**The Impact of Aquatic Alien/Exotic Species on Fisheries and Aquaculture**

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**Abstract:**

Exotic species are imported to many countries for use in aquaculture, recreational fishing, wildlife enhancement and fancy purposes or for natural control (mosquito hatchlings, vegetables, and phytoplankton). In spite of the fact that it has a positive effect on nourishment generation, its negative affect on ecosystems and biodiversity has pulled in around the world. The most concerns in presenting extraordinary angle are breeding, defilement of local seeds, infection, competition or contention with other species, financial misfortune, property harm, etc. This postures a risk to nourishment security and impacts nearby environments and biodiversity. The need for better and more dependable gauges of the esteem of a specific perspective executing such techniques cannot be overemphasized. This survey canters on the introduction of exotic species, the reasons for their introduction, species suitable for introduction, the disadvantages and advantages of exotic species, and various fish lessons. Finally, recommendation a plan to control the introduction of exotic species is proposed.

**Introduction**

With 2936 fish species (11% of general fish species) and over 300 remarkable fish species, India has a diverse biodiversity. Aquaculture, as defined by the FAO, is "the cultivation of aquatic organisms such as fish, molluscs, crustaceans, and aquatic plant life." Farming, constant stocking, feeding, predator protection, and so on" comprises all actions in schooling to boost manufacturing. It is no longer limited to meal supplements, which are essential for human nutrition; instead, it now provides part-time and full-time work, particularly in rural areas (1). According to FAO (2), 60 million people are directly or indirectly associated with fisheries or aquaculture, which provides a living for 10-12% of the arena's population. Aquaculture also accounts for more than half of global fish consumption (3).

With freshwater aquaculture generating over 95% of the country's annual production, aquaculture is the fastest-growing industry in India, expanding at a rate of over 7% in just 356 days. Small-scale agriculture also serves as the main source of manufacturing in rural areas. Widespread aquaculture may lessen the movement of people from rural to urban regions because small-scale rural fisheries are the leading providers of freshwater fish to developing nations for food safety and profit (4). If the rural area is viewed as a lucrative agency alternative for experienced farmers and permits higher incomes for contemporary farmers, then this can be done.

Jayasankar and Das (5) cautioned that horizontal growth can grow fish production due to the fact that an impressive 50% of ponds out of 2,414 million hectares are currently used. Likewise, vertical growth offers species diversification and consists of breeding and the traditional generation of the same vintage diversification business agency for freshwater species. A survey on fish farming in rural areas found that fish farming is achieved as an income-producing organisation, and farmers are little by little increasing their enterprise organisation by acquiring more land to create watersheds. Each extraordinary study by means of the method of Duarah and Mall (6) greater than 100% cross-return on investment on vertical diversification through the legacy of small native fish species, which includes carp in small-scale way-of-life ponds, sufficient to increase farmers' revenue. Similarly, amazing fish species are added to the cultivation device to improve aquaculture. In line with Kumar (7), the number one reason for introducing uncommon fish species can be: (i) to enhance the capability of neighbourhood fishing and to make the species larger inside the water gadget; (ii) game fishing; (iii) the reason of the aquarium; (iv) to manipulate weeds and unwanted organisms, which encompass flies.

Special fish are non-native species that come from other countries and have been added to Indian waters. They commonly establish cultural generation, manufacturing, and advertising abilities. Kottelat and Whitten (8) define added species (individual species) as species that are intentionally or accidentally transported and released via humans beyond their attainment. Consistent with Welcomme (9), unusual animals are species that arise outside their herbal variety. Likewise, the IUCN defines invasive alien species as alien species that arise in natural or semi-herbal ecosystems or habitats and threaten local biodiversity.

**Introducing exotic aquatic species**

The introduction of individual species has been practiced since the middle of the nineteenth century and is specifically utilized in aquaculture, recreation fishing, keeping ornamental fish, fly control, and so forth and in India, more than 3000 species were brought in (10). As noted above, exotic species are particularly useful for business functions.

