

Expanding studies on enclosure culture (Cage & Pen)

with special focus on fish species diversification in India

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ICAR-Central Inland Fisheries Research Institute, Barrackpore is the pioneer for the development of technology for both fingerlings raising and table fish production. Technologies developed by ICAR-CIFRI have been applied and extended successfully in many reservoirs in different parts of the country. The present article highlights the advances of enclosure culture and discusses species diversification, potentials, issues, challenges and way forward for sustainable fisheries enhancement and employment generation from reservoirs and floodplain wetland resources.

Keywords: Cage farming, ICAR-CIFRI, Loktak lake, Pen culture

FISHERIES is a sunrise sector which provides livelihood to millions of fishers and fish farmers in India. This sector has immense potential to double the fishers and fish farmers' incomes and the fish production has reached an all-time high of 137.58 lakh MT during 2018-19. The inland open water fisheries resources especially reservoirs (>3.51 million ha) and wetlands (0.5 million ha) have immense potential to produce more fish by bridging the gap between present production and potential. The fisheries management through different approaches like the adoption of stock enhancement, Culture Based Fisheries (CBF) and enclosure culture techniques like cage farming and pen farming are gaining momentum and importance, as they have proven to create more fish and thereby income and employment for the growing human resource of the country. Enclosure culture brings in new opportunities and avenues for optimizing fish production from the reservoirs and other inland open waters, and developing new skills

among fishers and entrepreneurs to enhance their earnings. Inland water bodies especially reservoirs due to its vast resources have immense potential for cage culture of fast growing and highly prized freshwater fishes.

Status and potential

In India, out of 3.5 million ha water coverage under reservoirs, 2,157,318 ha are under the purview of a medium and large category of reservoirs. Already there are 20,000 cages in Indian reservoirs of 20 States producing approximately 50,000 MT of fish. Commercial scale cage culture in India at present is mainly restricted to Pangas and GIFT Tilapia and an average production of 2-3 MT/cage is achieved. By using a mere 0.1% of the total area under large and medium reservoirs, 2,157 ha will be available to be covered under cage culture. There will be 400 cages to be accommodated in 1 ha area at a size group of 6×4 or 5×5 m² and thus, a total of 8.62 lakhs cages could be installed in these bodies.

In recent years, enclosure fish farming in reservoirs either for stocking materials or for the production of table size fish has attracted the attention of researchers, developmental agencies, entrepreneurs and policymakers across the nation. The growth of cage fish farming in reservoirs has gained further momentum during 2010-12 with financial support from National Fisheries Development Board (NFDB), Government of India, NMPS etc. In 2011, CIFRI ventured into raising table-fish of economically important species through cage culture by installing cage facilities with durable galvanized iron frames in Maithon Reservoir, Jharkhand (Figs 1 & 2). This paved the way for the adoption and popularization of this technology in several reservoirs belonging to more than 20 States in 'Mission Mode' through various schemes and programmes. Jharkhand, Chhattisgarh, Madhya Pradesh, Maharashtra have widely adopted this technology and scaling up is in progress in many states.

