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Open Water Farming of Pearlspot *Etroplus suratensis* (Bloch) in Low-Volume Cages

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Abstract

Pearlspot, *Etroplus suratensis* (Bloch) seeds of size 6.0-50.0 g were stocked @ 200 m^{-3} in low-volume cages of size 2 m^3 in open waters of mean depth 2 m and moderate water flow (> 0.05 $m.second^{-1}$) in Vembenad lake, on the south west coast of India. The fish was fed with 'Higashi' brand commercial sinking pellets of 20% crude protein. Average fish production was 26.76±9.308 (range 17.80-44.40) kg.2 m^{-3} in 205.3 ± 60.983 days. The stocked fish exhibited absolute growth rate of 0.50-0.90 $g.day^{-1}$ and maximum survival from 45 to 100%. The fish was observed to attain an average size of 163.76 ± 40.214g and a maximum size of 350-480 g at harvest. The specific growth rate ranged from 0.27 to 0.76% day^{-1}. Maximum production was achieved in cages with highest stocking density (230 m^{-3}), and the over all food conversion ratio was 3.52. Length–weight relationship indicated the general well-being of the cage-reared fish compared to that from natural catches. Net cages stocked with pearlspot were almost devoid of fouling and mesh clogging algae as the fish was observed to feed on the filamentous algae attached to the cage structure. These observations indicate the role of pearlspot as a 'scraping' species. Higher concentration of organic carbon in sediments and nutrients, especially nitrates in waters just under the cages indicates the essential need for restricting nutrient loading from cages to below the environmental carrying capacity.

Introduction

Sustainable intensification of food production through aquaculture calls for exploration of new systems of farming and diversification of species. In the context that water will be at a premium and its shortages are becoming critical, multiple use of water systems is also gaining attention world wide (FAO 2006). With reduction in facilities for production, the shift is from low-value species, such as cyprinids, to high-value species. Pearlspot, *Etroplus suratensis* is a high-value, non-tilapian cichlid, indigenous to peninsular India and Srilanka. It is a brackish water fish that has become naturally acclimatised to freshwaters. The fish feeds predominantly on filamentous algae and detritus in nature. Owing to good palatability, omnivorous feeding habits and hardy nature, it is greatly suited to aquaculture. Culture of commercially important fishes in enclosures in open water bodies is an accepted strategy that ensures high production

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and when adopted judiciously, it can promote parallel enhancement of natural fisheries (Hu & Liu 1997; Welcomme & Bartley 1997). The present study pertains to the evaluation of production performance of pearlspot, *E. suratensis*, in cage enclosures in open waters in the Vembenad estuarine system, on the south west coast of India.

Materials and Methods

Experimental cages were set up near Thaneermukkom and Muhamma in Vembenad lake (Lat. 9˚28´ & 10˚ 10´N and Long. 76˚13´ & 76˚31´E) on the south west coast of India, approximately 50 km south of Cochin near the National Waterway No. III (Fig. 1). Rectangular cages of size 1.70 x 1.20 x 1 m made of soft polythene webbing and hard HDPE square meshes of 15-17 mm were fabricated and used. The soft cages were kept in shape by sinkers and anchors. coconut reapers, which are considered water resistant, were used as cage frames for hard cages. The cages were fixed on to floating pontoons attached with a walkway in site I, Muhamma (M1, M2) and on bamboo rafts in site II, Thanneermukkom (T1-T8). The cages were positioned in open waters 500 m away from the shore and water depth 2 m, with moderate water flow (0.05 m.second^{-1}) and good wave action. The submerged volume of the cages was invariably 1 m^3. To avoid loss of feed pellets, the floor of the net cages was covered with 0.5 mm fine mesh netting. The cages were moored on to the lake bottom using cement concrete anchors of 25-30 kg. A cluster of eight replicate cages at site I and 32 cages at site II were used for the study. The rectangular cages were placed in such a way that the longer sides faced the water current, which effectively increased water exchange. To protect the cage installation from floating weeds, bamboo barricade was provided for each cluster of cages. Seeds of pearlspots, *Etroplus suratensis*, produced in the Regional Agricultural Research Station, Kumarakom were nursery reared to appropriate size in net cages (8 mm mesh) and were acclimatised to cage environment and stocked. A stocking density of 200 No. cage^{-1} was maintained in all the cages, and when the size of the seed was bigger, their number was reduced to rationalise the initial biomass. Cage mesh size was 15-17 mm, determined based on the head girth and the

