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# Present status and future scope for fish production in cages and enclosures in India

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ABSTRACT

The paper highlights the role of intensive fish husbandry system in cages and enclosures in the overall fisheries development of the country. This system of fish culture in widely dispersed aquatic ecosystems in India has yielded stimulating results, though there are some immediate constraints. The pressing problems of cage size, shape and material, diseases and parasites, and location of operational sites have been discussed. Such intensive culture systems have numerous advantages over the traditional pond culture.

It is concluded that cage and enclosure culture of fiifish and shellfish will ultimately carve its niche in the streams, rivers, canals, beels, lakes, reservoirs, estuaries, lagoons, bays and coastal areas of the country.

India has large habitat resources available for aquaculture. There already exist 28,000 km of river length, extensive anastomosis of irrigation canals, 1.6 million ha of available water area by way of ponds, tanks, etc., and 1.5 million ha of potential water area for fish culture. These resources occupied with 3 million ha of reservoirs, 2 million ha of brackishwater area and 6,100 km of coast line offer potential sites for such intensive culture.

The last decade has witnessed a considerable expansion of aquaculture in India. Broadly classified, 3 culture systems are currently used for aquafarming, viz. embanked pond enclosures, pens and cages. Considering the number of constraints of pond culture system in terms of shortage of ground nurseries, problems of retrieval of stock, predation, pollution, loss of water through seepage and cost of fertilization of waters, the recent trend has been to turn to intensive fish husbandry systems in cages, enclosures, raceways etc., which utilize lesser space, circumvent the environmental limiting factors and minimize cost of capital investment leading to higher fish production. The paper projects the present status of such intensive culture systems in India, highlights the problems encountered and lays stress on the future trust of research in identified areas.

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## PRESENT STATUS

### *Cage culture*

In Indian freshwaters, the fish species raised in cages are essentially cyprinids comprising Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*), exotic common carp (*Cyprinus carpio*) and silver carp (*Hypophthalmichthys molitrix*). Catfishes of the families Bagridae (*Mystus seenghala*), Siluridae (*Ompok bimaculatus*), Anabantidae (*Anabastes udineus*) and Heteropneustidae (*Heteropneustes fossilis*) have also given encouraging results when cultured in cages, especially the last 3 air-breathing species. Cage culture of murrels (Channidae), viz. *Channa punctatus*, *C. marulius* and *C. striatus*, has also been occasionally tried.

Prior to 1973, except for the work of Kulkarni (1969) who reared fertilized eggs of Indian major carps in floating cloth tanks (*hapas*) little was known about cage

and pen culture. During the last decade, culture of different fish species in cages was actively pursued. The species selected for cage culture, limnological conditions, types of cages, construction material, cage dimension and feed formulation varied very much in the experiments so far conducted in different ecosystems (Tables 1, 2). A critical appraisal of these results is made.

Cyprinids offer excellent potential for this type of culture. They grow rapidly, have high survival rate, accept artificial pelleted feed and adapt to high production densities. The production of common carp in cages is 30 times more than that obtained in its monoculture in stagnant ponds. In cage culture experiments carried out at Allahabad (Table 1) monoculture of the Indian major carp *C. mrigala* gave much higher production (16 kg/m²) than its polyculture with two other species (2 kg/m²), viz. *Catla catla* and *Labeo rohita*.

Culture of air-breathing fishes, viz. *A. testudineus*, *C. punctatus* and *C. striatus* in bamboo cages also gave high production in Assam (Thakur, 1975).