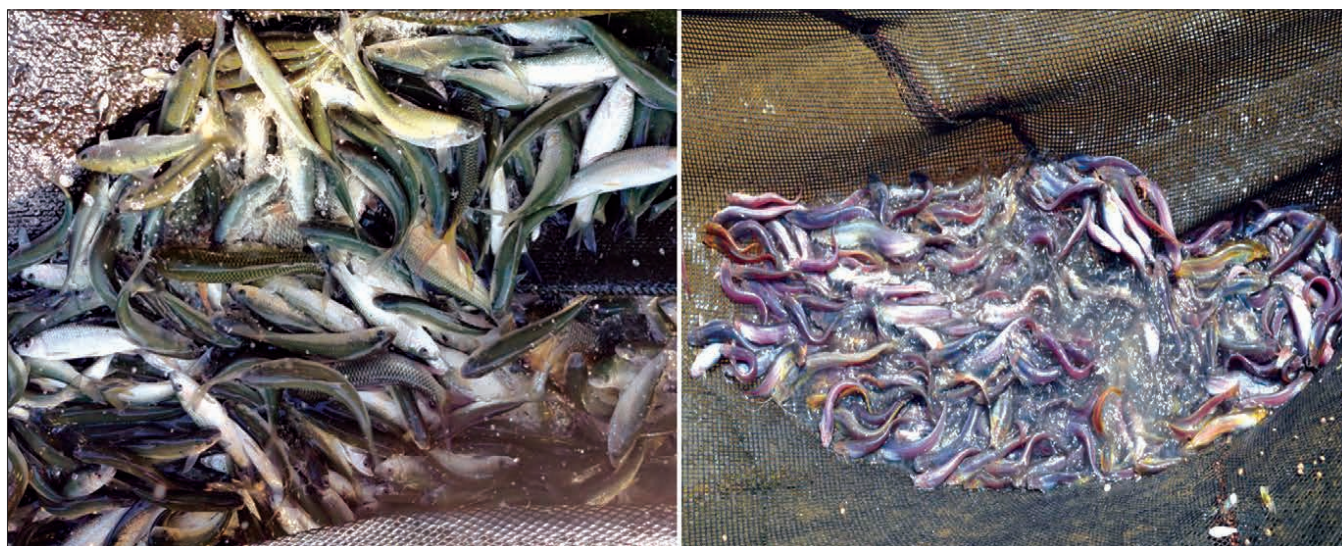


Fig. 1. Haul of Bata and Singhi harvested from cages at Maithon reservoir, India

Potential candidate species

The selection of species for cage culture shall be customized based on market demand and market value, hardy and tolerant nature of the species, and acceptance to external sources of food under confined conditions. It is preferable to culture species with high market value as the cage culture venture is capital and operational cost-intensive. The species selected should also be hardy and tolerant of confined, crowded conditions and to the rigors of handling during net changes, net cleaning, fish transfers etc. Since the reservoirs are mostly oligotrophic and fishes are stocked at higher densities, the external source of feed is a necessity and identified fish must be able to accept external sources of feed for higher growth and survival.

Economically viable cage culture of *Pangasianodon hypophthalmus* is practiced in reservoirs of the country.

However, cage culture of more species drawn from the indigenous species pool needs to be encouraged. Considering the consistent demand for species of high economic and nutritive value, and the regional preference for some species, the following indigenous species need to be inducted into the cage culture domain subjected to seed availability: *Labeo bata*, *L. rohita* (Jayanti rohu), *Osteobrama belangeri* (Pengba), *Systemus sarana*, *Ompok bimaculatus* (Pabda), *Heteropneustes fossilis*, *Etroplus suratensis*, *Macrobrachium* sp. etc. Apart from *Pangasianodon hypophthalmus* and GIFT tilapia, no other exotic species (including illegally introduced fishes) are strictly prohibited for cage culture in inland open waters.

Pen culture

Pens are areas along the periphery of water bodies, enclosed generally

on three sides by means of bamboo or net fencing or a combination of both, with the fourth side being contiguous with shoreline. In case of unproductive floodplain wetlands, where external fertilization is not feasible; cage and pen culture are perfect management options, wherein an area can be demarcated for enclosure culture. It is best suited for weed choked and productive wetlands as it help to overcome the issue of gear restriction and catchability. Table size fish production through pen farming could be a viable option for conflict management for fisheries development. In States deficient in stocking material (>10cm) suitable for open waters, seed raising in pens and subsequent stocking will enhance the fish production. Thus useful in meeting seed requirement for culture-based fisheries which in turn increase the fish yield.



Fig. 2. Haul of Jayanti rohu and Prawn harvested from cages at Palair reservoir, Telangana

Pen culture in Loktak lake, Manipur: Success story

Fifty fishers residing in the vicinity of Loktak lake undertook pen culture by taking an area of 0.5 ha each under lease from the Department of Fisheries, Govt. of Manipur with an annual lease value of ₹ 5,000 per year. Advanced fingerlings were stocked @ 5-7 nos.m⁻² constituting grass carp (60-70%) and IMCs (30-40%). Locally available aquatic weeds were fed to fishes. Fish production from an individual pen was in the range of 3,000-4,000 kg/ha in one year. The mean monthly income after the adoption of the technology (₹ 9,250) was significantly higher than that before adoption (₹ 6,183). The adoption of pen culture resulted in an increase of 49.6% in the mean monthly income of the fishers and benefit-cost ratio (BCR) ranged from 1.54-1.87.

