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Carp Fish and Effects on the Aquatic Environment

Abbas Dakheel, Mutar, Nawar K. Al-Saeedi Zainab Dakhil Degaim

[1],Animal Production Department, College of Agriculture and Marshes, University of Thi-Qar, Thi-Qar, Iraq

[2]. Microbiology Department, College of medicine , University of Thi-Qar, Thi-Qar, Iraq

dr.abbasmater@utq.edu.iq

nawarkhalid@utq.edu.iq

zainab-d@utq.edu.iq

Abstract

These findings highlight the importance of developing a strategic environmental view of fish culture, to establish the carrying capacity of the aquatic environment and adopt suitable farming practices. In addition, site-specific management approaches could benefit nature conservation actions on a local scale. This research furthers overall understanding of the relationship between fish culture and the ecological health of inland water bodies, contributing to the systematization of ecological knowledge in the growing field of aquaculture environmental science.

The aim of this work is to contribute to a comprehensive understanding of the impact carp breeding has on the aquatic environment, emphasizing an ecological perspective. The aquaculture sector, and in particular carp farming, is putting increasing pressure on the ecological health of inland water bodies, as the input (nutrients) is higher than the natural capacity of eutrophic lakes and reservoirs to buffer and cleanse the excessive levels of nitrogen, phosphorus, and organic matter. The results show that extensive carp farming depletes dissolved oxygen during the night, which may threaten the survival of oxygen-sensitive native fish species. Furthermore, carp are an invasive species that alter nutrient cycling, affect aquatic vegetation structure, nutrient and sediment cycling, and plankton composition. Although these effects are undesirable in the context of nature conservation, they can also have a regulating effect, reducing the high phytoplankton levels in hypertrophic standing waters.

Keywords: *Carp fish, Aquatic environment, Carp breeding*

I. Introduction

This text aims to present a complete report on the impacts of carp farming on the environment, both positive and negative. However, the report will focus more on the negative impacts, as it is believed that the positive aspects of carp farming do not counterbalance the negative impacts. The farming of carp began almost 3000 years ago in ancient China, and has spread to become the most important and widespread form of aquaculture globally. Around 70% of the world's freshwater fish are cyprinids, which makes them the highest single species of farmed fish. Carp contribute to about 80% of this, with the other 20% being made up of other species of cyprinids. Over the duration of time, carp farming has gone through several phases, from traditional farming in which ponds were connected to river systems and carp were moved in and out of the rivers around flood times, to intensive farming. Traditional carp farming is actually a sustainable, passive form of aquaculture, and many of the negative impacts stem from the more intensive farming methods. (Araujo et al.2022)(Lin et al., 2022)(Kari et al.2022)

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Environmental Effects of Carp Breeding

A loss of vegetation and increased algal growth, coupled with decreased insect and fish larvae activity would render most waters unproductive for higher trophic levels of game fish. This type of environment is very favorable to carp, although it is typically not the intention of the pond manager. The end result of a carp-dominated environment is one in which the water body is shallow, murky, and lacks in aquatic diversity. (Hossain et al., 2023)(Gai et al.2023)

The decrease in vegetation will also lead to increased nutrient availability, mainly through the loss of vegetation as a nutrient sink. The now nutrient-rich, sediment-laden water is ripe ground for algal blooms which block sunlight penetration to the bottom and reduce dissolved oxygen levels. High turbidity also decreases activity of plankton which serve as a food source for small fish and larval insects. High carp populations can result in the decreased recruitment of these organisms, which will impact the entire food web above them. (Cupp et al.2021)(Horvath et al.2023)(Wildhaber et al.2023)

This method of feeding upon organic matter, detritus, and vegetation will lead to increased turbidity, and in some instances, total eradication of macrophytes. Carp are capable of uprooting vegetation by digging into pond substrates with their snouts in search of food. This form of feeding can have a detrimental effect upon water quality in several ways. The loss of vegetation will lead to increased turbidity initially from the sediment that is uprooted and from the lack of rooted plants stabilizing bottom substrate. This can result in the increased siltation of marginal areas and stream beds. (Peterson et al.2022)(Su et al.2023)

In the following points, I will briefly summarize the information provided in the article and describe how it is or is not significant in impacting water quality. The significance of carp in regards to water quality can be attributed to their feeding methods. Carp have a more efficient digestive system than most other fish, and as planned, their highly nutritional food pellets leave little waste. If a pond is overpopulated with carp and the resources are not sufficient, they will consume plant life, insects, and small fish to provide sustenance. (Zhao et al.2020)(Xu et al., 2022)(Chen et al., 2022)