There's evidence of the success of the advent of a few distinctive species that might also be installed in Indian water sources and provide farmers with economic benefits; yet, there have been cases when the unsuccessful introduction of some exotic species has negatively impacted the biodiversity of herbal remedies. (11). The following lists are some significant foreign species that were brought to India: Table 1:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SC. NAME** | **COMMON NAME** | **HOST COUNTRY** | **INTRODUCED TO** | **YEAR** | **PURPOSE** |
| **GAME FISHES** |
| *Salmo trutta fario* | Brown trout | England | Nilgiris(TN) | 1906 | In stream, lakes and reservoirs |
| *Salmo levensis* | Loch Leven Trout | England | Nilgiris(TN) | 1863 | In stream, lakes and reservoirs |
| *Oncorhynchus mykiss* | Rainbow trout | Sri Lanka, Germany | Nilgiris(TN) | 1907 | In stream, lakes and reservoirs |
| *Salvelinus fontinalis* | Eastern Brook trout | Canada |  | 1959 | In stream, lakes and reservoirs |
| *Salmo salar* | Atlantic Salmon | USA | Kashmir | 1968 | In stream, lakes and reservoirs |
| *Oncorhynchus nerka* | Socko-eyeSalmon | Japan | Nilgiris(TN) | 1968 | In stream, lakes and reservoirs |
| **FOOD FISHES** |
| *Carassius carassius* | Crucian Carp /Golden Carp | England | Nilgiris(TN) | 1874 | Experimental Culture |
| *Tinca tinca* | Tench/Doctor Fish | England | Nilgiris(TN) | 1874 | Experimental Culture |
| *Ctenopharyngodon idella* | Grass Carp | Hong Kong | Cuttack | 1959 | Experimental Culture and weed Control |
| *Cyprinus carpio communis* | Common Carp /Scale Carp | Bangkok | Cuttack | 1957 | Experimental Culture |
| *Cyprinus carpio specularis* | Common Carp /Mirror Carp | Sri Lanka | Nilgiris | 1939 | Experimental Culture |
| *Hypophthalmicthyes molitrix* | Silver Carp | Japan | Cuttack | 1959 | Experimental Culture |
| *Osphronemus goramy* | Giant Gouramy | Java and Mauritius | Tamil Nadu | 1916 | Experimental Culture |
| *Puntius javanicus* | Tawes | Indonesia | Kalyani(W.B.) | 1972 | Experimental Culture and weed Control |
| *Tilapia mossambica* | Tilapia | Bangkok,Sri Lanka | Mandapam (TN) | 1952 | Experimental Culture  |
| **LARVICIDAL FISH** |
| *Gambusia affinis* | Mosquito Fish | Italy |  | 1928 | Mosquito Control |
| *Poecilia reticulata* | Guppy | South America |  | 1908 | Mosquito Control and Aquarium |
| *Nothobranchus guentheri* | Red Tail Notho | Africa | TN |  | Mosquito Control |
| ORNAMENTAL FISHES |  |  |  |  |  |
| 27 Species | Live bearers | From various countries |  |  | Aquarium Keeping |
| 261 Species | Egg Layers | From various countries |  |  | Aquarium Keeping |
| **UNAUTHORIZE INTRODUCTION** |  |
| *Aristichthys nobilis* | Bighead Carp |  |  |  | Aquaculture |
| *Clarias gariepinus* | African Catfish |  |  |  | Aquaculture |
| *Oreochromis niloticus* | Nile Tilapia |  |  |  | Aquaculture |
| *Oreochromis* sp. | Red Tilapia |  |  |  | Aquaculture |
| *Serrasalmus nattereri* | Red Piranha |  |  |  | Aquaculture |

The freshwater pond cultivation gadget in India consists of three foremost species of Indian fundamental carp: Catla (*Catla catla*), Rohu (*Labeo rohita*), and Mrigal (*Cirrhinus mrigala*). Those species make up about 61% of the entire aquaculture industry. Three rare species are included in India's freshwater aquaculture device: common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*), which account for approximately 9.5% of domestic production. (12). These three wonderful Carps had been delivered to India from China. They have mounted themselves within the essential Indian industrial freshwater and carp aquaculture sectors. Every other example of a catfish species, Panagsius, was delivered to India in 1995 (13) from Thailand through Bangladesh. Despite the fact that, to start with, India banned tradition, throughout 2009, the government of India allowed its own lifestyle in cultivation. This species grows collectively with carps or as a monoculture. Due to its feed consumption and growth price, this species attracts many farmers for cultivation. In pond cultivation, the growth duration is restricted with the aid of environmental factors; therefore, farmers have to be advised to apply their ponds to develop a couple of crops in a year consistent with seasonal overall performance. Lately, pacu. (*P. brachypomus*) changed into illegally imported from Bangladesh in components of West Bengal and Assam.

**Choice of exotic species:**

Surely, the majority of the entries are associated with aquaculture or directed in the direction of aquaculture development. Turner (14) proposed a few criteria for introducing exclusive species. Below are a few homes that are suitable for introducing alien or unusual species.

(1) Need to be a quick grower to atone for the lack of protein.

(2) They must to fulfil a need because there are no comparable ideal species available.

(3) Such species ought to be like-minded and no longer compete with treasured local species, which are causing their decline.

(4) Must be reproduced using native species in order to avoid creating unwanted hybrids.

(5 It must be free of diseases, parasites, and pests to prevent harm to native species.

(6) Ought to coexist peacefully with the new ecosystem, procreate, and refrain from posing an environmental threat.

(7) Need to be long-lasting and smooth to work with other advantages.

(8) Tradition has to have verified technology and suitable monetary viability.

**Motives behind the introduction**

There is no question that most of the presentations made were due to aquaculture exercises or equipped towards progressing aquaculture. Underneath are a few reasons that make an outsider species reasonable for introduction.

*1. to be used in aquaculture*

Aquaculture purposes were the foremost reasons for presenting outsider species. They have continuously been a significant portion of the entire, but in later decades, their significance has grown. The importation of outside creatures has driven an increment in the number of aquaculture species (15). The primary cause of this is the worldwide market's need for unique kinds and trade. Diverse species have contributed significantly to the growth of aquaculture and the aquaculture product trade. Because of this pattern, in 1996 the world's freshwater fish culture was accounted for by just nine species. Countries all around the world have been exposed to this important fish farming species. Current trends show more and more crustacean species being offered worldwide for freshwater shrimp farming which is growing rapidly. Regarding the introduction of shrimp, the introduction of Pacific white shrimp *Litopenaeus vannamei* in the Asian region is one of the important contributors to the extraordinary development of aquaculture in the region in recent times(16).

*2. Improving the condition of wild animals*

There are many motivations for stocking fish species to improve wild populations: creating freshwater fisheries for food, filling "empty spots", replenishing natural waterways and giving predators food, restoring fishing grounds, creating wild stocks, controlling short-lived species. This is especially true in poor locations like temperate zones, where they are frequently imported into manmade lakes where autochthonous species cannot settle. In fact, all fish introductions to improve wild populations are based on the concept of a "vacuum" in the sense that there are resources in a body of water that are not being used effectively due to a lack of compatible native species. Alien organisms are capable of fully exploiting the available niche in cultural facilities. The polyculture of grass carps, silver carps, bighead carps, and other fish species is one example (17, 16).

*3. for the aim of research*

However, the growth and survival rate of the Akosombo strain has been a source of frustration for many Ghanaian commercial farmers in recent years. The Ghana Government Aquaculture Research Centre (ARDEC) imported GIFT (Genetically Improved Farmed Tilapia) strain in 2012 to experiment with the Akosombo strain as part of the development and validation of the Akosombo strain (18). A non-indigenous tilapia strain (GIFT) escaped into the wild, and efforts to reverse this activity were ineffective.

