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A pilot study on culture of Asian seabass *Lates calcarifer* (Bloch) in open sea cage at Munambam, Cochin coast, India

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ABSTRACT

India ranks third in global fish production with 6.4 million metric t, but mariculture in the Indian seas is yet to be popularised. The limited availability of protected sites and the probable conflicts with other activities such as fishing, tourism and navigation are factors likely to influence mariculture development in India, besides finance, technology, expertise and government policy. A pilot scale inshore marine cage culture experiment has been undertaken since 2007 at Visakhapatnam coast of India in the Bay of Bengal. A similar cage was launched at Munambam for the culture of Asian seabass *Lates calcarifer.* Asian seabass seed (3.5 ±1.5 g) reared in hapa installed in ponds for a period of 30 days were stocked in the cage and cultured for a period of 120 days and harvested at an average weight of 315.5 g. Analysis of nutrient levels in seawater near the cage, revealed no noticeable accumulation of solid particulate wastes indicating that water current (0.5 to 1.0 m sec^{-1}) was adequate in the site to prevent accumulation of wastes in the cage as well as in the premises. The cage culture activity was found to influence the planktonic and benthic fauna.

Keywords: Asian seabass, India, *Lates calcarifer,* Mariculture, Open sea cage farming

Introduction

Mariculture has great potential in augmenting fish and shellfish production and food supply, creating employment possibilities and high potential for export. Cage farming could be considered the main system to facilitate the rapid growth of marine fish farming. It has been predicted that fish consumption in developing countries will increase by 57%, from 62.7 million t in 1997 to 98.6 million t in 2020 (Delgado *et al*., 2003). Rapid population growth, increasing affluence and urbanisation in developing countries are leading to major changes in supply and demand for animal protein, from both livestock and fish. The origin of the use of cages for holding and transporting fish for short periods can be traced back to almost two centuries ago in the Asian region (Pillay and Kutty, 2005). Marine commercial cage culture was pioneered in Norway in the seventies with the rise and development of salmon farming (Beveridge, 2004). The first marine cage farming success in Asia was in Japan for culture of Japanese amberjack or yellowtail *Seriola quinqueradiata* and red seabream *Pagrus major* (Watanabe *et al*., 1989). Over the last 20 years, marine finfish culture, predominantly cage farming, has spread throughout Asia. Asian seabass, *Lates calcarifer* is a candidate species for open sea cage farming as well. Its production has been increased during the past ten years, and FAO statistics showed that 26,000 t were produced in 2004 (FAO, 2006). Seabass farming in Asia is carried out in freshwater, brackishwater and marine environments, with most production based on hatchery-reared stock. Seabass is mostly cultured in ponds and cages located in brackishwater estuaries or coastal areas. Major issues to be addressed before commercialising cage farming in India are, marine policy in leasing out specific areas for cage farming to avoid conflicts among different users of the water, proper site selection measures with easy access to the site with minimum pollution, adequate water quality parameters and proper awareness campaign among fishermen, aquaculturists and entrepreneurs.

Pilot scale inshore marine cage culture experiments have been conducted by Central Marine Fisheries Research Institute (CMFRI) since 2007, at Visakhapatnam coast in the Bay of Bengal with financial support from Ministry of Agriculture, Government of India. A successful harvest of 550 kg seabass was obtained in about four months culture period by stocking 1400 numbers of fingerlings. The present pilot study was carried out to understand the ecological and biological parameters of an open sea cage farm at Cochin coast of the Arabian Sea in the course of a 120 day production cycle. This preliminary study will help to identify the logistic, sampling and other cage related problems for successful cage farming operations in the south-west coast of India, besides introducing the idea of mariculture through cage farming to the local fishermen of Cochin coast to have an alternate livelihood option.

Materials and methods

Site selection

A pilot survey was conducted prior to the commencement of cage farming. The water quality criteria for marine life and aquaculture as collected from different sources are summarised in Table 1. The water and sediment quality parameters of the proposed sites were determined prior to the installation of cage. A site at Munambam, Cochin, about 2 km west from Cherai beach, with wave height 1-1.2 m and maximum tidal amplitude of 1.23 m was chosen. The site had wind velocity less than 30 km h^{-1} during the culture period. The site was 10 m deep at 10° 08' 083'' N; 076° 08' 915'' E and was away from any source of direct pollution from land.