Water Quality

Water quality can be altered in a myriad of ways, the most well-known being nutrient enrichment. Excrement from the fish directly inputs nutrients and tends to stimulate algal blooms and increased macrophyte productivity. Consequently, the primary productivity of the water is increased, making the water more turbid as a result of the increased suspended matter in the water column. Algae blooms can shade out native vegetation. Carp have also been found to degrade water quality by the destruction of macrophytes and rooted vegetation. This increases sedimentation rates, as there is less vegetation to bind the sediment. This has the same effect as nutrient enrichment, and often the water becomes hypertrophic. These changes in basic trophic structure to vegetation and algal-dominated states tend to favor carp in terms of food availability, and species diversity and abundance of other fish tend to decline. (Peterson et al.2022)(Li et al., 2023)(He et al.2024)

Species that live in an aquatic ecosystem have specific environmental requirements, including water quality conditions. Water quality can be measured by its chemical and physical attributes and can be altered in various ways. Changes in the water can make it inhospitable to some species, thereby favoring the proliferation of others. Carp, with their high adaptability to various environments and their disturbances to the biotic environment, tend to degrade aquatic habitats to favor their own proliferation. Water quality degradation due to carp breeding is a significant and profound environmental change that has received an increasing amount of attention over the past decade. (Yu et al.2023)(Jerônimo et al.2022)

. Aquatic Ecosystem Disruption

Native fish species are likely to be negatively affected by the establishment and spread of Asian carp. Changes in the abundance and composition of native fishes are frequently observed following invasion by non-indigenous species. Competitive interactions are likely between Asian carp and native species that utilize similar foods or habitats. Because Asian carp are fast growing and can achieve high abundances, competition for food and space could be intense. Direct predation on the eggs and larvae of

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native species is a possibility, because both species of Asian carp are known to feed on plankton and detritus. Disruption of food webs is likely in systems where Asian carp reach high densities. This could occur as a result of heavy grazing by carp, or through competition with native planktivores and detritivores. Alteration of river hydrology and morphology resulting from the presence of Asian carp are additional factors that could affect native fishes. Silver carp have been shown to be highly sensitive to changes in hydrologic variables and river channel modifications could create additional habitat for Asian carp and affect river fish communities in novel ways. (Li et al.2021)(Kajgrová et al.2022)(Lin et al., 2022)

Asian carp species have the potential to affect the structure and function of aquatic ecosystems within the United States. Of greatest concern is the potential for establishment of self-sustaining populations of Asian carp in the Mississippi River basin and elsewhere in the United States. A specific habitat and flow conditions needed by these eggs and larvae, and the current availability of these conditions in the Mississippi and many of its tributaries are not well understood, due to the ability of Asian carp to monopolize rivers habitats and their rapid rate of reproduction, it is likely that free-flowing reaches and suitable spawning habitat are available in many river systems. Given an entry point, this likely that Asian carp would colonize and establish populations in many areas of the U.S. (Li *et al.*,2021) (Nekrasova *et al.*,2024) (Battaglin *et al.*,2020)

Management Strategies for Minimizing Environmental Impact

Apursuit and implementation of surveillance and regulation measures is arelatively recent field for the management of aquatic plants and carp. It is a vital element of a comprehensive management plan and the sole means to determine any alterations taking place within the community, as well as the efficacy of the management efforts in achieving the intended outcomes. The complexity of ecosystems, combined with the impacts of various conditions and other organisms, makes it often difficult to detect changes that are caused by carp. There are also various direct and indirect impacts of carp on water quality and native fish that may take a long time to become noticeable, so many monitoring programs are looking at long-term changes in the environment. High-quality monitoring programs will enable adaptive management, which can be used to alter management actions in response to new information and knowledge gained from monitoring. This could be crucial in the future with biological control of carp. It is not known yet what would happen if the numbers of carp were reduced to a significant level, and it is possible that a sudden increase in recruitment of native fish could result in competition for the same resources. Monitoring the situation could allow the release of additional numbers of a certain organism in times of need or the time out of biological control on the carp population. (Cupp et al.2021)(May et al., 2022)

Management strategies and management systems are becoming increasingly important to fish biologists and fishery managers with the establishment of national and international goals for the maintenance and enhancement of biodiversity. Management systems are concerned with moving a fish community towards a desired state, although defining what the desired state is can be very difficult when it comes to alien species. "Management would be easier if we knew the directions and had sure knowledge of the results of our actions" (Rahel 2002). The goals of carp management are varied, site-specific, and depend on the wishes and resources of the community, stakeholders, and managers. When it comes to native fish and ecosystem health, the desired goal is to minimize the impact of carp on aquatic communities, rehabilitate damaged ecosystems, and restore native fish populations while preventing further carp impacts. (Jaya et al.2022)(Elliott et al.2022)(Galambos and Sekulić2024)

Monitoring and Control Measures

Over the past two decades, growing awareness of the environmental impacts of potentially degrading activities has led to widespread recognition of the need for effective protection and conservation of natural resources. Previously, environmental protection was not considered an integral part of natural resource harvesting, and it was not until the 1980s that a gradual shift in attitudes towards environmental conservation took place. Responses such as regulatory measures, development of habitat restoration programs, and increased research into fish biology and ecology represent an important turning point in