4. *Biocontrol substances*

The majority of fish species can assist in resolving environmental issues caused by humans. Silver and bighead carp can graze on phytoplankton and zooplankton. These carp may consume potentially harmful blue-green algae. and are thus useful in tackling algal blooms (eutrophication) of water and are therefore used for water purification.

Efforts were made to eradicate mosquito larva causing malaria, exotic fish species were introduced as early as in the 1920s. Although twelve species are included in the mosquito control repertoire, three species—*Poecilia latipinna*, *Poecilia reticulata*, and *Gambusia affinis*—have been introduced most widely. The suppression of mosquito larvae by means of small, larvivorous-fish species has proven to be highly effective. However, the use of insecticides to control mosquito larvae has become less environmentally friendly and more steeply priced. Also in some cases Molluscivorous fish were introduced to control the aquatic snail vector of Schistosomiasis (16).

*5. Recreational fishing*

The goal of being wild or manipulating stocks in natural water bodies is to use them for commercial and recreational fish food as well as sports and leisure fishing. The primary motivation for the several introductions made each decade is sport fishing, however the significance of these introductions has decreased since the 1950s. By using 1988, seventy-8 species had been recorded as introduced for recreation around the world. Lots of these salmonids or large predators with preventing characteristics are well known with the aid of sports activities fishermen. In India also, salmonids have been introduced in upland areas to promote sport fishing (16). Recently, the decline in fish populations in rivers, lakes, and dams has affected the fishing business. The result of this has been the introduction of hunter fish species into numerous freshwater habitats (19).

*6. A casual introduction*

Ballast water can be sea water or fresh water added to the ballast tank to balance the water boat and the main source of casual dating, because the water is diverse. A place filled with ballast during the journey to a ship that can carry a lot plants and animals of different regions from where they are taken. One third of aquatic species have been reported to introduce to the Great Lakes of North America with ballast water (16).

*7. Decorative purpose*

Given the global demand for colourful fish and the growing aquarium trade maintain an aquarium at home and workplace, introduce exotic fish species all over the world. The primary species utilized for this purpose is the gold fish, *Carassius auratus*, which has spread considerably outside of its normal habitat and frequently turned wild. These large species are introduced to stock natural water or decorative ponds. Put differently, the thriving aquarium commerce has resulted in the extensive dispersal of numerous species of tropical fish (16).

**Impacts of introduction of alien species**

Generally speaking, ecosystems and biodiversity can be positively or negatively impacted by the introduction of an exotic aquatic organism. Effects are often recorded. Most exotic species assessed were affecting more than one native species by different mechanisms, with 65% reporting negative impacts and 35% positive impacts on the others. In several circumstances, illegal immigrants have also affected key species or high conservation value species. 49 assessed species are reported to be ecosystem engineers, creating or defining habitats by changing their physical or chemical characteristics (20; 21).

**Positive influence**

Although there are some negative effects of introducing alien fish, there are some positive effects of introducing alien fish. Here are the positive effects of introducing exotic fish species.

*1. It helps in genetic research*

Most exotic species have been utilized as research subjects. Research efforts are carried out to increase the production of biomass and lipids in bioreactors for the production of biofuels. The introduction of exotic species and their establishment in new areas and ecosystems opens up new opportunities for ecological research, as they can be used to study concepts such as adaptive strategies, land construction, land measurement, keystone species, niche relationships, trophic cascades, rapid evolution, reproductive pressure, ecosystem engineering, connectivity, and dispersal mechanisms.

*2. Improvement of fish inventory*

Some introductions aim to manipulate wild or changed stocks in herbal water bodies. This includes growing new food fisheries, 'filling the gaps', conserving natural water, feeding predators, restoring fisheries, creating flora and fauna reserves, and dealing with endangered species. That is specifically proper in fauna-bad areas inclusive of ice-age glaciers, east of the Wallace Strait islands, or mountain streams in high altitude.

*3. Organic regulation*

These include, specifically, the management of infectious agents found in aqua farming facilities, position of cleanser reef fish, the biological regulation of the development of human diseases spread by vectors and the management of invasive species. Natural enemies are an environmentally acceptable alternative to insecticides commonly used to control invading organisms. Examples, fish consist of *Gambusia affinis* and grass carp, which are broadly promoted as organic controls of flies and algae.

*4. Increase the manufacturing of cultivation*

Unique species have played a crucial role in the improvement of aquaculture. Before 1900, the first worldwide movement of species, in particular freshwater salmonids, which included *Oncorhynchus mykiss* and *Salmo trutta trutta*, was brought to temperate areas to help with sport fishing and aquaculture for food manufacturing. Since the Seventies, the introduction of salmonids (especially *Salmo salar* and *Oncorhynchus kisutch*) refers to anadromous species that are widely cultivated in cages.

*5. Symbolic and aesthetic value*

It's approximately the presence and beauty of habitats and charismatic species, together with beaches, habitats, or species, and the cost positioned at the herbal and cultural monuments of the coast, reefs, or marine mammals.

