



## Consequences of Exotic Species Invasion and Mitigation Measures in Fisheries

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**Conflict of interests:** The author has declared that no conflict of interest exists.

### How to cite this article?

Ramya *et al.*, 2023. Consequences of Exotic Species Invasion and Mitigation Measures in Fisheries. *Biotica Research Today* 5(3), 266-269.

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### Abstract

Exotic species invasions have been well-documented throughout the world, and the reasons for introduction vary according to the requirements of each nation. The secondary threat to biodiversity, after the primary threat of habitat alteration, is the impact of alien species in natural water bodies. The impacts are divided into ecological, genetic, and socio-economic effects. Competition for shelter, food, predation, hybridization with native species, tainting of the gene pool, and introduction of diseases are the main problems of invasiveness. The introduction of invasive species often results in their dominance over native species due to their wide range of physiological and environmental tolerance. Before introducing any biological species, a thorough analysis of the ecosystem and its effects should be assessed. The most difficult task in open water bodies is the eradication of introduced species. Early detection and prevention could lead to the investigation of conservation strategies for biodiversity.

**Keywords:** Exotic, Impact, Invasive, Open water

### Introduction

The world is experiencing unprecedented biotic invasions, resulting in unanticipated negative impacts on native biodiversity, ecosystem functioning, human health, and regional economies. Native species are disappearing, and regional uniqueness is being eroded globally as a result of the slow but sneaky replacement of native biota by non-native species. The rate of such homogenization is especially noticeable in freshwater systems. The accelerating introduction and spread of invasive species are the most serious threats to global biodiversity according to biodiversity concern.

Exotic fish are non-native fish species that occur outside of their natural range. When these exotic fish establish themselves and begin to reproduce in their new environment, they are considered invasive species. Invasive species typically include all taxa of organisms, ranging from microscopic insects to large mammals, and can intrude into any ecosystem. According to the IUCN, an invasive species is an alien species that establishes itself in a natural or semi-natural ecosystem or habitat, threatening native biological diversity. The description of an invasive fish species

is one that does not naturally exist in a particular aquatic environment and whose introduction adversely affects or is likely to negatively impact native fish species already existing in the aquatic system or may harm the ecosystem economically or environmentally.

### Status of Exotic Fish Introduction in India

India possesses rich aquatic diversity spread across different ecosystems, owing to its vast and varied geographical features. The recent list of fin fishes comprises a total of 3,157 species, including 1,545 marine, 892 freshwater, 391 brackish water-marine, 115 freshwater-brackish water, 197 freshwater-brackish water-marine, and 17 brackish water species (Joshi *et al.*, 2021). Several of these introduced fishes are now established in the natural water bodies, including rivers, wetlands, and reservoirs, and some others are in the progression of establishing breeding populations.

The introduction of alien fish species started during 1863 in India, when Sir Francis Day made an unsuccessful attempt to import brown trout eggs to the Nilgiri hills. Later, F.J. Mitchel successfully introduced brown trout eggs from Scotland to Harwan in 1900. *Tinca tinca* was imported to India in 1870 for aquaculture. A total of nine fish species

### Article History

RECEIVED on 10<sup>th</sup> March 2023

RECEIVED in revised form 19<sup>th</sup> March 2023

ACCEPTED in final form 20<sup>th</sup> March 2023

had been introduced during the pre-independence (1870-1947) period. The introduced species were *T. tinca*, *Carassius carassius*, and *Cyprinus carpio*; the salmonid game fishes, *Salmo trutta fario*, *Salmo gairdneri*; larvicidal *Gambusia affinis*, *Lebistes reticulatus* and the tropical osphronemid, *Osphronemus goramy* (Natarajan and Menon, 1989). The post-Independence India witnessed the introduction of a number of food and ornamental fishes including carps (Chinese strain of *C. carpio*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, and *Puntius javanicus*), cichlids (*Oreochromis mossambicus* and *O. niloticus*), salmonids (*Salvelinus fontinalis*, *Salmo salar*, *Oncorhynchus mykiss*, *O. nerka*). In general, the present list of introduced fish species in India comprise of 500 species including food fishes (29), sport fish (2), mosquito control fish (3) and the rest are ornamental fishes. However, many of these fish were introduced without assessment of their likely impacts on ecology and fish diversity.