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attitudes toward the environment with regards to fisheries management. Initially, little thought was given by government agencies to the ecological consequences of fish stocking, and it was not until the expansion of stocked fisheries and declining water quality led to a decrease in native fish stocks that attention turned towards investigating the impacts of introduced fish species on the environment. Monitoring and control measures have been broadly implemented in an attempt to curb the spread of negatively impacting introduced fish species, and their efficacy can be seen via the cancellation of some fish stocking programs and attempted eradications of damaging fish. (Fonken et al.2022)(Su et al.2023)(Mir et al.2022)(Pandit et al.2023)

Habitat Restoration

Major impact of carp in aquatic ecosystems is the turbid water in which no aquatic plants can grow. Consequently, no life can exist that is not supported by phytoplankton. Guthrie and Paling (1987) calculated that the Mississippi River would require a phytoplankton-free period of 92 days to reach pre-European conditions. This would require aquatic plant growth throughout the summer, whereas now plants are often restricted to a spring growth period due to excess sediments which smother the plants . The reasons for this excessive effect of carp on vegetation are their method of feeding and high fecundity. Common carp are benthivores, feeding on the bottom sediments where a large portion of nutrients are usually not available to algae and other aquatic plants. Carp feeding acts to resuspend these nutrients in the water column, making them more accessible to planktivores and leading to turbid water and eutrophic conditions. High carp numbers also result in a lower survival of fish and the recruitment of other species. This occurs because the high numbers of small carp also feed on small fish and invertebrate species, thus out-competing the native fish and reducing their population sizes. Following the decrease in native fish populations, there is evidence in many areas to suggest that the carp population will experience a population explosion. This occurs because the biomass of fish on lower trophic levels is released and, in the absence of predation, becomes available to the carp (Huser et al.2022)(Han et al.2021)(Yongo et al.2023).

. Fishery Regulations

An example of the attempt to eradicate common carp (Cyprinus carpio), an exotic pest species in many areas, from the River Murray catchment in Australia, caused extensive mortality of native fishes and mussels and increased frequency and severity of toxic algal blooms that are still impacting some sections of the river more than 30 years later. Another negative consequence of invasive fish control can be the overabundance of small-bodied fishes and disruption of trophic structure in ways that promote the proliferation of other invasive species. (Koehn, 2021)(Sobieraj & Metelski, 2023)(Hnytka et al.2022)

Regulation of invasive fishes through harvest, chemical, or physical methods also has the potential for major negative ecosystem impacts. The most extreme case is the complete eradication of a species from an ecosystem. While eradication is often the stated goal, its feasibility is generally overestimated and attempted eradication may result in significant secondary ecological damage with little likelihood of long-term success. Chemically eradication methods frequently use piscicides, and while these are often highly species-specific for fishes, the kill usually extends to many other aquatic organisms. Temporary or permanent damage to water quality may occur through the release of nutrients from dead fish and decaying vegetation or large algal die-offs. (Frye, 2021)(Kasper et al.2022)(Intisar et al.2023)

Direct manipulation of fish populations in aquatic systems has been a common management tool for achieving a variety of objectives. Stocking of desirable or game fishes to rehabilitate communities or create fisheries where none existed is a widespread practice. Despite the good intentions of stocking, if the goal is to re-establish self-sustaining fish populations or to hasten the natural recovery of fish communities, it is a risky approach. Stocking can produce negative ecological effects lasting many decades, particularly with predatory fishes. (Su et al.2021)(Radinger et al.2023)(Niedrist et al., 2023)

It is evident that many aquatic ecosystems have been degraded by human activity, and efforts to restore and manage these habitats often involve elements of fisheries management for native and non-native species. Thus, a review of the damaging impacts that introduced fishes may have on aquatic ecosystems

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is directly relevant to the conservation and management of both inland and coastal marine waters. (Yuan et al., 2022)(Xu et al.2021)

II. Conclusion

The escape of a few species of domesticated variety carp from aquaculture facilities seems to have made, and in some cases is still making, a significant impact on the aquatic environment. This is particularly so for the common carp, which has been introduced and become established in at least 59 countries where it is known to have negatively affected native species and their habitats. The impacts of the species are both direct and indirect. Direct impacts occur via selective predation on benthic invertebrates, amphibians, and fish eggs, consumption of fish, and the degradation of aquatic vegetation. Indirect impacts are associated with the destruction and change of habitat. These impacts are largely due to the feeding practices of the species, commonly referred to as 'rooting' or 'sifting'. This is when they uproot and disturb the substrate to feed on benthic organisms and detritus, which cause a decline in water quality, increased sedimentation, and higher turbidity. This can cause the decline or extinction of native fish and invertebrate species, as their habitat becomes unsuitable. High turbidity can also cause a dramatic decrease in light penetration, which can kill submerged species of vegetation.Common carp have been described as the worst aquatic pest, with their impacts being a significant threat to aquatic biodiversity in many lakes and rivers. (Tadese & Wubie, 2021)(Mutethya and Yongo2021)(Kang et al.2023)(Sales et al.2023)

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