Fingerlings of common carp and *C. catla* have been successfully raised in cages. The stocked fry showed survival rates of 90–97.5% and attained fingerling size (100 mm) in about 2 months as compared to the normal 3 months. These results indicated that with further refinement, this technology can give the necessary boost to the carp fingerling production in the country for seedling the waters under aquaculture. The present capacity of the fish seed farms in the country is sufficient to produce only 4% of the total need of the country (Natarajan *et al.*, 1979)

Cage culture in brackish water, lagoons and lakes has largely remained confined to prawns. Stray experiments were conducted on the edible crab *Scylla serrata* and the milkfish *Chanos chanos*. In a series of net cages installed in Ennore estuary, Madras, the post-larvae of *Penaeus indicus* gave 1,250–2,880 kg of *P. indicus* and 1,450 kg/ha of post-larvae of *P. monodon* (Maheshwari, 1984). In the Vizhinjam farm, the highest production and survival was obtained at a stocking rate of over 1 l/m² in floating cages. In fixed cages, the highest production was obtained with a stocking density of 10/m². These results compare favourably with the production rates of prawn in Japan (2,000 kg/ha/6 months), even through the recovery was only 38%. In the only experiment reported, the crab (*S. serrata*) seeds (45–55 mm) were stocked @ 4 crabs/component/cage of 16 compartments fixed in brackishwater of Tuticorin. Eye-stalk-ablated crabs showed a rapid growth of 57 g/month. In chelate and dactylopodite-removed crabs, the growth was slow with average weights of 20 and 29 g/month respectively.

In a culture of spiny lobster (*Panulirus homarus*) in cages suspended in coastal waters of Tuticorin at the end of 8 months, the maximum growth was 210 g (av. 165 g) and survival rate 57.5%.

*Pen culture*

Ox-bow lakes, the water bodies associated with river basins, are important inland fisheries resources in the Indo-Gangetic plain. In experiments conducted in pens installed in an ox-bow lake in Muzaffarpur (Bihar) *C. catla*, *L. rohita* and *C. mrigala*, stocked in the ratio of 5 : 4 : 1 with an average size of 100 g, achieved in 6 months when all these fishes registered remarkable growth of over 1 kg pen culture experiments at Killai backwaters on *P. monodon* gave production of 250 kg/ha of *P. indicus*. The lower yield obtained than in saline ponds at Adyar (514 kg/ha/5 months) and Porto Novo (335 kg/ha/34 months) was due to low tidal emplitude and sandy nature of the area. Culture of *P. monodon*, on a pilot scale, in Chilka lake gave a record production of 100 kg/ha/2 months with 50% survival.

Natarajan *et al.* (1984) recorded very high production rates of 92.4 tonnes/ha/year for the blood clam *Anadora granosa* in Kakinada Bay, 120–150 tonnes/ha/year for the backwater oyster *Crassostrea madrasensis* at Tuticorin coast, 180 tonnes/ha/year for *Perna indica* in the open sea at Vizhinjam and 480 tonnes/ha/year for *P. virdis* in Goa. Such high productions

speak of the immense potential and scope that pen culture offers. Pens were tried as an alternative for nursery ponds towards carp seed production. A bamboo enclosure of 250 $m^2$ fixed in the littoral areas of Poongar swamp yielded advanced fry and fingerlings of *C. mrigala* and *Labeo fimbriatus* @ 1.27 million/ha in 90 days (CIFRI, Barrackpore, 1979). Similar results were obtained in Tungabhadra reservoir (Swaminathan and Singit, 1984).

The growth characteristics of the euryhaline species, viz. *Chanos chanos*, *Mugil* sp., *Siganus canaliculatus*, *Etroplus suratensis* and *Carank* sp., in a pen of 100 $m^2$ installed in the Pullavathi brackishwaters. *E. suratensis* showed the highest monthly growth (52.5 g) followed by *Mugil* sp. (36.5 g), *Carank* sp. (34.0 g), *S. canaliculatus* (33.0 g) and *C. chanos* (31.0 g). The maximum growth of *E. suratensis* was attributed to its herbivorous habit. Encrustations of algae *Polysiphonia*, *Ectocarpus* and *Entermorpha* on the pens provided a good food source for the species. The poor growth of *C. chanos* was ascribed to the poor net phytoplankton content, and of other species to their stenohaline nature, feeding habits and high stocking density.

