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Reservoirs Fisheries Development and its Trade-offs with Conservation of Natural Fish Genetic Resources

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The reservoirs spread across India are ideal water resources for fish production at very low input costs through environmentally safer and socially equitable manner. Nevertheless, the present fish production from the reservoirs is about one-third of its estimated potential. Enhanced capture fisheries, culture-based fisheries and recently cage culture systems are being implemented to bridge this gap, where stocking or artificial recruitment is the essential management tool. The stocked fishes can, at some stage or other, interfere with the natural ecosystem processes and have trade-offs with conservation of natural fish genetic resources, mainly of the rivers on which the reservoirs are built. Though it is difficult to prescribe a totally safe stocking protocol from a genetic point of view, scientifically sound strategies need to be put in place to minimize the adverse impacts of stocking. This paper focuses on the potential adverse impacts of stocking and suggests means that can help minimize its adverse impacts on the fish genetic resources.

Introduction

Reservoirs are "man-made impoundments created by obstructing the surface flow by erecting a dam of any description across a river, stream or any watercourse". However, such water bodies, if less than 10 ha in area, have been excluded from the purview of this definition (Sugunan, 1997). Based on the area, the reservoirs are classified as small (<1000 ha), medium (1000 to 5000 ha), and large (>5000 ha) by the Government of India for the purpose of fisheries management (Srivastava *et al*., 1985; Sugunan, 1995). India has about 20,000 reservoirs, covering 3,460,301 ha area. In terms of number, reservoirs are predominantly distributed in Tamil Nadu, Karnataka, Andhra Pradesh, and Odisha, while by area, the predominance is in Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, Uttar Pradesh, Gujarat, and Maharashtra. Besides these, many reservoirs are either under construction or in the project stage. India presently produces 14.15 million tonnes of fish annually and by 2025, the demand for fish is expected to touch 20 million tonnes. The bulk of this additional production needs to emanate from the inland segment as marine fisheries have plateaued already. As no substantial increase in fish production is expected from rivers, estuaries, backwaters, and coastal lagoons in the country due to a number of reasons, the reservoirs dotting the length and breadth of the country need to be tapped for meeting our fish production targets.

The fish fauna of reservoirs basically represents the species present in the river on which they are constructed. Indian reservoirs support relatively rich fish diversity; harbouring not less than 60 species, of which about 40 species are contributing to commercial fisheries (Sugunan, 1995). The Indo-Gangetic carps generally dominate the commercial fisheries of Indian reservoirs. The Indian major carps, catfishes, feather backs, air-breathing fishes, and minnows are the most widely distributed fishes in Indian reservoirs. The average fish yield from reservoirs has been estimated at 110 kg/ha/year (Sharma and Suresh, 2013), while the category-wise mean fish yield has been estimated at 190 kg/ha/year from small reservoirs, 98 kg/ha/year from medium reservoirs and 34 kg/ha/year from large reservoirs against the potential yields of 500, 250 and 150 kg/ha/year from the respective categories. The present production from all categories of reservoirs is estimated at 386,259 tonnes, which is only about one-third of its potential of 1,022,062 tonnes. To bridge this gap, various forms of enhancements are being implemented in the reservoirs.

Enhancements

Enhancements in general are limited technical interventions in existing aquatic resource systems, which

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can substantially alter the environmental, institutional, and economic attributes of the system (FAO, 1997). The common enhancement practices followed in reservoirs are enhanced capture fisheries and culture-based fisheries. The medium and large reservoirs are utilized as enhanced capture fisheries, while the small reservoirs are utilized as culture-based fisheries. Recently, enclosure culture systems such as cage and pen culture, involving artificial feeding are also being popularized in Indian reservoirs. The main accent of enhanced capture fisheries is augmenting the natural fish stocks and conserving them through encouraging natural recruitment and growth. Stocking is an integral part of enhanced capture fisheries as a measure to build up initial stocks of breeding populations along with periodic re-stocking to compensate for recruitment failure or stock losses. Introductions are resorted to for correcting imbalances in the species spectrum. Stocking and recapturing at regular intervals (often annual) are the basic strategy followed in culture-based fisheries, where the stocked fishes are recaptured before they breed within the water body. Selection of species for stocking, determining the size of seed at stocking, stocking density, growing time, and size at recapture are the key management decisions to be taken for culture-based fisheries. Principles of culture-based fisheries are akin to extensive aquaculture, although the fishes are grown in open water systems without artificial feeding or fertilization of water. Available examples in India suggest that the unit cost of fish production in culture-based fisheries, involving Indian major carps can be as low as Rs. 8.2/kg, with a benefit-cost ratio of 3.67. The benefit-cost ratio involving *Macrobrachium rosenbergii*, in culture-based fisheries, can be as high as 5.3 (Kutty *et al*., 2008). These are way better than their production through aquaculture.