**Unfavourable reactions**

 *1. Adjustments in genetic variety and genetic pollutants*

Most research has concluded that the genetic consequences of alien transplants lead to a discount in the effective population size and a change or extinction of the gene pool of the species. The release of fish into the wild can also have genetic outcomes. Direct effects consist of the impact on a species via initiating modifications in gene flow through hybridization and development. The indirect impact is mainly the discharge of a small number of people or the effect on local species through ecological approaches including competition, predation, new illnesses, or parasites. Hybridization can result in hybrid energy, heteroticity, or genetic infection due to dominance and heterozygosity at multiple loci. This genetic development no longer only leads to genetic pollution; however, in some instances, it additionally leads to the extinction of species. In maximum research, a full-size discount in the variety of offspring because of genetic contamination and genetic barriers is the result of genetic development. Similarly, researchers have identified reproductive problems due to this transplant, which include frame deformities, stunted boom, behavioural adjustments, and even reproductive melancholy. Such genetic effects can lead to a lack of regionally adapted populations and genetic variety. The evolutionary outcome of direct effects can also strongly depend on whether the launched fish are taken from wild or cultured shares. Domestication, which entails adjustments within the range, range, or combination of alleles, produces results that include a lack of population diversity in nature. At the same time, loss of diversity through genetic glide is random, and variety is lost.

Moreover, the impact of glide on genetic diversity is inversely proportional to the dimensions of the effective population, with genetic range misplaced through domestication related to genetic tendencies and the depth of selection. Therefore, if domestication permits culture to develop, it could also lead to reduced overall performance inside the wild because domesticated fish show worse effects than wild ones in terms of survival of fingerlings and adults, hiding behaviour, staying power, and migration. Because phenotypic and genetic characters can trade at some stage in captivity, they interact with every other neighbourhood populace or species, resulting in the dilution of domestically adapted gene swimming pools and a decline in the overall performance of local populations through the loss of species traits. Fish have a greater capacity for spontaneous hybridization than mammals or birds, which may cause complex evolution when domesticated fish meet wild stock. Consequentially, exotics can merge with local families or other aliens. Due to introgression pressure, conventional behaviour may be abandoned, and hybrids typically emerge from unrelated species.

*2. Habitat destruction or Alteration of Habitat*

The advent of wonderful aquatic species can adversely affect native species' habitats. Consumption of plant cloth by means of herbivorous fish, destruction of macrophytes by way of digging for meals or nesting web sites, and natural enrichment that will increase turbidity and reduce light penetration and photosynthesis can all make a contribution to the displacement of aquatic flora. The commonplace carp, *Cyprinus carpio*, is famous for muddying the water with its bottom-rooting dependency. It causes disruption to benthic invertebrates, overshadows macrophytes, and speeds up the recycling of phosphate, which accelerates eutrophication. The ancient fish fauna of India is changing in terms of composition and quantity. The species of the genus *Schizothorax* have vanished from the water, bringing goldfish and fisheries that are mostly dependent on it. In order to harm and eventually emerge from underwater plant life, *Ctenopharyngodon idela* has been introduced to numerous regions of the world*.* It typically does the process well enough; however, by selectively feeding on milder species, it can increase the number of flowers, which is more than a nuisance.

The feeding behaviour of wonderful fish that damage flora and degrade sediments can have an effect on the predation of native fish that devour organisms in lakes or sediment streams. Substrate disturbance for the duration of feeding by European carp (*Cyprinus carpal*) is related to accelerated turbidity (22). This applies to various creatures that hunt for food visually and have an impact on the photosynthetic potential of vegetation. Lack of vegetation further destabilizes bottom sediments, water transparency continues to deteriorate, and the entire system collapses. Therefore, degradation of the environment is associated with the loss of aquatic plant life, river erosion, water turbidity, and elevated nutrient availability. This could wreck local fish, invertebrates, and circulation habitats.

*3. Competition with native species*

Given the direct interplay among delivered and endemic species, organisms can change trophic relationships in at least three one-of a kind ways. Their presence can significantly increase the amount of prey available to local predators. Delivered fish-ingesting conduct can reduce the quantity of natural food available to local species through predation or opposition. Competition isn't always constrained to trophic consequences, but additionally to reproductive space, and so forth. Some brought species compete aggressively with local species for meals and area. Despite the fact that some introduced fish efficiently show common consumption behaviour and trophic opportunism (23, 24), in many systems there is huge similarity between the diets of introduced and endemic fish (25). Aggressive feeding of certain species on positive flora can lessen their availability for native species. A comparable mechanism has been identified in local species that cannot compete with delivered tilapia in a few parts of the United States. But a few other elements have been tested to play an essential role in the decline of neighbourhood species, such as the impact of human activities and changes in hydrographic parameters over time. Eutrophication and the advent of new fishing strategies have considerably contributed to the decline of the world fish fauna. The decline of endemic fish is often related to degraded and polluted habitats. The excessive productiveness of introduced species, including tilapia, can, without problems, lead to the stockpiling of available space and resources to be used by endemic species. This is a serious hassle, in particular in the course of the dry season, when the water usually reaches small ponds.

Eggs of *Gambusia affinis* or *Lepomis gibbosus* are reported to be eaten by other species. The excellent fish stocks within the surroundings can also be deteriorated by added species. Stunting is the manner by which a populace species expands unexpectedly, generating massive numbers of people that mature and reproduce in very small sizes, for that reason extensively reducing its recreational or business cost. Fish species that have been said to produce stunted populations encompass *Carassius* *auratus*, *Lepomis cynellus*, *L. gibbosus*, *L. macrochirus*, *Oreochromis mossambicus*, *O. niloticus*, *Tilapia rendalli*, and many others. Stunted populations suppress current and, in severe instances, can cause oxygen deprivation (16).

*4. The creation of pathogens in new surroundings*

Most examples are taken from the United States of America's understanding that fish hygiene is superior and manipulation is implemented. However, sicknesses can also be introduced to different locations of the sector and have not been reported thus far. Especially because it is related to the introduction of pathogens. Due to its familiarity, tropical fish tradition is a well-studied topic. The introduction of invasive species is responsible for the advent of parasites and the unfolding of sickness. Even though a few parasites require intermediate hosts, many no longer affirm the host, and others have a more complicated existence cycle. While searching for the enjoyment of different species, there are examples of species migrating past clean barriers or causing surprising disorder issues while reintroduced. Atlantic salmon travel from the Baltic Sea to Norway, where they are infected with parasites to which Norwegian Atlantic salmon are not resistant.