Table 1. Water quality criteria for marine life and aquaculture

Parameters	
Salinity	25–40 ppt
pH	7.8–8.4
Temperature	no abrupt change
Dissolved oxygen	>4 mg l^{-1}
Total inorganic nitrogen	<0.1 mg l^{-1}
Ammonia (NH_4 + NH_3)	<1 mg l^{-1} for pH^{-8}
Transparency (yearly mean)	<5 m

Cage frame and nets

Indigenously fabricated high-density polyethylene (HDPE) cage measuring 6 m diameter with catwalk and hand rail with provision for connecting different nets was used. HDPE pipes were filled with polyurethane foam (PUF) for floatation. HDPE outer predator (braided 60 mm mesh) and inner growout (40 mm mesh) nets with a net depth of 6 m were used. A bird net (80 mm mesh) was used to protect the stock from birds. A 6 m diameter HDPE ballast pipe (63 mm diameter) at the bottom with holes for the free flow of the water, lined with 10 mm iron ropes for increasing the weight, was used to maintain proper shape of the nets

Mooring

A system of moorings with a single fixed point in the seabed was used, like the Froya System of Norway (Fröyaringen, 2003). This type of mooring system is relatively cost effective and easy to install. Instead of expensive anchors, the cost effective gabion box (3x1x1m polypropylene, Garware Wall Ropes, India) with 15 cm mesh filled with about 2.5 t of raw granite stones, was used instead of anchor weight. A 10 mm MS mooring chain of 30 m was connected to the cage frame using D-shackles and the swivel connected to the chain rotates the entire cage by mooring only at a single point. Tension on mooring cable was maintained by cylindrical HDPE floats (100 m^3 pressure) connected with a shock absorber of 100-150 kg, which in turn resists any pressure on the cage structure.

Stocking

Based on criteria like market demand, growth performance and availability of complete hatchery production technology, Asian seabass *Lates calcarifer* was selected as the candidate species for the present study. At the beginning of the culture period, 6000 numbers of *L. calcarifer* weighing 3.5±1.5 g (2-4 cm) were randomly distributed in equal numbers in two nylon hapa (2x2x4 m with 10 mm mesh) placed inside the inner grow-out net. After 60 days, on reaching about 100 g size, the fish were released into the inner grow-out net of 40 mm mesh size.

Feeding

The fish were fed two to three times a day with finely chopped shrimp discards (20-30 kg day^{-1}) till they reached 100 g size (in about 60 days). Subsequently, the fish were fed with chopped or small trash fish twice a day in the early morning and evening hours, throughout the culture period (40-100 kg day^{-1}).

Growth performance, water and sediment quality parameters

Data for a period of four months, starting from December 2008 till April 2009 were collected. Monthly samples comprising 25 numbers of fish was netted from the cage and the growth increment in terms of length and weight were recorded. Water samples were collected monthly from the cage area and analysed for temperature, pH, dissolved oxygen, ammonia, nitrite, nitrate and phosphorus levels (APHA, 1989). Sediment samples were collected and analyses of sediment texture, organic carbon content and total aerobic heterotrophic bacterial count were done (Jackson, 1958). Total production was recorded at the end of culture period and measurements like weight gain (g d^{-1}), specific growth rate (SGR, %) and production (kg m^{-3}) were calculated as mentioned by Ballestrazzi *et al.* (1994) and Essa (2000).

Weight gain (g per day)	=	(Final weight - Initial weight)/ trial days
Specific growth rate (SGR %)	=	100 x (ln. final weight - ln. initial weight)/trial days), where 'ln' is the natural log

The phytoplankton, zooplankton and benthic macrofauna at the cage culture site were also collected using plankton net before and during the culture period. The samples were preserved in lugol's iodine or 4 % formalin till identification.

Results and discussion

Seabass were reared in the cage for 120 days during December 2008 - April 2009. Seabass grew from initial weight of 3.5±1.5 g to an average weight of 315.5 g in 120 days (Fig. 1 and 2). The total fish recovered on harvest was only 20%. Even though salinity acclimatisation of seeds was carried out gradually from 15 ppt to 32 ppt, change of habitat of the fish from pond water to the sea might have caused some mortality to the fingerlings. It has also been presumed that most of the mortality occurred immediately following the stocking of the fingerlings in the cages and may be attributed to some extent, handling and other unknown stress factors. Though the fish were quite small (3.5 g) while stocking in the hapas inside the cage and needed periodic grading to control cannibalism and for management of differential growth, it was not done due to the practical difficulty in doing grading in the open sea conditions. The reason for poor survival rate obtained at the end of the study may be mainly because of cannibalism due to non-grading of the stock in the hapa, or due to the escape of small fish (3.5±1.5 g) from net during post-nursery rearing period in the cage. The rate of fish production from the cage was 4 kg m^{-3}, and can be increased to 20-25 kg m^{-3}, with a stocking density of 50-60 numbers of seabass fingerlings m^{-3}. In semi-intensive cage farming of European seabass (*Dicentrarchus labrax*), lower production (4.78 and 5.40 kg m^{-3} in 323 days) was reported by Essa *et al.* (2005). Due to the low survival rate, feed conversion ratio was not worked out. Mean weight gain was 2.6 g day^{-1} and specific growth rate (SGR) was 3.75%, which are very good for seabass. The present data suggest that juvenile seabass were in the lag phase of growth between 2-100 g and begin rapid growth (exponential phase) above 100 g size (Fig. 1 and 2). The growth of seabass is the maximum during the last month of the culture period *i.e.,* from day 90 to day 120 (Fig. 2) compared to the post-nursery phase up to 100 g (Fig. 1).