Successful demonstration of climate resilient pen system (CRPS)

Although a number of fish species have been documented in various wetlands, their potential for inclusion in enclosure culture has not been evaluated except for IMC and a few minor carps. Recent trials have revealed the potential for diversification from the indigenous fish pool. Besides pen culture with indigenous fish, there are other potential shellfish suitable for pen culture. The black clam, *Villorita cyprinoides* was successfully reared in climate resilient pen systems installed in Vembanad lake, Kerala and production of more than 2 MT was achieved through community participation. Studies using local indigenous fish species such as *Amblypharyngodon mola*, *Systomus sarana*, *Mystus tengra*, *Ompok bimaculatus*, *Gudusia chapra* and *Labeo bata* were also undertaken in pens installed in wetlands of Assam and West Bengal. The adoption of these systems can help to restore the vulnerable species and increase the

adaptive capacity of wetland fishers and their income.

Recent developments

ICAR-CIFRI has developed and refined a number of technologies and management strategies for inland open water fisheries development during the last seven decades. Recently, the institute has commercialized CIFRI GI cage, CIFRI HDPE Pen and Cage Grow Feed (low cost).

CIFRI GI Cage

Standardized the cage culture technology of *Pangasianodon hypophthalmus* in reservoirs and an average production of 2-3 MT/GI cage of 5m×5m×4m has been achieved in different states (Fig. 3). Commercialised CIFRI GI CAGE can be used for both fish seed raising and table fish production. Owing to immediate need for diversification for increased adaptability and profitability, the feasibility of several commercially important indigenous fish species viz. *Labeo rohita* (Jayanti),

Ompok bimaculatus, *Labeo bata*, *L. gonius*, *Barbonymus gonionotus*, *Systomus sarana* in different agro-climatic zones were evaluated and standardized their stocking density for production in cages.

CIFRI Pen HDPE

Developed and commercialised CIFRI Pen HDPE (one unit: 0.1 ha) which can hold fish and prawn as captive stock in open waters either for producing table size fish or for raising stocking material (fingerlings). It is a fixed enclosure with sides of HDPE netting in which the bottom is in the bed of the water body (Fig. 4). Seed production or table fish production through pen culture can help overcome threats and risks associated with open water fish production to a great extent. Seed production through pen culture could be befitting counterparts for stocking enhancement technology by ensuring timely availability of seeds of required species, number and size. The HDPE made pen has been tested in several multi-location trials with Indian



Fig. 3. CIFRI Cage Farm at Maithon reservoir, Jharkhand



Fig. 4. CIFRI HDPE Pen installed in a floodplain wetland, West Bengal

Major Carps, minor carps and minnows. The CIFRI pen culture technology has been adopted by the States of West Bengal, Bihar, Uttar Pradesh, Assam, Manipur, Meghalaya, Odisha and Kerala in wetlands and reservoirs for fish seed raising and table fish production.

New initiatives on species diversification in inland open water fisheries

Owing to the immediate need for diversification for increased adaptability and profitability of

cage culture, studies were carried out by the Institute on the feasibility of several commercially important indigenous fish species and developed their production technology in GI cages installed in reservoirs and wetlands (Table 1). Stunted fingerlings of Pabda were reared at Maithon reservoir and an average size of 50-62 g was achieved in seven months. The *L. bata* stocked at the rate of 30/m³ in GI cages in at Maithon reservoir, Jharkhand attained an average weight of 52

g in 120 days. Growth performance of stunted fingerlings of *Pangasianodon hypophthalmus* revealed a stocking density of 45/m³ for optimum for growth in Maithon reservoir, Jharkhand.