### Effect of Exotic Species on Native Fauna

The alien fish introduction negatively impacts the native fauna of the ecosystem. The impacts are the elimination of native species through competition or predation, contribute to a reduction in local biodiversity, introduce novel parasites and pathogens, erode or dilute local genetic diversity by hybridizing with indigenous species, alter habitat in ways that make it unsuitable for local species, reduce ecosystem productivity and thus causing economic losses.

### Key Factors for Invasiveness

An introduced species' ability to spread and harm native species and ecosystems depends on both the behaviours of the species and the tendencies of the invasion site. The major characteristics of an invasive species are wide distribution, high physiological tolerance, ecological versatility, rapid growth, a high reproductive rate, a short interval for generations, and rapid dispersal.

### Ecosystem Habitat and Invasion Success

Characteristics of a habitat or geographic region that make it more susceptible to species invasions are resemblance of native site, the existence of underutilized niches, scarcity of indigenous species, and ecosystem disturbance caused by humans. Intense alterations in soil properties, adequate fires, pastures, nutrient inputs, hydro-meteorological changes, and ecosystem incoherence are just a few instances of man-made activities that put a region at risk (Singh and Lakra, 2011). Ecologists are perplexed by the fact that many non-indigenous species that switch to becoming intrusive in the introduced region are typically as safe as in their native range.

### Reasons for Introducing a New Species into Natural Water Bodies

1. Introduce a new fish with high growth rate, high resilience to overfishing, and more economic value than native fish. To generate additional fisheries and increase the variety available to anglers for recreation.
2. For the effective utilization of niches and all trophic levels of an ecosystem, when the water bodies are underutilized

by the existing species.

3. **Pest control:** Species are introduced in the motive of controlling insects, which act as intermittent carriers of human illness.

4. **Manage hydro-biological features:** Specific species for controlling macrophytes and tolerate eutrophic condition, were utilized to manage the biological balance.

5. **Fishery enhancement:** The primary reasons for species introduction around the world were to increase production and hardy species that could survive in a wide range of environments.

### Reasons for Introduction of Exotic Fishes into Aquaculture System

1. **Issues regarding native fishes:** Indian Major Carps do not breed in confined waters, and their natural recruitment fails at times due to changes in the monsoon.

2. **Increased fish production:** To increase the fish production per unit area, high-value, fast-growing, hardy fish were introduced for developing the aquaculture industry.

3. **Development of game fishing:** The alien fish introduction for recreational fishing has resulted in the extinction of many native fishes worldwide.

4. **Aesthetic and other purposes:** The intentional and unintentional release of ornamental fishes resulted in the spread of exotic fishes into open waters, directed to negative impact in the ecosystem.

### Impacts of Exotic Species

The impacts are majorly characterized as ecological, genetical, and socio-economical. The socioeconomic changes caused by alien species can in turn cause more ecological or genetic changes, which may result from direct interaction with an exotic species, over fishing of native fishes, and changes in fishing practices.

### Ecological Impacts

Some common ecological concerns include the competition of exotic fish with native species with the same niche preference for space, for same types of feeding habits. Omnivorous species may not have a specific feeding habitat, and may consume the eggs and larvae of native fishes including the young ones. Predation on native fish and the spread of parasites and pathogens are also concerns in the ecosystem.

### Genetic Impacts

The introduction of alien fishes into natural water bodies resulted in the alteration of gene pool of native fishes. The major genetic impacts are reduction in heterozygosity, reduction of effective population size, reduction or loss of potential alleles, extinction of fishes or stocks, hybridization between native fishes, introduction of individuals through cross breeding, and back crossing with native fishes that sometimes resulted in the generation of new species or genera. It may indirectly induce the bottleneck effect and inbreeding results in a reduction of haplotype diversity and the introduction of deleterious alleles.

### Socio-Economic Impacts

The impacts on society and the economy are visible. The majority of endemic fish are highly preferred in the local market and fetches high price than exotic fishes. Subsequently, the total economic return of fisher folk and stakeholders may reduce. In contrast, the preference for exotic fish like tilapia is more and the high catch leads to a high return for poor fishers. But the rise in economy and social status is a short term affair; the deteriorations in ecology derive long term negative impact.