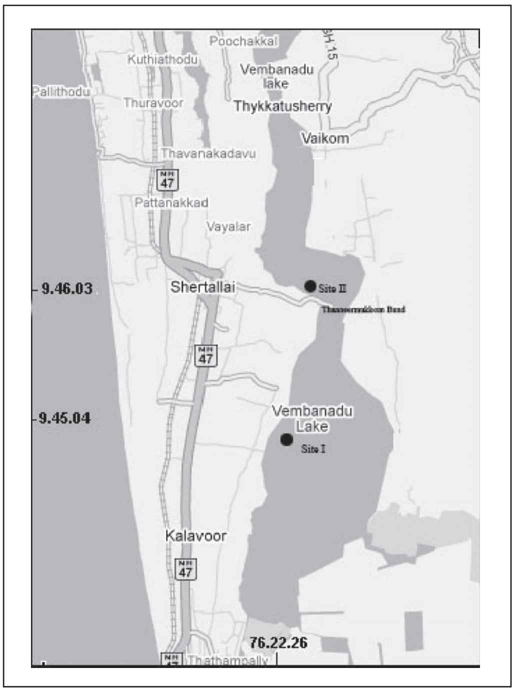

Figure 1. Experimental sites in the Vembanad lake

size of seed, following the formula, *A* = 0.026 x TL, where *A* is the stretched length of the mesh and TL is the total length of the fish fingerling. The stocking size of fishes varied from 6.0 to 50.0 g. Prior to stocking, all the fishes were disinfected by a prophylactic bath in povidone iodine solution (50 ppm) for 15 minutes. The stocked fishes were fed on 'Higashi' brand dry sinking pellets of size 2.5 x 5.0 mm and crude protein 20%. Daily feed was adjusted to size of fish, calculated at 5% of the biomass and at approximately 70-80% of satiation. Fish was trained to congregate near the feeding point, and feeding was performed manually twice a day. Every month the feed ration was modified after ascertaining the fish biomass and rate of consumption. As a protection from the sun, the top portion of the cage surface was covered by shading cloth. Fish was bulk harvested as it reached a minimum marketable size after 130-330 days. The survival rate, mean weight, specific growth rate (SGR = 100 x (*ln* mean final body weight - *ln* mean initial body weight)/duration), absolute growth rate (AGR; g/fish/day), production rate ($kg.m^{-3}$) and food conversion ratio (FCR) were determined. Average size of the fish was determined monthly by weighing and measuring 10% of the fish in each cage. Critical water quality parameters such as temperature, transparency, pH, dissolved oxygen (DO) and salinity were monitored at monthly intervals. Organic carbon content of the bottom sediments was estimated after Buchanan (1971) and nutrients, PO_4-P, NO_2-N and NO_3-N of the waters after Strickland & Parsons (1968). Water samples were collected from the cage site and open lake locations 1 km away from the cage installation for analysis. The primary productivity of the experimental plot was assessed by dark and light bottle method.

Results

Mean survival of fish in cages varied from 45% to 100% (Table 1). In a few cases, the retrieval exceeded the initial stocking density, owing to auto stocking of the cages by natural entry of seeds from the surrounding waters. The AGR of the fish in cages was 0.72 ± 0.141 (0.50-0.90 $g.\ fish^{-1}.day^{-1}$). The mean SGR was 0.50 ± 0.134% day^{-1} (0.27-0.76). The fish was observed to attain an average size of 163.76 ± 40.214 g (112-222g) and a maximum size of 480 g. The stocking density was not found to affect the mean size. Average fish production was 26.76 ± 9.308 kg/ 2 m^3 cage (17.80- 44.40) in 205.3 ± 60.983 (130-330) days. Fish yield of 38 kg/2 m^3/182 days was achieved at highest stocking density (230 m^{-3}). Final biomass increased to 44.0 $kg.cage^{-1}$ when the fish was retained for a period of 330 days. Total production of fish in cages increased with the increase of initial biomass and stocking size. The overall FCR was 3.52 (2.91-4.61) in the replicated cages. The length–weight relationship of fish harvested from cages (Fig.2) was compared with identically sized catches from the open lake (Fig.3). It indicated that the cage-reared fishes were in a better condition compared with fish collected from natural catches.