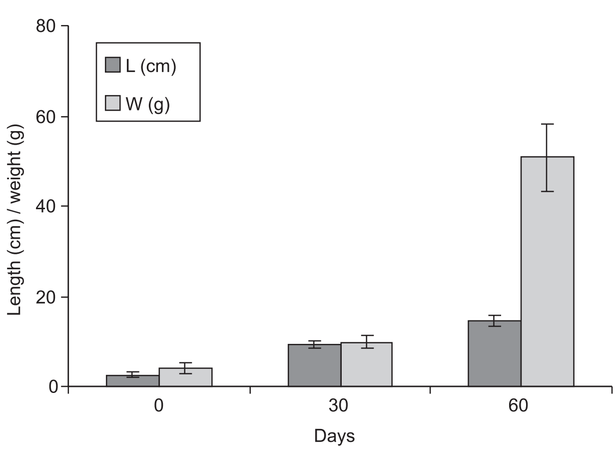

Fig. 1. Growth measurements of *L. calcarifer* fingerlings during post-nursery phase

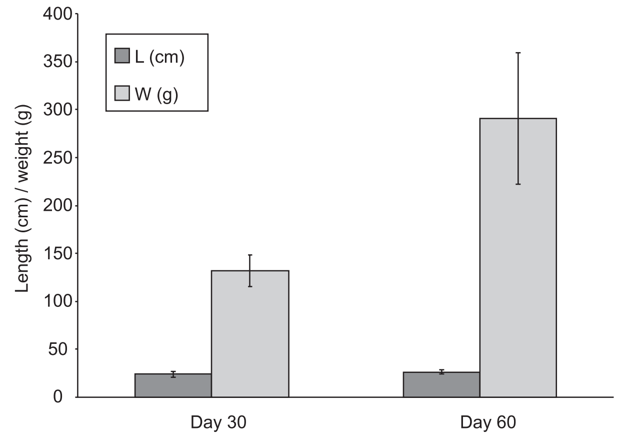

Fig. 2. Growth measurements of *L. calcarifer* during grow-out phase

Water and sediment quality parameters of cage area are shown in Table 2**.** Muddy bottom is characteristic of Cochin coast. However, sandy or gravel bottom is reported to be ideal for cage farming. On sediment analyses, it was observed that the sand content in the cage site increased from the initial 26.02 to 52.80% during cage culture and silt content reduced from 34.93% to 22.05%. The clay content in the sediment had reduced from 25.25% to 11.33% during the culture (Table 2). The changes in sediment quality may be attributed to the variation in current pattern, which lead to some changes in the bottom parameters. The sea surface temperature varied between 29.5 °C in December and 31.6 °C in April. In addition to being a globally important fisheries and aquaculture species, *L. calcarifer* is also reported to have a wide thermal tolerance range of 15-40 °C (Kartersky and Carter, 2007). For salinity, the values were found to be in the range of 30.63 to 31.43 ppt and the pH values were almost in the alkaline side, which do not have much implication on growth of seabass. The cited results in Table 2 also revealed that, dissolved oxygen values in cage area were not less than 4.70 mg l^{-1} and the unionised ammonia did not increase above 0.05 mg l^{-1} throughout the culture period. The values were found to be in the desirable range for seabass (Gundersen, 1981). Nitrate and nitrite values were not toxic to fish (Wu, 1995; Alvardo, 1997). Phosphorus is not important in promoting algal growth in the marine environment (Handy and Poxton, 1993) and therefore, its low values in the cage area are unlikely to have any significant effect on fish growth too. With respect to the organic carbon content of the sediments, the values oscillated between 0.24 and 2.46%. It is possible that the water current velocity (0.50 -1.20 m sec^{-1}) in cage area resulted in distributing solid wastes, thus avoiding the undesirable effects of organic sediment accumulation both near the cage and in the environment. The physical and chemical characteristics of cage site including depth,

Table 2. Water and sediment quality parameters of the cage culture site at Cochin