Detrimental illnesses are also said to be mainly generic in the shrimp industry. White spot syndrome virus (WSSV) has been related to the emergence of distinguished species. A recent disease outbreak has prompted mass mortality among cultured penaeid beetles around the sector, in particular in Asian international locations. WSSV disorder brought on excessive mortality and excessive harm to the shrimp farming enterprise in China, Thailand, Japan, Taiwan, Indonesia, and India. The herpes virus is thought to be sexually transmitted and smuggled into India from Southeast Asian countries where the virus is endemic, as reported by a few authors (26). 1994–95, white spot virus disease caused intense mortality of cultured shrimp *P. monodon* and *P. index* from the east coast of India (27). Karunasagar *et al*. (28) found a scourge of WSSV on the west coast of India.

*5. Loss of surroundings offerings*

Adjustments in species and network shape can both directly and indirectly affect ecosystem offerings. Direct consequences include the discount of economically treasured species, especially those used for meals, fodder, fiber, gasoline, or medication. With the emergence of "annoying creatures" such as pervasive plants or floating plants, aesthetic value is misdirected. Disruptive invasive species threaten nature's offerings, especially pollination and pest management. The loss of genetic diversity and the extinction of species additionally affect the loss of selection fees. Indirect effects include decreased atmospheric resistance and resilience to change as a result of the postulated relationship between resilience and biodiversity trade (29). Consequentially, fantastic feedback because of invasive species interactions can cause accelerated vulnerability to further invasions and reduced atmospheric offerings (30).

 *6. Financial losses*

Invasive species of phytoplankton can cause great damage to aquaculture, aquaculture, or fisheries. *Alexandrium minutum* has brought on persistent blooms in northern Europe since 1985, inflicting considerable monetary losses to aquaculture (31). *Karenia mikimotoi*, called the fish killer, has induced a massive variety of deaths of fish and marine animals in north-western Europe, considering the fact that 1968, which included farmed fish and shellfish (32). *Gymnodinium catenatum* has become a common and harmless species in the Alborian Sea, and it is usually linked to harmful events*.* At some stage in the past many years, the growth of *G. catenatum* has precipitated episodes of Parasitic Shellfish Poisoning (PSP) on Spain and Portugal's west coast of the Iberian Peninsula, which has caused excessive financial losses and reduced shellfish harvesting and commercialization (33). The ichyotoxic (34) flagellate *Pseudochattonella verruculosa* (E) killed 350 tons of farmed Norwegian salmon in 1998 and 1100 lots in 2001 (35) and wild fish on the west coast of Denmark (36).

*7. Socio-financial effect*

The effect of inputs is not confined to biological and ecological parameters. It could, without delay or indirectly, have an effect on socio-monetary elements. Unwanted species can occur once they displace rather precious native fish. This case is determined in Europe (Lake Constance) and the United States (Laurentian extremely good lakes). When local economies depend upon fish farming for human intake, their financial vulnerability is considerable. Introducing extraordinary species can have negative influences and socio-economic results, specifically in the event that they include the emergence of new diseases or the genetic damage of cultivated seed shares. Aquaculture operators have to be cautious to decrease the risks concerned, as a lot depends on the change of genetic material in their inputs. In this case, the fishing industry cannot forget about the devastating impact of the whitefly disorder, which has shown severe mortality in *P. mondon* and *Penaeus* spp., endemic species of India. This induced a large financial loss to the farmers in addition to a social impact, as many farmers had been struggling for meals and work at that point.

**Advantages and disadvantages of uncommon fish:**

It has also been suggested that the introduction of exotic species has contributed to the decline in freshwater aquatic biodiversity alongside human activity. Added (distinguished) species are those that have been accidentally or purposefully moved outside of their current range by man.

It has been reported that 168 fish species, or 37 households, have been introduced outside of their native region on a global scale. At least 67 of these have been shown to have established themselves in unique water within human bodies; of them, 27 have become real pests.

Many distinct fish species have established themselves in natural water bodies throughout India. Extensive research on their effects in Indian waters has clearly revealed the devastating effects of these remarkable species (such as Tilapia, Silver Carp, *Gambusia*, common carp, and so on) on aquatic ecosystems in India. Here are some of its advantages and disadvantages:

*I. deserves unique fish:*

Even though there are a lot of native fish species in India (about 637 species total), some remarkable species were introduced either to enhance the beauty of aquariums or because they have exceptional qualities that the native species do not.

Fish were mostly delivered in two ways:

(a) Fisheries department scientists, who weigh the benefits and drawbacks frequently, decided it was appropriate for creation, which may help fishermen.

(b) Unapproved production, assisted by:

(i) The fishermen who have added fish in order to obtain low-budget mileage, or

(ii) Via any tiny water outlet and accidental discharge caused by a group of fish-eating mammals and birds.

*The advantages of specific fish can be summed up as follows:*

(a) The unusual carps have shown to be excellent candidates for the composite fish culture approach because of their rapid increase rate (excessive food conversion ratio). They significantly increase yield and could address India's protein need. It was announced that grass carp had reached a weight of five kg in a year.

(b) Farmers no longer have to visit the rivers for their seed series during the breading season because common carp may be bred in ponds with limited water.

(c) Because they are omnivores and scavengers, common carp help keep a pond's water clear of pollution.

(d) In India's warmer climate, silver carp reaches adulthood at age 1, but in its natural habitat, it reaches adulthood at age 5–6.

(e) Silver carp are able to take advantage of the intense phytoplankton bloom and help hold it below the test.

(f) Grass carp are employed to suppress weeds since they can consume a variety of aquatic plants.