Table 1. Growth performance of pearlspot, *Etroplus suratensis* in cages of Vembenad Lake.

Parameters	Site I		Site II							
	M1	M2	T1	T2	T3	T4	T5	T6	T7	T8
Cage size (m^3)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Stocking Density ($No.m^{-3}$)	110	230	200	200	200	200	200	200	200	200
Period of rearing (days)	166	182	130	130	197	207	214	231	266	330
Mean size at stocking										
Weight (g)	50.0	32.0	27.0	27.0	6.0	12.0	6.0	6.0	12.0	27.0
Length (cm)	9.0	8.0	10.1	10.1	6.3	7.8	6.2	6.3	7.8	10.1
Mean size at harvest										
Weight (g)	200.0	185.7	127.2	111.7	184	167	127	115	198	222
Length (cm)	20.0	19.0	15.2	14.2	17.7	18.0	15.8	16	16.3	18.9
Maximum size at harvest										
Weight (g)	350	325	200	210	410	320	275	225	300	480
Length (cm)	21.0	20.0	20	18.0	24.0	23.0	21.0	20	20	25
Total Biomass ($kg.cage^{-1}$)	24.10	38.00	20.9	19.4	31.3	32.7	21.1	17.9	17.8	44.4
SGR (%)	0.363	0.420	0.518	0.474	0.755	0.552	0.619	0.555	0.458	0.277
AGR ($g. fish^{-1}. day^{-1}$)	0.90	0.84	0.77	0.65	0.9	0.75	0.56	0.50	0.70	0.59

Critical water quality parameters such as water temperature, tran-sparency, pH, DO and nutrient levels in the cage site did not show any significant variation compared with open lake location (Table 2). Water temperature varied from 27°C to 30.5°C at the cage site. The surface and bottom waters did not exhibit any significant difference, Secchi disc transparency fluctuated between 86.50 ± 35.41 and 114.25 ± 17.98 cm. Water was more turbid during monsoon, owing to monsoonal turbulence and riverine inflow. Similarly, transparency was also reduced during postmonsoon months, associated with increased algal production.