## PRESENT CONSTRAINTS ON TECHNOLOGY DEVELOPMENT

Cultivation of fishes in cages and other enclosures installed in streams, rivers, lakes, reservoirs, ox-bow lakes, estuaries, bays and coastal areas have given stimulating results, yet there are a number of problems which need immediate attention. Some of them are described in the following paragraphs.

### *Cage material and dimension*

Synthetic net cages, though good and lasting, were prone to turtle and crab attacks and quite often gave way resulting in the escaping of stacked and reared material. Studies at Allahabad vitiated that placement of cages, away from the embankments provided ample protection from crab attacks, and that the nylon net cages could be strengthened by reinforcing with 75 mm wide nylon tapes at all the seams and at intervals of 70 cm where double stitching with nylon threads were given. In split bamboo cages some portions get crumbled soon after their submergence in water. At Allahabad, the bambo frame was fixed with iron nuts and bolts which provided easy assembly, dismantling and transport of such frames to the work site. Galvanised iron-mesh and conduit pipe frames proved l ght and sturdy but poor galvanising resulted in rusting of wire meshes. No amount of enamel or water-proof paint was able to save the meshes from erosion once rusting started. Vinyl-coated wire mesh, as used and recommended by Swingle (1971), is yet to become popular in this country.

The cage should not be too large. Coche (1976) recommended 20 $m^3$ as the upper limit with 5–10 $m^3$ preferred. In India, the emphasis has been on cages of 1–4 $m^3$ size but cages as large as 60 $m^3$ have also been used with varying degrees of success. This probably is due to the specific conditions prevailing at a particular place.

### *Stocking density*

The stocking density followed on cage and pen culture in different ecosystems vary widely. The optimum stocking densities for different species are yet to be worked out. *C. catla*, *L. rohita* and *C. mrigala* kept in bamboo cages showed no significant differences in growth in different stocking densities. However, common carp showed significant growth in lesser density in bamboo cages than in net cages. Similarly, no significant differences in growth were observed when *Macrobrachium malcolmsonii* and *M. idae* were raised in cages installed in a seasonal canal. The stocking densities for prawns grown in cages varied from 3 to 25/$m^2$.

### *Food ration*

If fish are to be kept in high density culture a suitably formulated pelleted feed has to be provided. Maximum growth was obtained with Indian major carp when poultry feed with 24% crude protein was provided to the fingerlings (CIFRI, Barrackpore, 1973). Pelleted feed of soya-

bean, rice polish and groundnut-cake (1 : 1 :1) fortified with 20% NaCl, 1% vitamin B-complex and 1% terramycin is a very good feed. There is a need for feed pellets with better consistency, uniformity and stability providing the nutritional requirement of the cultured species. By improving the pellet quality and by adjusting the daily ration to the specific needs of the fish and by fractioning its distribution, conversion values of less than 2 could be obtained with fish densities of 300–350/m³ (Coche, 1976). The mechanization of feed distribution by automatic and demand feeders is becoming more and more important. Division of daily ration into several smaller rations plays a significant role in cage culture.

*Diseases and parasites*

Crowding and supplemental feeding often causes diseases. The two commonly encountered bacterial organisms are *Chondrococoue columnaris* and *Aeromonas liquefaciens*. These can be controlled by feeding tetracycline-incorporated feed. Fungal (*Saprolegnia* sp.) attacks, often causing heavy mortalities of major carp fingerlings in cage, could be overcome by treating the fish with 3% NaCl and 1 ppm of $KMnO_4$. In floating cages installed in fresh as well as saltwater, salmonids are infected by gram-negative bacteria, *Vibrio anguillarum*, causing vibrio disease. Treatment of diseases is much simpler in cages than in ponds because of early detection and close control. Smaller cages can be dipped in containers having the desired chemical for control of disease. The cages should be more than 2 m above the benthic sediments to reduce the incidence of fish parasites and to avoid the bottom deoxygenated zone.