Parameters	Surface (05 m) Before culture (Mean ± SD)	Surface (05 m) During culture (Mean± SD)	Bottom (10 m) Before culture (Mean± SD)	Bottom (10 m) During culture (Mean± SD)
Water quality				
Temperature (^{0}C)	29.65±0.21	29.74±1.56	29.2±0.28	29.3±0.92
pH	7.69±0.38	7.78±0.07	7.76±0.36	7.86±0.08
Dissolved O_2 (mg l^{-1})	6.49±0.32	5.80±0.67	4.97±0.02	4.63±0.83
Salinity (ppt)	27.78±4.04	31.75±0.59	33.54±0.78	32.39±0.27
Chlorophyll *a*, (mg m^{-3})	0.563±0.01	0.245±0.13	0.186±0.10	0.3198±0.19
Total suspended solids, TSS (mg l^{-1})	31.82±3.71	23.63±14.14	45.07±42.82	39.44± 20.46
Phosphate (ppm)	0.009±0.01	0.009±0.01	0.015±0.01	0.013± 0.01
Nitrite (ppm)	0.004±0.00	0.003±0.00	0.011±0.01	0.008± 0.01
Nitrate (ppm)	0.080±0.11	0.006±0.01	0.014±0.02	0.009± 0.02
Ammonia (ppm)	0.003±0.00	0.019±0.02	0.050±0.04	0.004± 0.01
Silicate (ppm)	0.175±0.01	0.041±0.06	0.145±0.14	0.054± 0.07
Biological oxygen demand, BOD (mg l^{-1})	1.28±0.80	1.78±1.08		
Gross primary productivity, GPP (mg C l^{-1} h^{-1})	0.052±0.07	0.057±0.03		
Net primary productivity, NPP (mg C l^{-1} h^{-1})	0.010±0.01	0.030±0.04		
Total heterotrophic bacterial count (x 10^2 cfu ml^{-1})	3.45±2.48	3.32±1.88	1.20±0.85	2.26±2.09
Sediment quality				
pH			7.19 ± 0.54	7.48 ± 0.18
Organic carbon (%)			2.07 ± 1.07	1.18± 0.81
Sand (%)			26.02±34.97	52.80±26.61
Silt (%)			34.93±23.79	22.05±22.23
Clay (%)			25.25±14.99	11.33±7.27
Total heterotrophic bacterial count (x 10^6 cfu g^{-1})			1.27±0.30	1.23±1.58

current and the short term fish culture may also have influenced this finding. The gross primary productivity recorded was 0.052 and 0.057 mg C h^{-1} before and during the culture period.

The total cultivable heterotrophic bacterial counts (THB) of the surface water, near bottom water (10 m depth) as well as of the sediment, near the cage site were monitored at monthly intervals and the results are given in Table 2. There was no significant difference between the mean values of bacterial load recorded during the pre- and post-stocking periods. However, there was a substantial increase in the total heterotrophic bacterial load in the surface water, bottom water as well as in the sediment about 2 months post-stocking, which again came down to normal values within a fortnight. No disease or parasites were observed in the cultured fish at any occasions.

Among the 19 genera of phytoplankters recorded from the cage site, diatom *Chaetoceros* sp. dominated with 32.74% followed by *Pleurosigma* sp. with 16.5%. At the cage site, the average density of phytoplankton observed before and during the culture period were 8.5 x 10^3 and 4.5 x 10^3 cells l^{-1}, indicating an increased consumption of phytoplankton cells during the culture period. Nineteen groups of zooplankton were recorded from the cage site and copepods formed the major component and contributed 68.77%. The mean values of zooplankton at the cage site before and after stocking the cage were 1.6 x 10^4 and 3.2 x10^4 no. 100 m^{-3} respectively, showing an increase of productivity at the secondary level during the culture period. Among the six groups of macrobenthos observed from the cage site, foraminifera formed the major component contributing 64.28%. The mean number of macrobenthos at the cage site before and during the culture period was 6.1 x 10^4 and 22.67 x 10^4 no. m^{-2} respectively, indicating a tremendous increase at the cage site during the culture period. The reason may be due to organic inputs such as trash fish, shrimp discards *etc.* leading to the accumulation of phytoplankton and zooplankton with considerable impact on the planktonic and benthic macrofauna at the given site. The amount of uneaten feed in Atlantic salmon cage farming has been reported to vary from 1% in dry feed up to more than 30% in wet feeds (Barg, 1992; EAO, 1996; Winsby *et al.*, 1996; Nash, 2001; Pearson and Black, 2001).

The most striking observation during the culture period was reduced level of cage net fouling, which is an incentive for future selection of the site for cage farming. The nets were attached with only few filamentous algae (*Enteromorpha* sp.) and some species of molluscs like oysters which did not cause clogging of the net. Presence of cage has favoured the establishment of fish shoals surrounding the area that takes advantage of the presence of organic matter derived from fish cages and they definitely would have a positive effect in reducing the environmental impact of cage fish farms.

Globally, the system of marine cage farming has had an important role in meeting the global demand for fish products and India is endowed with vast fisheries resources in terms of a coast line of 8118 km and 2.02 million km^2 of exclusive economic zone, including 0.53 million km^2 of continental shelf. A great potential is existing in India for mariculture activities in future and cage farming is the best option for it.

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