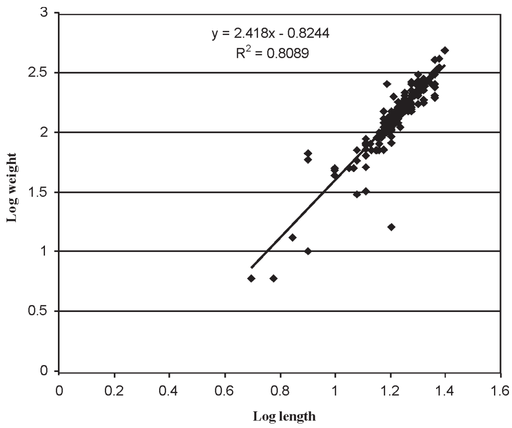

Figure 2. Length weight relationship of *E. suratensis* from cages

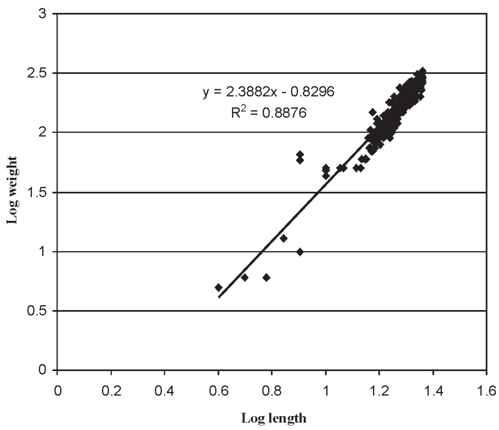

Figure 3. Length weight relationship of *E. suratensis* from natural water

Table 2. Water quality parameters in the cage culture sites and open lakes

Parameters	Cage culture site				Open lake	
	Site I		Site II			
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Depth(cm)	177.00 ± 20.03	135.0 - 190	219.3 ± 20.7	174 - 242	131.2±18.52	100 - 154
Transparency(cm)	86.50 ± 35.41	50.0 - 170.0	114.25±17.98	90 - 150	106.4±35.79	35.5 - 150
Temperature(^{0}C) Air	28.20 ± 0.42	28.0 - 29.0	30.0 ± 1.54	26.0 - 31.0	29.67±1.91	26.3 - 33.2
Water	27.30 ± 0.48	27.0 -28.0	28.50 ± 1.15	27.0 - 30.5	28.89±1.31	26.7 -30.8
pH	6.95 ± 0.16	6.5 -7.0	7.17 ± 0.25	7.0 - 7.5	6.58± 0.53	5.80 - 7.60
Salinity (ppt)	1.28 ± 1.26	0.06 -3.47	1.73 ±2.90	0.08-7.07	1.82± 2.16	0.06 - 6.42
Dissolved Oxygen(mg. l^{-1})						
Surface	8.37 ± 1.26	6.4 -10.1	8.48 ± 0.66	7.6 - 10.0	7.56±1.34	4 .0 - 8.6
Bottom	7.81 ± 1.37	6.4 - 9.9	8.04 ± 0.65	7.2 - 9.6	6.84±1.15	4.2 - 8.0
Primary productivity						
GPP (mg C. m^{-3}. $hour^{-1}$)	126.82±54.06	30 - 210	96.11± 37.89	53.33 - 154.29	66.84±32.82	24 - 120
NPP (mg C. m^{-3}. $hour^{-1}$)	65.38±52.68	15 -202.5	44.31± 27.30	13.32 - 90.57	43.77±26.26	0 - 80.0
Organic carbon (%)	1.06±0.65	0.06 - 1.93	2.60± 2.45	0.72 -6.64	1.37±0.68	0.3 - 2.7

The DO levels at the cage site were moderate with monthly variation ranging from 6.4 to 10.10 mg. l^{-1} for surface and from 6.4 to 9.9 mg. l^{-1} in bottom waters. In the open lake locations, DO varied between 4.0 and 8.6 mg. l^{-1}. Salinity ranged from nil to 3.5 ppt during the period of study. Salinity variations were less pronounced at site I situated upstream the salinity regulator at Thanneermukkom. In site II, located on the seaward side, salinity levels were high and variations more pronounced Organic carbon percentage in sediments below the cages was found to increase perceptibly, and it ranged from 1.06 ± 0.65 to 2.60 ± 2.45%. Organic content in sediments at the cage site increased perceptibly from initial levels, 0.5 to 2%. The gross primary productivity at the cage sites was also higher (96.11 ± 37.89 to 126.82 ± 54.06 mg C. m^{-3} $hour^{-1}$) than that in the open lake location (66.84 ± 32.82 mg C. m^{-3} $hour^{-1}$) away from cages. Nitrite concentration in water increased from 0.006 to 0.068 µg. l^{-1}, during the culture period. However, the maximum concentration of nitrite at site I (4 µg. l^{-1}) was lesser than its highest concentration (28 µg. l^{-1}) at the adjacent open lake location, observed during monsoon. The nitrate concentration also increased sharply at the cage site during the farming period compared with its initial levels, its maximum concentration was 15.2 µg. l^{-1} compared with 4.0 µg. l^{-1} at the adjacent open water location.

Discussion

Growth performance of pearlspots (*E. suratensis)* to an average size of 200 g in 166 days and maximum size of 350 g is remarkable in the context that pearlspots are generally considered slow-growing species, growing hardly to 120-130 g in pond conditions (Thampy 1980). Apparently, unlike in ponds, the production capacity of fish in cages is not limited by water quality or feed inputs (Rowland et al. 2004). The attainment of an average size of 127g in 130 days in open water cages indicates the versatility of pearspots for cage culture. Apparently, production of fish in cages increased with increase in initial stocking size and stocking density. The results indicate that even at low stocking densities, higher stocking size results in a reasonably better fish yield. This implies that for maximizing production in cage farming, it is essential to ensure an optimum individual size and biomass. The results show that an initial stocking size of 30-50 g will be good if the commercial target is to market pearlspot at 200-250 g in 6-8 months. Survival rates are also very good when stocking size is high. The observed biomass gain of 0.9 $g.day^{-1}$ for pearlspot under cage culture in open waters is apparently linked to high stocking density employed in the study. High stocking rate coupled with heavy feeding contribute to enhanced production in cage fish farming. The results also reveal that pearlspot adapts well to captivity in low-volume cages. Probably being a schooling species, the fish tolerate such crowding in cages.