Advance fingerlings of *L. rohita* (Jayanti) stocked in Salia dam, Odisha exhibited significantly high growth at a stocking density of 10/m³. Advanced fingerlings of *Systomus sarana* achieved an average weight of 150 g in 90 days. Incorporation of a 10% level of

Table 1. Diversified fish species cultured in cages in different reservoirs by ICAR-CIFRI

Species	Reservoir	Achievement/findings
<i>Labeo bata</i>	Maithon reservoir, Jharkhand	Attained average weight of 52 g in 120 days.
<i>Labeo rohita</i> (Jayanti)	Salia reservoir, Odisha Palair reservoir, Telangana	Significantly high growth achieved at stocking density of 10/m ³ . Achieved an average size of 1-1.2 kg in 10 months.
<i>Pangasianodon hypophthalmus</i>	Maithon reservoir, Jharkhand Gobindsagar and Pong reservoir, Himachal Pradesh Palair reservoir, Telangana	Stocking density of 45/m ³ found to be optimum for growth. An average production of 1.9 MT/cage was achieved in Pong reservoir. A total of 102.85 tonnes of fish was harvested from 48 cages. Produced a total of 75.9 MT of Pangas and generated a revenue of 59 lakhs.
<i>Ompok bimaculatus</i>	Maithon reservoir, Jharkhand	An average size of 50-62 g was achieved in seven months.
<i>Systomus sarana</i>	Salia reservoir, Odisha	Achieved an average weight of 150 g in 90 days.
<i>Labeo gonius</i>	Samaguribeel, Assam	Stocking density of 40 fingerlings/m ³ was found to be optimum for growth.
<i>Macrobrachium rosenbergii</i>	Palair reservoir, Telangana	Achieved an average size of above 32 g in 6 months.

herbivore fish (rohu) was found to effectively control the biofouling organism growth in the commercial grow out *P. hypophthalmus* cage farming. Stocking density of 40 fingerlings/m³ and 30/m³ was standardized as optimum for the production of table-sized *L. gonius* and *L. bata* in cages in the beels of Assam.

Successfully demonstrated *in situ* fish seed raising and table fish production of *P. hypophthalmus*, *L. rohita*, *L. rohita* (Jayanti variety), *Labeo catla* and *Macrobrachium rosenbergii* in 64 numbers of GI model cage installed in Palair reservoir. A total of 106 MT of fish was harvested from cages and generated a revenue of 96 lakhs benefitting 40 fishers.

Demonstration of pen culture in Takmu pat (a part of Loktak lake), located at Bishnupur district, Manipur in collaboration with the Directorate of Fisheries, Govt. of Manipur yielded good growth performance of the fish *Osteobrama belengeri* showing technological feasibility. The pen culture system was found to be economically

viable with a benefit-cost ratio of 1.37.

Issues

The appropriate adoption of enclosure culture technology offers enormous scope for enhancement of fish production. There are several key issues to be addressed such as species diversification, seed production of diverse species, development of low-cost environment friendly feed, development of a package of practices, estimation of carrying capacity, the environmental impact of cage culture etc. for ensuring the sustainability of enclosure culture in inland open waters. Diversification of fish species based on regional preference, nutritional value and local acceptability will ensure the popularization and profitability of culture practices.

Conclusion

Inland open waters are potential resources that are ideal for augmenting production through the adoption of refined technologies viz. cage and pen culture. The Govt. of India has prioritized increasing fish

production from reservoirs and wetlands through various schemes and programmes under the ambitious PMSSY. The diversification of fish species is very crucial in maximising the profit from inland fisheries and also for better adoption of technology. Hence, the inclusion of potential value added species from the indigenous pool may be encouraged with technological backstopping from ICAR institutes. The involvement and linking of FPO's in promoting inland fisheries and exploring opportunities for the value chain will open up new avenues. Ensuring quality seed availability, development of suitable feed and dissemination of package of practices coupled with capacity building, fund flow will ensure better adoption of open water inland fisheries to meet the increasing demand for quality fish and thereby better income, nutritional security and employment generation.

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