8.17	7.9
O_2	(mg/l)	6.78	4.03	4.75	8.0	8.31	7.9
Conductivity	(µmhos/cm)	533	579	567	516	573	540
TDS	(mg/l)	347	376.3	368	327	372.4	351
Transparency	(cm)	41.6	34	35.6	68	70	59
CO_2	(mg/l)	–	–	–	–	–	–
Total alkalinity	(mg/l)	190.4	22.6	32.15	180	20.0	31.0
HCO_3^-	(mg/l)	154.6	15.3	22.6	135.1	13.0	21.8
CO_3^{--}	(mg/l)	35.7	6.9	9.5	44.9	7.0	9.2
Hardness	(mg/l)	217	234.6	220	200	231	230
Calcium	(mg/l)	31.8	33.1	43.75	30.1	28.0	44.20
Magnesium	(mg/l)	11.32	12.26	12.15	10.31	10.13	13.20
Phosphorous	(mg/l)	0.033	0.042	0.061	0.04	0.016	0.051
Nitrate	(mg/l)	0.737	1.08	0.640	0.328	0.992	0.435
Silicate	(mg/l)	15.1	15.0	15.21	14.9	17.7	18.2
Plankton	(nos/l)						
Phytoplankton		52656	22513	1347	111980	96870	76900
Zooplankton		–	–	–	40	80	–
Benthos	(nos/m^2)	50.0	86.5	202	432	519	605.5
Primary production	($mgC/m^3/hr$)						
Gross production		141.8	251.1	223.9	195.3	234.3	187.5
Net production		89.6	140.3	163.1	83.6	199.2	125.0
Respiration		66.6	174.6	76	134	42.1	75

Table 3. Number of fingerlings recovered and survival percentage.

Pen	*C. catla*		*L. rohita*		*C. mrigala*		*C. carpio*		*C. idellus*		*Overall*	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	206	68.7	1905	95.3	728	67.4	2066	68.9	95	95	5000	77.2
2	125	47.7	1810	90.5	664	61.5	2202	73.4	97	97	4898	76.0
3	296	98.7	1775	88.8	533	49.4	2109	69.7	89	89	4802	73.8
4	131	43.7	1992	99.6	858	79.4	1706	56.9	100	100	4787	73.8
5	189	63.0	1785	89.3	753	69.7	1925	64.2	97	97	4749	73.3
6	264	88.0	1800	90.0	739	68.4	2204	73.5	90	90	5097	78.6

adopted a higher rate of stocking (700-2 500 fry/m^2). Menon (1983) went for a medium rate of stocking (500 fry/m^2). The lower stocking rate (32/m^2) used in the present experiment may be one of the reasons for the faster growth in all the species.

If technology for culture in pens is improved in terms of pen materials, fabrication, stocking rate, feed and feeding schedule, harvesting methods, etc., it may serve as a cheaper alternative to the expensive land-based nurseries for raising advanced fingerlings for stocking the reservoirs.

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Table 4. Economics of pen culture at the Odathurai reservoir

		Rupees
A.	**Capital cost**:	
	Cost of casuarina poles	17 600.00
	Cost of bamboo poles	6 000.00
	Cost of HDPE woven fabrics	14 000.00
	Stitching charges	1 000.00
	Total	**38 600.00**
B.	**Capital cost per crop** (25% of A - assuming that the material will go for 4 crops)	**9 850.00**
C.	**Recurring cost:**	
	Earth work (trench making)	2 000.00
	Synthetic and coir ropes, nylon twine, etc.	500.00
	Installation charges	1 500.00
	Cost of seed	8 400.00
	Cost of feed	3 100.00
	Watch and ward	3 000.00
	Netting and harvesting charges	1 000.00
	Total	**20 500.00**
D.	**Total cost (B+C)**	**30 150.00**
E.	**Estimated sale receipts**	**38 059.00**
F.	**Profit**	**7 909.00**
G.	**Return on investment**	**26.2%**

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