(g) In addition to providing food for omnivorous fish, the semi-digested meals found in grass carp excrement also enrich the pond water.

(h) Approximately 288 species of unique decorative fish with vibrant colours are much sought after by many aquarists.

(i) In order to control mosquitoes, larvicidal fish (Guppy, *Gambusia affinis*) were introduced.

(j) For the purpose of enjoying leisure time angling, game fish have been introduced in hill streams, lakes, and reservoirs.

(k) Unauthorized introduction of *Puntius javonicus* for rice field culturing occurred in India.

(l) Often referred to as "brilliant" fish and categorized as a "bird of water," tilapia is a fish that breeds easily because to its high fecundity, affordable feeding costs, and tolerance for a wide range of salinity and temperature. In comparison, they are disease- and parasite-free. Their hardiness makes them perfect for culture in ponds supplied by sewage.

(m) Because they can grow to adulthood in just two months, breed in confined waters, consume a wide variety of foods, and receive the proper care from their parents, tilapia require far less control over their lifestyle..

*II. Disadvantages of prominent fish:*

The indiscriminate creation of distinct fish has added to some problems. Not much research has been accomplished on the influences of unique species in Indian waters. But reviews from some other place provide a bleak state of affairs of the damages as a result of the sort of advent; that's the truth of Indian situations.

Below are list of some of the drawbacks experienced:

(a) Many experts agree that the introduction of African cichlids, or tilapia, to India was a beneficial development. However, an unexpected effect has recently been felt on the freshwater and brackish water fisheries. Because tilapia are tough and prolific breeders, they have overflowed numerous bodies of water, which has prevented IMC from growing in pond waters.

(b) The introduction of tilapia to Kerala's longest river, Bharathapuzha, has caused the local fish fauna to disappear in several areas. Furthermore, it has been claimed that freshwater turtles have vanished from our bodies as a result of widespread gill net fishing for tilapia.

(c) The natural fish population in Dal Lake and Loktak Lake has been impacted by the introduction of *Cyprinus carpio*.

(d) Because common carp rely on sucking meal creatures in the dust on the pond's borders and bottom, the water becomes murky and the pond dyke's foundation is weakened, which leads to erosion. *Cyprinus carpio*, a valuable resource for anglers, has been regarded as a problem in game waters due to its tendency to cause filthy pond water

(e) The introduction of silver carp to Govind Sagar reservoir has a disastrous impact on the variety of fish.

(f) Because of their low price, exceptional carps have an unprofitable lifestyle in India. Those fish have terrible, disagreeable meat that smells like grass (grass carp).

(g) The impact on aquatic biodiversity of the introduction of guppy and mosquito fish (*Gambusia*) to India has been negative. It has been claimed that mosquito fish are predators because they are resilient and abundant breeders that can enter the microhabitats of rare local species. Mayer (37), a renowned Ichthyologist, called this species a "fish destroyer." Furthermore, the IUCN has stated that the emergence of guppy farming has contributed to the global extinction of some species.

(h) The introduction of game fish into Indian waters was once thought to be simple. In addition to being discovered to be a high predator (Rainbow Trout) on the eggs and young of nearby species, gift trouts were advised to no longer be the best to compete with neighbourhood stocks.

(i) Fish that are illegally brought into India include aquarium fish like red Piranha (*Serrasalmus nattereri*) and carnivorous feeders like massive-head carp (*Aristichthys nobilis*) and African catfish (*Clarius gariepinus*). The specific fish species found in our body's herbal water pose a serious threat to smaller native fish species and invertebrates.

The Union Agriculture Ministry has ordered the complete eradication of these fish due to the harm they pose. But the authority's decree meant nothing. In Kerala and West Bengal, farms continue to grow African catfish and piranhas.

(j) In addition to the appearance of unique species, the spread of diseases and parasites from Indian waters has also been proposed. This may result in a large amount of dangerously altered bureaucracy.

(k) The introduction of unique fish species to diverse settings in India may potentially lead to a decline in biodiversity.

It follows that in addition to no longer having to fight with native species for food and habitat, foreign fish will now also likely become prey. First-rate species degrade the physico-chemical characteristics of the aquatic environment, bring in new parasites and diseases, and eventually give up, creating hybrids and genetic "erosion" of native species. Eventually, those kinds of will lead to a lack of biodiversity. The danger to capabilities also affects the socioeconomic aspects of the human population because they rely on the aquatic environment for survival.

**Conclusion and recommendations:**

The following are the recommended plan for controlling alien species before species are allowed to enter.

o. Guidelines for the management and transportation of fish and fish products must be prepared by the ministries of agriculture in a number of different countries.

o. Importing the most basic species that have little to no negative effects on the environment is necessary.

o. It is necessary to implement regional and global codes of conduct.

o. Various nations must have severe laws in place when bringing prestigious fish into their countries.

o. The cultivation of rare fish species in different countries ought to be encouraged, but not near health-related bodies of water.

o. More investigation is required into the effects of the unique species that exist today on the environment.