Stocking – the Key to Reservoir Management

Reservoir, as an ecosystem, includes both natural and man-made features and the fisheries management involves capture fisheries, enhancement, and enclosure aquaculture. Stocking or artificial recruitment is an essential management tool deployed in both enhancement practices and enclosure aquaculture. Obviously, fish stocks inducted into the ecosystem from extraneous sources can cause changes in the recipient system and its fish community (Mbabazi *et al*., 2004). Reservoirs, being a continuum of the riverine ecosystem, the stocked fish, at some stage or other, will have an unavoidable interface with natural ecosystem structure and processes, mainly of the rivers. Hence it is difficult to prescribe a totally safe stocking protocol from a genetic point of view. At the same time, being a resource of colossal size, with high untapped production potential and very low cost of production, utilization of this resource cannot be ignored while formulating the development agenda. This paper focuses on the potential adverse impacts of introductions and stocking and suggests means that can minimize (not totally neutralize) the adverse impact of stocking as a management tool on fish genetic stocks.

Species Stocked

Indian major carps (*Labeo catla, L. rohita, Cirrhinus cirrhosus*) have been the mainstay of stocking in reservoirs in India. They do not generally breed in the reservoirs outside their natural distribution and do not seriously compete with other indigenous fish species (Khan *et al*., 2015), and are thus ideal candidate species for stocking. Examples of successfully involving shellfish species in culture-based fisheries in India are *M. rosenbergii,* in Malampuzha reservoir in Kerala (Kutty *et al*., 2008), and in Ukai reservoir, Gujarat without noticeable environmental impacts.

Impact on Native Fish Genetic Resources

Species that got introduced or stocked into a reservoir can lead to a range of impacts on the native species. This may be in the form of competition, predation, parasitism, niche modification, etc. The inducted species establishes itself if it can overcome resistance from the natives and the resultant ecological conditions disturb the indigenous fishes. Stocking for culture-based fisheries in small reservoirs is considered to cause a lesser impact as most of these water bodies dry up during summer or the water level becomes too low allowing complete harvest. Fish stocks are not allowed to breed in the system and the whole process is more akin to culture fisheries. Hence chances of contaminating the wild natural fish stocks are relatively less. The enhanced capture fisheries, however, present a different scenario altogether as the system has to co-exist with natural ecosystem processes, and fisheries management norms are in the lines of capture fisheries.

Thus, stocking for enhanced capture fisheries can lead to a higher adverse genetic impact on the natural stocks. The introduction of common carp in 1957 into the Dal Lake in Kashmir has altered the energy flow of the ecosystem to the disadvantage of native Snow Trouts. In Gobindsagar Reservoir, common carp has adversely

affected the fishery of *C. cirrhosus* and *C. reba*. Silver carp was introduced in India, largely for aquaculture, guided by the hope that being a phytoplankton feeder it can effectively utilize the phytoplankton, a vacant niche in culture systems. The fish accidentally escaped into Gobindsagar Reservoir and established there at the cost of *L. catla*. Silver carp has also affected the population of *L. rohita* and *Osteochilus waandersii.* At present, commercial catches of Gobindsagar reservoir have three exotic species (Common carp, Grass carp, and Silver carp). The story of Tilapia is well known; it has well-established breeding populations in most of the reservoirs in peninsular India. They have brought down the population of *L. kontius* in Vaigai reservoir and *Hypselobarbus dubius* in Amaravati reservoir. There are reports of the predatory African catfish (*Clarias gariepinus*) being established in reservoirs. A sizeable proportion of stocking material used in Dahod reservoir in Madhya Pradesh and Pahuj reservoir in Uttar Pradesh involved *Ctenopharyngodon idella* (25 to 40%) and *Cyprinus carpio* (10%) (Sharma and Suresh, 2013). Stocking of *C. carpio* has been in practice in several other reservoirs too despite it being among the world's worst 100 invasive species (GISD, 2019).

