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Fish as Bio-Control Agent for Microalgae and Macrophytes in Various Aquatic Ecosystems

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Abstract

Infestation of microalgae and macrophytes in aquatic ecosystems is posing serious challenges to their ecological functioning and aquaculture use. Various studies indicate that fishes can be effectively used for the control of microalgae and macrophytes weeds in aquatic ecosystems such as aquaculture ponds, tanks, reservoirs, irrigation canals *etc*. Accordingly, this article reviews the promising candidate fish species which can act as bio-control agents for excessive algal and weed growth, such as silver carp, common carp, grass carp, tilapia, barbs, giant gourami and mahseers. It also covers the experimental studies carried out using these species in different ecosystems and discusses their potential as well as constraints.

Introduction

Fish farmers in India are facing severe threat of excessive algal growth in ponds. They hamper the growth of fishes and disturb the ecological balances in various ways. The enrichment of water body due to the runoff from domestic sewage and other phosphatic fertilizers for agriculture paid the way for eutrophication. The uncontrolled growth of algae is also not desirable from aesthetic point of view. Further, the water treatment practices demands enormous costs which is not feasible for fish farmers. Biomanipulation is a widely accepted concept which has huge potential to improve the environmental quality of lentic systems. Shapiro *et al*. (1975) introduced this as a method for lake restoration. The bio-control of algal blooms in eutrophic freshwater ecosystems using algal feeding fishes can be achieved easily as it has no adverse effects on other organism, can be applied in wide areas without disturbing the ecology, minimum cost and can perform best if areas are undisturbed or inaccessible.

Candidate species for biocontrol of algae are discussed below.

1. Silver Carp (*Hypophthalmichthys molitrix*)

The freshwater cyprinid fish, *Hypophthalmichthys molitrix* commonly known as silver carp is widely farmed in polyculture with other Asian carps or other species. Silver carp was found the most suitable for removing *Microcystis* infested bloom when grazed it with bighead carp (*Aristichthys nobilis*) and Tilapia. Drastic reduction of *Microcystis* population was reported by when silver carp and bighead carp where stocked in high densities in eutrophic lake. Research conducted to control phytoplankton biomass in aquaculture pond using the combination of zooplankton and silver carp has reduced 99% of algal biomass and showed improved growth rate of silver carp. This technique could be applied to both intensive and extensive aquaculture systems. There was a significant reduction of algae, zooplankton, and suspended organic matter when silver carp were stocked with 300-4500 fishes per hectare, indicates silver carp can prevent the growth of blue-green algae. The eutrophic Paranoa Reservoir in Brazil when stocked with moderate silver carp biomass (850 kg ha^{-1}) caused the reduction of microzooplankton (copepod nauplii and rotifers <200 µm) and total phytoplankton (expressed as chlorophyll-*a*). The observed improvements in water quality suggest that stocking silver carp in eutrophic reservoirs to control blue-green algae is a promising biomanipulation practice.

Constraints

The silver carp is a highly invasive species. There are many case histories of invasion of silver carp in Indian water, such as Govind Sagar reservoir where it was accidentally introduced and it drastically reduced the populations of the native *Catla catla* and *Tor putitora*. As it is not native to Indian waters, caution should be taken while using the species for bio-manipulation of aquatic systems and it is not recommended for use in open water bodies such as rivers and lakes.

2. Nile Tilapia (*Oreochromis niloticus*)

The African native cichlid fish, *Oreochromis niloticus* is been widely introduced in aquaculture. It is a hardy species which prefers shallow water and has wide range of trophic and ecological adaptions. The lower and upper lethal temperatures for Nile tilapia are 11-12 °C and 42 °C, respectively, while the preferred temperature ranges from 31-36 °C. It is an omnivorous grazer that feeds on phytoplankton, periphyton, aquatic plants, small invertebrates, benthic fauna, detritus and bacterial films associated with detritus. Nile tilapia can filter feed by entrapping suspended particles, including phytoplankton and bacteria, on mucous in the buccal cavity, although its main source of nutrition is obtained by surface grazing on periphyton mats. Young Tilapia (6 cm total length) is entirely an herbivorous feeder, mainly feeds on phytoplankton.