It’s distant as difficult to assess the satisfaction of presentations for the spread of thought processes. The number one issue expressed by Allendorf (38) is that angle presentations are regularly made without appropriate mechanisms to evaluate on the off chance that the specified objective(s) are accomplished. Geological and transient scales of differentiate had been utilized to survey triumphs, but were found to show a few inconveniences. For instance, presentations in certain cases have progressed the amount of species current inside a particular geological put. On this slim scale, presentations could appear to boost biodiversity. But these presentations have also caused the termination of numerous species. In this manner, on a worldwide scale, such presentations reduce biodiversity. The transient scale is, moreover, exceptionally basic to bear in intellect. Any valuable results of presentations regularly happen right presently, as the harming impacts are regularly behind plan. Hence, we are continuously confronted with political and monetary stretch to exemplify short-term points of interest at the cost of the long-term well-being of the environment. Going ahead, the desire to completely secure and constrain the threats of presentations such bundles are carried out cannot be overemphasized. The presentations need to be objective-driven, and appropriate components of assessment and following of the favoured destinations have to be a necessarily portion of this endeavour. Tips show that instruction, participation, law, and consideration are the key issues when adapting to species presentations. A designer program to require a see at the long-term impacts of particular angle species on the environment and fishing resources is exceptionally basic for home-grown asset preservation and administration. Man or women, countries and their individuals have an obligation to assist protect neighbourhood situations from undesirable uncommon. Control determinations as respects angle presentations ought to be completed by way of umbrella control organizations in inclination to character states being permitted to seek after their individual plan. Approaches and rules need to be created and implemented to secure and energize participation among responsible companies to protect the home-grown environment. Numerous past and modern contentions in support of presentations have been based completely on seen societal needs. Society ought to get it that such presentations include "esteem," and we now not get characteristic frameworks adequately to know what esteem may be. There may be a crave to extend endeavours to instruct the open and control companies approximately the restrictions and threats of angle presentations.

**REFERENCES**

[1]. P.Jayshankar. Present status of freshwater aquaculture in India - a review. Indian Journal of Fisheries, 65(4), 157–165, 2018. https://doi.org/10.21077/ijf. 2018.65.4.81300-20

[2]. D.Pauly. & D.Zeller. Comments on FAOs state of world fisheries and aquaculture (SOFIA 2016). Marine Policy, 77, 176–181, 2017.

[3]. R.Subasinghe, D.Soto. & J.Jia. Global aquacul ture and its role in sustainable development. Reviews in Aquaculture, 1(1), 2–9, 2009. [https://doi.org/10.1111/j. 1753-5131.2008.01002.x](https://doi.org/10.1111/j.%201753-5131.2008.01002.x)

[4]. T. V. R. Pillay. Aquaculture: Principles and practices. Fishing News Books, 1990.

5. P.Jayasankar. & P. C. Das. Vertical expansion strategy for increased freshwater aquaculture production. Fishing Chimes, 35, 44–51, 2015.

[6]. J. P. Duarah. & M.Mall. Diversified fish farming for sustainable livelihood: A case-based study on small and marginal fish farmers in Cachar district of Assam, India. Aquaculture, 529, 735569, 2020, https://doi. org/10.1016/j.aquaculture.2020.735569

[7]. A. B. Kumar). Exotic fishes and freshwater fish diversity. Zoos’ Print Journal, 15(11), 363–367, 2000, https:// doi.org/10.11609/JoTT.ZPJ.15.11.363-7

[8]. M.Kottelat. & T.Whitten. Freshwater biodiversity in Asia: With special reference to fish. The World Bank technical paper No. 343, pp. 59, 1996.

[9]. R. L. Welcomme(Ed.). International introductions of inland aquatic species (Vol. 294). Food & Agriculture Org., 1988.

[10]. R. P.Raman., A.Mishra, S.Kumar., S.Sahay., M.N.Bhagat., & S.Kumar. Introductions of exotic fish species into Indian waters: An overview of benefits, impacts. Advances in Fish Research, 6, 1–14, 2013.

[11]. B.Laxmappa. Exotic fish species in aquaculture and aquatic ecosystem in Telangana State, India. Journal of Aquatic Biology & Fisheries, 4, 1–7, 2016.

[12]. A.Kumar,P.K. Pradhan,., P.C.Das, S.M.Srivastava, K.K.Lal, & J.K.Jena. Growth performance and compatibility of Rupchanda, Piaractus brachypomus with Indian major carps in polyculture system. Aquaculture, 490, 236–239, 2018.https://doi.org/10.1016/j. aquaculture.2018.02.052

[13]. Rao. A comprehensive study report present status of Pangasius farming in Andhra Pradesh, India, 2010.

[14]. H.J.Turner. Growth of the North Pacific oyster in New England. In: Report on investigations of methods of improving the shellfish resources of Massachusetts. Commonwealth of Massachusetts. Woods Hole Oceanographic Institution, pp. 8-10, 1949.

[15]. J.Stuart. Biological Prerequisites for Aquaculture. Grafton Aquaculture Centre, 2016.

[16]. B. Vishnu Bhat and T.K.Singh. INTRODUCTION OF EXOTIC AQUATIC SPECIES FOR AQUACULTURE IN INDIA: SOME PERSPECTIVES. Aquaculture: New Possibilities and Concerns, Pages 157–172 Edited by: V.R.P. Sinha and P. Jayasankar, 2014.

[17]. K.Saura, Et Al. Introduction of Exotic Fish Species into Indian Water: An Overview of Benefits, Impacts, Issues, and Management. Research Gate, 2013.

[18]. Y.B.Ansah, E.A. Frimpong, E.M. Hallerman. Genetically-improved tilapia strains in Africa: Potential benefits and negative impacts. Sustainability, 6, 3697–3721, 2014.

[19]. Golzio C, et al. KCTD13 is a major driver of mirrored neuroanatomical phenotypes of the 16p11.2 copy number variant. Nature; 485:363–367, 2012.

[20]. Wallentinus I, Nyberg CD. Introduced marine organisms as habitat modifiers. Mar Pollut Bull. 55(7-9):323-32, 2007. doi: 10.1016/j.marpolbul.2006.11.010.

[21]. S.K.Berke. Functional groups of ecosystem engineers: a proposed classification with comments on current issues. Integrative and Comparative Biology 50(2): 147–157, 2010. <http://dx.doi.org/10.1093/icb/icq077>

[22]. H. R. Mc.Crimmon. Carp in Canada. Fish Res. Board Can. Bull. 165. 93 pp., 1968.