The net cages stocked with pearlspots were almost devoid of algal growth and mesh clogging, a common problem encountered in cage fish farming. This is apparently due to the algal browsing behaviour of pearlspots. Studies on food preference of

E. suratensis (Devaraj et al. 1975; De Silva et al. 1984; Keshava et al. 1988; Jayaprakas & Padmanabhan 1985; Bindu & Padmakumar 2008) indicate that the fish is essentially an algal grazer subsisting mostly on filamentous algae and detritus. Probably, the cage enclosures functioned as a substratum for the growth of filamentous algae, which became an additional source of food for the fish in cages. The fish apparently consumed large quantities of mesh clogging algae by nibbling or scrapping (Keenleyside 1979; Yamaoka 1991). The semicircular nature of the mouth and minimum protractibility of the lips are adaptations for such a complex food capturing process (Geetha et al. 1990). This observation shows that pearlspots can be employed as a 'scraping' species in cage culture systems.

Earlier studies on cage farming in India were mostly exploratory, and the species used were either carps or murrells (Parameswaran 1993). Being a high-valued species, locally fetching almost six times market value compared with carps, the study points to the immense possibilities of farming of pearlspot in net cages. Unlike carps, *Etroplus* is not a jumping species, and being very gentle they do not damage the cage netting during sampling or at harvest. The laterally compressed body shape foils easy escape of the fish from cages and also permits larger mesh size and a better water turn over for the cages. From the length–weight relationship of this species, it obvious that the cage-reared fishes attain a higher biomass increment (b = 2.418; $p<0.05$) with reference to length compared with fish from natural waters (b = 2.388; $p<0.05$). Apparently, this is a reflection of the superior well-being and adaptability of the fishes to cage farming.

Accumulation of organic matter and decomposition of feed residues affect the oxygen availability and oxygen consumption of the fish in cages (Jiwyam & Chareontesprasit 2001). The DO levels and transparency have been reported to go very low levels near cages (Vargasmachuca et al. 2007). In the present study, high oxygen levels observed at the cage site indicates that caged fishes were not constrained by oxygen in such large open waters. The DO concentration in fish cages was apparently dependant on rate of exchange of water (Li & Xu 1988). In sediments below the cage, the organic carbon percentage was found to increase from its initial levels and so also the nitrate concentration in the waters. This has contributed to high primary productivity in the lake waters. It could therefore be inferred that in oligotrophic water bodies cage culture shall be of help to enhance fish production while in eutrophic waters, cage farming beyond limits can lead to severe problem of pollution. In common carp cages at Philippines, Beveridge (1996) observed 90% of the phosphate was lost to waters. In Chinese cage culture system, Li (1994) reported that 27% of the N and 14% of P introduced as fish feed were only utilized by the fishes. In salmon cage culture in Europe, Kautsky & Folke (1989) reported that 75% of N and 77% of P introduced as feed were reportedly lost to the water. Beveridge (1984) put forth a predictive model for fish production by keeping water quality within acceptable limits. This indicates the dire need to maintain an appropriate cage-to-open water ratio, for restricting nutrient loading.

Experiments on cage culture in India have been mostly exploratory and the yield rates range from 0.7 to 1.3 $kg.m^{-3}.month^{-1}$ (Bandhyopadhyay 2003) and a net fish production of 16.03 $kg.m^{-3}.year^{-1}$ (Kumaraiah 2006) has also been reported. However, very high productivity has been reported by authors elsewhere (Li 1994; Hu & Liu 1997; Zainal & Effendi 1998).

The relatively promising performance of pearlspot in the present study is apparently due to species attributes, superior quality of the feed utilized and the high environmental resilience offered by the vast water body. The food conversion efficiency achieved in the present study is comparable to that reported earlier in India (Dehadri 1975; Kumaraiah et al. 1986; Sukumaran et al. 1986). When feed with higher protein percentage (35-40%) is utilized, over all FCR up to 1.3-2.0 has been reported by some workers (Luchini & Quiris 1990; Rowland et al. 2004). The impressive growth performance of pearlspots indicates the tremendous potentials of this species for cage farming in open waters. Being a brand cuisine of the backwater tourism and with high market demand, cage culture of pearlspots offer great promise. The stimulated algal production in waters outside the cages though in very small scale warrants the need for setting limits while popularizing commercial cage farming.

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