Tilapia is used for the biocontrol of *Microcystis* population when stocked with silver carp and bighead carp and showed the population reduction of 60-93% of the algal biomass. An experiment was conducted by Turker *et al*. (2003) on partitioned aquaculture system, where Tilapia was incorporated for filtration of green algae and cyanobacteria and the results revealed the maximum filitartion of cyanobacteria (865 mgC/kg/h at 59 mgC/l) which was followed by green algae (641 mgC/kg/h at 26 mgC/l). Significant reduction in algal groups such as Chlorophyceae, Bacillariophyceae and Cyanophyceae in pond was observed under polyculture system of tilapia (*Oreochromis niloticus*) and freshwater prawn (*Macrobrachium rosenbergii*).

Constraints

Nile Tilapia is a highly invasive species, owing to its hardy nature and prolific breeding habitat. As it is not native to Indian waters, caution should be taken while using the species for bio-manipulation of aquatic systems and it is not recommended for use in open water bodies such as rivers and lakes.

3. Common Carp (*Cyprinus carpio*)

The common carp is a widespread freshwater fish of eutrophic waters in lakes and large rivers in Europe and Asia. It has been domesticated and introduced into environments worldwide. Wild common carp live in the middle and lower streams of rivers, in inundated areas, and in shallow confined waters, such as lakes, oxbow lakes, and water reservoirs. They are mainly bottom dwellers but search for food in the middle and upper layers of the water body. Typical carp ponds in Europe are shallow, eutrophic ponds with a muddy bottom and dense aquatic vegetation at the dikes. With a broad ecological spectrum, the common carp can perform best growth when water temperature ranges between 23 °C and 30 °C and even can survive cold winter periods. Salinity up to about 5 ppt can be tolerated.

Common carp is found to be mainly useful for controlling submerged rooted vegetation because of its roiling nature. The combination of common carp and grass carp was used to control *Vallisneria* in irrigation canals of Tungabhadra project in Karnataka. The amount of plankton consumed by the common carp fry tended to rise gradually with increase in average body weight of carp. Studies reported that, in the rice-fish culture system of Arunachal Pradesh, India, common carp feeds on Chlorophycea, Cyanobacteria and Bacillariophycea, while selectivity changed with the flood phases between phytoplankton and periphyton. Various strains of common carp, especially Israeli carp, have been recommended for filamentous algae control. These long-lived carp control filamentous algae by feeding in the pond bottom and breaking off the algae as it begins to grow. Their feeding habit in the pond bottom can have detrimental effects on ponds by causing muddy water. Rahman *et al*. (2006) studied variation in feeding habits in common carps and found out that when formulated feed was given fishes prefer more phytoplankton.

Constraints

The common carp is often considered a very destructive invasive species, being included in the list of the world's 100 worst invasive species. As it is not native to India, caution should be taken while using the species for bio-manipulation of aquatic systems and is not recommended for use in open water bodies such as rivers and lakes. The habit of feeding on bottom sediments, which uprootes aquatic plants and stirs the sediment and in turn caused increased water turbidity, makes common carp an unwanted species in some water bodies, especially, which serve as a source of drinking water.

4. Grass Carp (*Ctenopharyngodon idella*)

Grass carp have also been successfully introduced for weed control to North and South America, other parts of Asia, Africa and Australia. In some tropical countries, grass carp is an integral part of fish culture, as its flesh forms an important source of protein for human consumption. Since its introduction to India, Grass carp has been used in composite culture of carps, particularly in ponds infested with aquatic weeds. It is suggested that, grass carp can control the population of *Hydrilla, Najas, Ceratophyllum, Wolffia, Lemna, Spirodela, Ottelia, Vallisneria, Potamogeton, Utricularia, Trapa, Myriophyllum, Limnophila, Nechamandra*, and algae *Nitella, Spirogyra, Pithophora.* The grass carp can convert the excreta of aquatic macrophytes thereby reduces the cost of fish production. In India, grass carp has also been used for control of aquatic macrophytes with limited success in the Chambal irrigation system. The submersed weeds were effectively controlled in a small drainage canal in the Province of Giza near Cairo, Egypt. It also decreased the submersed aquatic weeds from 35% to 6% in irrigation canals of Egypt. The grass carp has proven effective in controlling the aquatic weed infestation including Chara (stonewort), water plantain, sago pondweed, Canada waterweed, and filamentous algae. The high nutrient loading can be controlled partly by the recycling of nutrients in to fish flesh. Triploid grass carps developed in the early 1980's are artificially produced carps, incapable of reproduction, were being used in aquatic weed control. In 1984, the South Carolina legislature legalized the stocking of triploid grass carp from certified dealers in private and public waters in South Carolina.