*Location and mooring*

The location of cages should be such that there is proper flow of water through the cage material to optimize production. The rivers, especially in northern India, are subjected to heavy water-level fluctuations. During summer because of low river level it is difficult to find a place having suitable depth and water current; In monsoon months, the rivers keep on effervescing and the cages moored or set afloat are to be shifted to suitable locations. Similar problems are encountered in small impoundments where the water level is drastically diminished in summer as in Gulariya reservoir to 4.5 ha from the full reservoir level of 300 ha.

*Wind and wave action*

Damage to cages through wind and wave action is a serious problem both in offshore installations and in cages set afloat in small irrigation impoundments usually devoid of sheltered areas. A case in point is Gulariya reservoir where split bamboo covers had to be all round the nylon cages to mitigate the high wind and wave action. This also prevented cages from attacks of turtles and crabs.

*Predation*

Predation on the net cages is circumvented by enclosing the cages with a large-meshed predator net made of nylon gill netting, the distance between the 2 nets being 1.5 m (Lindbergh, 1976). The predatory gastropods of *Cymatium* sp. cause large-scale mortality in pearl-oysters cultured in cages (Jayabaskaran *et al.*, 1984). The predatory birds like cormorants, eagles, pelicans, storks and cranes feed on the fish in the pens when water level is low in the lagoon. The bird menace can be checked by covering the pens with large-meshed nets and by scaring the birds by using crackers (*Marichamy et al.*, 1982).

*Fouling*

Fouling of various degrees occurs in net cages. In cages used for culture of spiny lobsters barnacles and molluses on the tray, posing problems for the lobsters to move about and occupy the tubes. The tray, its holding ropes and PVC housing get infested with simple ascidians, sponges, edible oysters and barnacles, and requires periodical cleaning (Lal Mohan, 1984). In a study on milkfish culture in net enclosures, the barnacle *Balanus amphitrite* settled on a large number of poles but not on the nylon

webbing. Nevertheless, the webbing got damaged when it rubbed against the barnacles attached to the palmyra poles. The algae often get deposited on the net affecting the free flow of water in the pens.

Periodic cleaning of cages of algae, mussels, barnacles, etc. which, by reducing water enchange, influence the fish growth negatively (Milne, 1972). Use of copper salt on synthetic fibre reduces fouling by 50% (Brett, 1974). This problem is not severe in freshwater cage culture. (Tatum, 1974) recommended adding 30 *Mugil cephalus*/m³ of cage in brackishwater culture. *Tilapia nilotica* is also effective in removing the growth of algal colonies on cage walls.

## FUTURE SCOPE

Intensive culture systems offer immense scope and potential to increase fish production. The productivity through intensive culture is much higher than that of pond culture for comparable inputs and area (Pantulu, 1976; Coche, 1976). Cage culture eliminates loss of stock due to flooding, seepage, evaporation losses and the resultant need for water replacement, dependence on soil characteristics, contamination of pond by agricultural chemicals and pressure on land resources. It also has the merits of easy and economical control of predators and diseases, complete harvest of fish production and cutting down on the cost of preservation and transportation since they can be located in water ways and water areas near urban markets. The limitations of these intensive systems are : difficult operation in rough surface water, high dependence on supplemental feeding and increased risk of poaching.

The experience gained on aqua-farming in cages and enclosures at the ICAR fisheries institutes has to be advanced through intensive research in identified areas. There is an urgent need to design and construct suitable low-cost cages. Another area which needs urgent attention is formulation of balanced pelleted feed, based on the nutritional requirement of the species confined in cages.

Although work on fish culture in cages and enclosures is still in its infancy in India, it promises to carve its niche through greater efficiency that will be forthcoming from concerted research efforts. It holds a great potential in terms of the need of growing population.

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