[23]. J.N.Taylor, W.R. Courtenay. & J.A. McCann. Known impacts of exotic fishes in the continental United States. In W.R. Courtney and J.R. Stauffer (eds.) Distribution, Biology and Management of Exotic Fishes. Johns Hopkins University Press, Baltimore. 132-173, 1984.

[24]. A.H.Arthington. & D.S.Mitchell. Aquatic invading species. In R.H. Grooves and J.J. Burdon (eds.) Ecology of Biological Invasions: an Australian Perspective,. Australian Academy of Science, Canberra. 34-52, 1986.

[25]. A.H.Arthington. Impacts of introduced and translocation of freshwater fishes in Australia, p. 7-20. In S.S. De Silva (ed.) Exotic Aquatic Organisms in Asia. Proceedings of the Workshop on Introduction of Exotic Aquatic Organisms in Asia. Asian Fish. Soc. Spec. Publ. 3, X, Manila. Philippines. 132-173, 1989.

[26]. K.M. Shankar. & C.V. Mohan. Epidemiological aspects of shrimp viral diseases in India--a review. Journal of Aquaculture in the Tropics, 1998.

[27]. Anon. Submission to JMPR on the proposed changes to the ERL for DDT. Information on monitoring DDT residue data for meat by the Ministry of Agriculture, New Zealand, 1994. Unpublished, 1994.

[28]. I.Karunasagar. & S.K. Otta. Histopathological and bacteriological study of white spot syndrome of Penaeus monodon along the west coast of India. Aquaculture 153:9–13, 1997.

[29].D.U.Hooper,F.S.Chapin FS,Ewel JJ,Hector A,Inchausti P,Lavorel S,Lawton JH,Lodge DM, Loreau M,Naeem S,Schmid B,Setala H,Symstad AJ,Vandermeer J,Wardle DA. Effects of biodiversity on ecosystem functioning:a consensus of current knowledge. Ecol Monogr 75:3–35, 2005.

[30]. D.Simberloff. & Von Holle B. Positive interactions of nonindigenous species: Invasional meltdown? Biol Invasions 1:21–32, 1999.

[31]. S. Nehring. Non-indigenous phytoplankton species in the North Sea: supposed region of origin and possible transport vector. Archive of Fishery and Marine Research 46: 181-194, 1998.

[32]. Raine, O’Boyle S, O’Higgins T, White M, Patching J, Cahill B, McMahon T. A satellite and field portrait of a Karenia mikimotoi (Hulbert) bloom off the south coast of Ireland, August 1998. Hydrobiologia 465: 187–193, 2001. http://dx.doi.org/ 10.1023/A: 1014524420705

[33]. S.Ribeiro, A.Amorim, T.J.Andersen, F.Abrantes, M.Ellegaard. Reconstructing the history of an invasion: the toxic phytoplankton species Gymnodinium catenatum in the Northeast Atlantic. Biological Invasions 14: 969–985, 2012. http://dx.doi.org/10.1007/s10530-011-0132-6

[34]. B.Skjelbred, T.E.Horsberg, K.E.Tollefsen, T. Andersen, B.Edvardsen. Toxicity of the ichtyotoxic marine flagellate Pseudochattonella (Dictyochophyceae, Heterokonta) assessed bysixbioassays. Harmful Algae 10(2): 144–154, 2011. http://dx.doi.org/10.1016/j.hal.2010.08.007

[35].B.Edvardsen, W.Eikrem, K. Shalchian-Tabrizi, Riisberg I, Johnson G, Naustvall L, Throndsen J. Verrucophora farcing gen. et sp. nov. (Dictyochophyceae, Heterokonta) - a bloom-forming ichthyotoxic flagellate from the Skagerrak, Norway. Journal of Phycology 43: 1054–1070, 2007, http://dx.doi.org/10.1111/j.1529-8817.2007.00390.x

[36]. L.J. Naustvoll NOBANIS – Invasive Alien Species Fact Sheet – *Pseudochattonella farcimen*. Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS. 2010, http://www.nobanis.org (Accessed 25 February 2013)

[37]. P.E.Meyer-Waarden. Mastversuche mit portugiesischen Austern im deutschen Wattengebiet. Inf. Fischw. 11: 77-78, 1964.

[38]. F.W.Allendorf. Ecological and genetic effects of fish introductions: synthesis and recommendations. Can. J. Fish. Aquat. Sci. 48 (suppl. 1): 178-181, 1991.

**CONSULTED WEBSITES:**

<https://www.notesonzoology.com/india/fishery/exotic-fishes-meaning-selection-and-culture/766>

<https://www.fao.org/3/y3610e/y3610e12.htm>

<https://edis.ifas.ufl.edu/publication/FR449>

<https://oceanservice.noaa.gov/facts/aquaculture.html>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3265713/>

<https://link.springer.com/chapter/10.1007/978-3-030-45367-1_2>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9397527/>

<https://iopscience.iop.org/article/10.1086/342978/fulltext/16434.text.html>

<https://www.who.int/news-room/fact-sheets/detail/biodiversity-and-health>

<https://besjournals.onlinelibrary.wiley.com/doi/10.1111/1365-2664.12079>

<https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1910415>

<https://www.fisheries.noaa.gov/feature-story/local-farm-table-our-history-sustainable-fish-production>

<https://www.notesonzoology.com/india/fishery/exotic-fishes-meaning-selection-and-culture/766>

<https://oceanservice.noaa.gov/facts/invasive.html>

<https://www.frontiersin.org/articles/10.3389/fmars.2023.1150213/full>

<https://www.doi.gov/blog/invasive-species-finding-solutions-stop-their-spread>

[www.openventio.org](http://www.openventio.org)

[www.fisheriesjournal.com](http://www.fisheriesjournal.com)

[www.ipbes.net](http://www.ipbes.net)

www.journalppw.com