Constraints

The controversy associated with grass carp is the occurrence of parasites and diseases. The undigested plant material released in the fish faeces can also cause changes of water quality, sediment chemistry and thus create changes in communities of producers including aquatic macrophytes and phytoplankton and consumers (*i.e.*, zooplankton, zoobenthos, fish, amphibians and water birds). The uncertainty of the effect on native fish, lack of knowledge of proper stocking rates; difficulty of live capture and possibility of natural spawning may create adverse effects on the system.

5. Giant Gourami (*Osphronemus goramy*)

Osphronemus goramy is a voracious herbivore, has wide occurrence in rivers, lakes and freshwater swamps of Southeast Asia. It is commercially important as food fish and has high ornamental value. It was introduced into irrigation wells in India from Java to control submersed macrophytes. In India, giant gourami has also a large appetite for *Pistia stratiotes*, on which mosquitoes transmitting filariasis, breed. Fully grown gourami consumes 300 g of *Pistia* per day, and can clear one hectare pond in a month.

Constraints

The giant gouramy is an exotic fish introduced to India, may be as an ornamental fish. It is not recommended for use for algal and macrophyte control in open waters.

6. Barbs (*Barbonymus gonionotus*/ *Hypselobarbus* spp./ *Systomus* spp.)

Barbs are an important group of freshwater food and ornamental fish belonging to the family Cyprinidae, many species of which are abundantly present in Indian rivers. The native species of the region offers great scope for control of algae without any threat of invasion.

Java barb (*Barbonymus gonionotus*; Figure 1) is a native to Thailand, Malaysia, Laos, Vietnam and Java (Indonesia) is now widely distributed throughout the Asian region, due to its use in aquaculture and introductions to establish commercial fisheries. It is generally omnivore but shows high tendency towards plants. It feeds on algae and aquatic macrophytes and is used extensively for weed control in fish ponds. *B. gonionotus* controlled a dense cover of *Ceratophyllum* in a 284 ha reservoir in East Java in Indonesia within 8 months of stocking. Experiments carried out in Bangladesh on the diet and feeding ecology of the introduced *B. gonionotus* revealed the representation of 39.2% and 15.7% macrophytes in the gut content of small and large fishes respectively. In Bangladesh, Java barb was effective in controlling aquatic vegetation under experimental conditions. In Indonesia and a few other Asian countries it serves the dual purpose of fish production and weed control. In recent years, the species is widely used in net cages as control for biofouling and many studies are being carried out on optimizing its potential use in cage aquaculture.

Figure 1: *Barbonymus gonionotus*

Hypselobarbus pulchellus supports good fishery in Anjanapur reservoir, Karnataka was found to feed on *Cyperus, Typha, Scirpus, Leersia, Pseudorphis, Hydrilla, Vallisneria, Lemna,* and also on the roots of water hyacinth. Fingerlings stocked in cisterns with *Lemna* and *Hydrilla* fed on them at a rate of more than 50% of their body weight per day. Reports suggested that *H. dobsoni* and *Systomus sarana* (Olive barb) can feed on *Chara, Vallisneria, Hydrilla*, diatoms and green algae.

7. *Tor* spp.

The genus *Tor* comprise of large cyprinid fishes endemic to Asia with a distribution spanning from Afghanistan, Pakistan, India, Sri Lanka, Nepal, Bhutan, Myanmar, Thailand, China, Laos, Cambodia, Vietnam, Indonesia and Malaysia. They are popular cultural icons of economic, recreational and conservation interest in many of these countries. In general, all *Tor* species throughout Asia are threatened by overfishing (often using destructive gears), loss of habitats including migratory routes, deterioration and alteration of habitats as a result of both agro-based and sewage pollution.

Tor barb (*Tor tor*) and Golden mahseer (*T. putitora*) can control the growth of submersed plants such as *Ceratophyllum demersum*, *Myriophyllum* sp., *Hydrilla verticillata* and *Vallisneria spiralis*. Similarly, *T. tor* was found to feed mainly on aquatic macrophytes and filamentous algae in Narmada River. A study on the food and feeding habits of *T. tor* in Meghalaya, found that larger fishes feed predominantly on algae and macro vegetation, where as juveniles consume more insects.

Conclusion

The wide of usage of harmful chemicals for algal and aquatic weed control pose serious threats to aquatic systems. In this scenario, more focused research is required to utilize fish as a bio-control agent for warranting the excessive microalgae and macrophytes infestation. This will help the fish farmers to reduce the cost and improve fish production.

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