Stocking of Indo-Gangetic carps in peninsular reservoirs in the past did not make a significant adverse impact, mainly since they by and large did not breed in the recipient ecosystem. As the only exception, *L. catla*, stocked in Stanley and Sathanur reservoirs (Cauvery river system), and Ukai reservoir (in Narmada), has been established in the systems and formed a fishery (Sreenivasan 1984; Sugunan, 1995). However, in most reservoirs in the peninsular rivers (Nagarjunasagar, Bhavanisagar, Krishnagiri, Malampuzha and Peechi), the Gangetic carps failed to breed (Sugunan, 2010).

Enclosure Culture

Enclosure aquaculture is fast picking up pace in India (Sugunan, 2015). Nearly 16,000 cages have already been installed across various states in different water bodies and reservoirs. (https://www.newindianexpress.com/opinions/2022/may/23/cage-culture-for-fisheries-holds-promise-2456939.html). Species used in these cages are *Pangasianodon hypophthalmus*, mono-sex Tilapia (GIFT variety), *L. rohita* (Jayanti variety), *Puntius brevis, L. bata, Lates calcarifer, C. carpio,* and the freshwater prawn, *M. rosenbergii*. As enclosure culture systems in reservoirs mainly involve exotic species, the risks involved in terms of genetic and ecological impacts are far higher compared to enhancements. Cage aquaculture is practiced mainly in larger reservoirs where enhanced capture fisheries are followed, hence the chances of the introduced species entering the natural ecosystems and possibilities of their interaction with other biotic communities are higher. Almost all the fish species cultured in cages carry higher risks of adverse impacts on native species. Accidental escape of fishes stocked in the cages to natural waters is not completely avoidable. Cage farming is expected to have other environmental impacts too due to the use of artificial feed, antibiotics, and other irrational practices for gaining revenue, which are potential threats to native fish species.

Cage culture is being pursued aggressively in reservoirs of Andhra Pradesh, Telangana, Karnataka, Bihar, Jharkhand, Orissa, Maharashtra, Chhattisgarh, Tamil Nadu, Rajasthan, and Uttar Pradesh. Cage culture needs to be practiced by following the best management norms to ensure environmental protection and to avoid adverse impact on native species. The selection of water bodies for cage culture and determination of the number of cages to be installed need to be taken after assessing the carrying capacity of the water body in question. Similarly, only mono-sex fish seeds are allowed for stocking in cages, especially when exotic and genetically selected species like GIFT tilapia are involved. All stocking materials used in India are hatchery produced, mostly by private hatcheries without following any certification or guarantee procedures to ensure quality. In most cases, non-targeted or undesired species get mixed up with Indian major carp seeds used for stocking. Many private hatcheries follow mixed spawning of Indian and exotic major carps, which results in hybridization and genetic contamination of seeds that are sold from the hatcheries. Such seeds, if stocked in reservoirs, can play havoc with the genetic integrity of natural riverine fish fauna. All the brood stock and seed in nursery stages are raised on artificial feeds, possibly containing growth and disease resistance enhancing drugs. The environmental and economic consequences of the escape of these stocks into natural waters are yet to be completely ascertained. Though appropriate guidelines have been promulgated by the Government of India for cage culture in reservoirs (DAHDF, 2016), the monitoring and control mechanism for compliance is rather weak.

Suggestions

- Culture-based fisheries should be practised in small shallow reservoirs, preferably where near-total, annual harvesting is possible. Small reservoirs dry up during summer or water level drops drastically allowing near total harvests. This allows an 'annual stocking-harvesting system' that minimizes the genetic mixing up of stocked and natural stocks.
- In enhanced capture fisheries, stocking exacerbates the genetic contamination of wild stocks. As far as possible, native species should be selected for stocking.
- The seed for stocking should be produced by breeding wild-caught parents. The farm-produced fish seed with genetic depression (especially the seed produced through mixed spawning) should be strictly avoided.
- Exotic fishes of any kind should be totally banned from stocking in reservoirs, especially in large and medium reservoirs, where enhanced capture fisheries are the option.
- Exotic fish seeds when used in cage culture, should be of mono-sex so that they do not get a chance to breed if they escape from cages.
- Certification and monitoring of hatcheries and implementation of 'good hatchery practice' need to be made mandatory.
- Reservoir fisheries in India being a State subject, the State Governments have to play the lead role in improving governance and monitoring the environment by framing and implementing appropriate policies.

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