### Strategies to Follow when Introducing Exotic Fish Species

As much as possible, fish introduction should be avoided, and specific management plans should be explored to enhance the native fish production and ecology. The efforts may be based on the adaptation of advanced technologies in biotechnology and biological sciences. For species diversification and enhancement purposes, the preference should be for native or endemic fish. If the alien species are highly preferred for introduction, it is necessary to handle with extreme caution the negative impact on the ecosystem. Before introducing an alien species in to open waters, the long term effects on ecology, genetics, and socioeconomic impacts should be explored. A nodal agency or panel should be designated to investigate the effects, risks, and benefits of the proposed introduction. Import of live fish consignment for the ornamental trade should be subjected to stringent quarantine measures. It should be ensured that they do not escape into natural waters accidentally. Ornamental fish traders and customers can be persuaded to use native varieties by raising awareness through training and education. A comprehensive legislation is required to prevent illegal acts in this field. An integrated river basin management approach to the prevention and control of invasive alien species should be implemented. Involvement of local and indigenous communities and other relevant stakeholders should be promoted at all levels for the identification, prevention, and control of invasive alien species in inland water ecosystems.

### Most Common Exotic Species in India

Tilapia (Figure 1) is creating problems in culture and open water systems, once the tilapia is introduced into an ecosystem; it becomes difficult to remove the species from the system. Because of hardy nature, wide feeding niches and prolific breeding with short generation interval resulted in well establishment of this species. Even after a



Figure 1: *O. niloticus*

pond is properly dewatered and restocked with native fish, the dominance of tilapia hampers the growth, feeding, and finally the total production through competition for food and space.

African catfish (*Clarias gariepinus*), one of the exotic invasive fish species, poses severe risks to aquatic biota, which leads to the threat or extinction of native or endemic fishes. It has been found in all water bodies, from culture systems, streams to rivers to wetlands, causing the decline of indigenous fish species. The fish is a nocturnal predatory fish, feeds primarily on living, as well as dead, animal matter including fish, invertebrates and small birds. It has the ability to survive in shallow mud and can tolerate poorly oxygenated water giving it an advantage over native fish species.

*Piaractus brachypomus*, commonly known as the 'red-bellied Pacu', a highly invasive fish species was introduced in 2004 from Bangladesh for ornamental and aquaculture purposes. The breeding and culture of the fish began in West Bengal and gained popularity in other states. This fish was widely introduced in to the fish market and is now cultured and reared throughout India.

The common carp (*Cyprinus carpio*) (Figure 2) is one of the most widely cultivated species in aquaculture worldwide and is one of the most extensively distributed introduced species, with a high likelihood of habitat expansion. Carp feed on sediments, fish and plant matter, which they don't fully digest, the partially digested excretion promotes algae growth. The species is an omnivorous bottom feeder fish. Since it disturbs the bottom sediment while feeding, it is known to increase the water turbidity (Ali *et al.*, 2010).



Figure 2: *C. carpio*

Other than the food fish, the exotic ornamental fish also found their way to natural water bodies from the aquarium. These happen mainly due to accidental escape during flood from the rearing or breeding tanks, the release of unwanted healthy ornamental fishes, or when the fish become too large to be accommodated in the aquaria (Singh and Lakra, 2011). For example, the sucker mouth catfish (*Pterygoplichthys pardalis*, *P. disjunctivus*) (Figure 3) a popular aquarium fish native to South America has spread into open water bodies (Ramya *et al.*, 2021). The presence of sucker mouth catfish poses negative impacts on the indigenous fish varieties, a decline in other aquatic biota such as aquatic insects, composition of aquatic vegetation, and also damaging fishing gears.





Figure 3: *P. disjunctivus*

### Conclusion

The establishment of alien species in open water resources could be attributed to their wide range of habits such as hardy, resilient, eurythermal, omnivorous nature, easy breeding in all ecosystems and high rate of adaptation in different environments. Based on their virtues with respect to high growth rate and increased fish production the introduction of species is widely practiced worldwide. But the potential negative effects on natural ecosystem through the escape from the culture system and the possibility of spreading, call for an urgent need to implement strict management measures to control the alien fish species.

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