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Impacts of Non-native Fish (Tilapia Species) on Native Fish Production in Freshwater

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Abstract

This study aimed to review the results of introducing exotic tilapia and its impacts on native fish production and the freshwater biodiversity. This review focuses on the Tilapia fish. It is an exotic species that has gained attention in various regions for its adaptability and impact on local fish fauna. Tilapia (*Oreochromis mossambicus*, O. niloticus, O. aureus) is an exotic fish and well-established in India. The introduction of Tilapia fish has been associated with several ecological impacts. Tilapia fish compete with native fish species for food, habitat, and breeding sites, leading to population declines in native fish and their production. In some cases, Tilapia fish may prey on the eggs and larvae of native fish, further exacerbating their decline. The presence of Tilapia fish can disrupt existing food webs, leading to changes in native biodiversity, degrading habitats, species composition and native fish production. We explore the biological characteristics of Tilapia fish, their ecological roles, and the implications of their presence on native fish production. Through a comprehensive examination of existing literature, this review aims to provide insights into the management of Tilapia fish to mitigate negative impacts on native ecosystems.

Keywords: Native fish, composition, fish diversity, exotic, fish production.

Introduction

Tilapia is a popular fish known for its nutritional benefits. It is a good source of high protein content, low in calories, and rich in Omega-3 fatty acids, essential vitamins, minerals, contains essential vitamins, selenium, and phosphorus. Vitamin B12 supports physiological health and selenium acts as an antioxidant. Phosphorus contributes to strong bones. Tilapia is native to Africa. Invasive species can significantly disrupt local ecosystems when farming tilapia by altering food webs, outcompeting native species, and affecting water quality. Invasive species can become dominant predators or competitors, impacting on the native species. This alteration can lead to a decline in native fish production that compete with tilapia for food, space and habitat. A study by Simon and Ridd (2020) highlighted that the introduction of invasive fish led to a 30% decrease in the local biodiversity of fish fauna in freshwater systems. Tilapia is one of the most cultivated species in worldwide, because of its adaptability to different environmental conditions, such as habitat destruction and water pollution. The presence of invasive species in water bodies can threaten local ecosystems by altering food webs, outcompeting native species, disrupting nutrient cycles, and affecting water quality, ultimately leading to biodiversity loss and native fish production. Invasive fish can cause big problems for water ecosystems (Radkhah *et al.* 2021) [12]. One of the biggest fish families is the Cichlidae family, which includes 1,706 different species (Eschmeyer & Fong, 2018) [4]. These fish are found all over the world and naturally live in places like South America, Texas, India, Africa, Madagascar, Syria, Palestine, Sri Lanka, and Iran (Moreau 1983). Nile tilapia is a freshwater fish originally from Western Africa and the Nile region (Trewavas, 1983) [15]. It has now spread too many tropical areas around the world, mostly because it's used in fish farming. About 98% of Nile tilapia farming happens outside its native area (Canonico *et al.*, 2005) [2].

Tilapias (Oreochromis) have been introduced to more than 135 countries and are now the second most widely distributed fish species globally, after common carp. Mozambique tilapia (*Oreochromis mossambicus*), blue tilapia (*O. aureus*), Nile tilapia (*O. niloticus*), Zanzibar tilapia (*O. hornorum*), and the red belly tilapia (*O. zilli*) are some of the commercially important species of Tilapia. Over the past three decades, significant progress has been made in the global aquaculture of Tilapia, with farming now established in many countries. While invasive species such as Tilapia may initially coexist with native fauna, their competitive superiority often becomes apparent gradually. As their populations grow in abundance and density, they exert increasing ecological pressure on native species through intensified competition for limited resources. This sustained competitive interaction can ultimately lead to declines in native populations and elevate

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the risk of local extinctions (FAO, 2020) [6].

Their role in global aquaculture has grown significantly, with production rising from 2.6 million tonnes in 2004 to 3.6 million tonnes in 2008 (FAO, 2010) [5]. However, their rapid breeding has negatively affected native fish production in India and other countries. Despite these concerns, the Government of Haryana recently decided to introduce tilapia across many of its districts (The Tribune, New Delhi, Sept. 8, 2006), and the species has now also spread to the Ganga River system, where its presence is increasingly reported. In India, a substantial number of exotic fish species have been introduced over the past five decades for various purposes such as aquaculture development, recreational fishing, ornamental trade, and biological control of mosquito populations. Many of these species have successfully established self-sustaining populations in Indian aquatic ecosystems (Singh A. K. & Lakra W.S., 2011) [14].

Tilapia fish are characterised by their adaptability to various environmental conditions, making them successful in colonizing new habitats. Tilapia fish have high fecundity and can reproduce throughout the year, which allows for rapid population growth. Tilapia fish thrive in freshwater and brackish environments, often outcompeting native species for habitat space. The optimum growth temperature of tilapia is 25-30°C and in this temperature range, they grow, reproduce and spawn (Lowe-McConnell, 2000) [7]. Tilapia can tolerate high temperature range and adverse water conditions such as a lack of oxygen, high salinity, and water pollution (Nivelle *et al*. 2019) [10]. Tilapia fish have high fecundity and can reproduce throughout the year, which allows for rapid population growth. Tilapia fish thrive in freshwater and brackish environments, often outcompeting native species for habitat space. They mature fast and reproduce at four months of age and have a high rate of reproduction. As a result, they can produce thousands of young fish in a short time, i.e. in four months. Tilapia can keep eggs in their mouths in times of danger condition. Therefore, the eggs are protected from predators. This type of behaviour increases the survival rate of tilapia (Rana, 1988) [13]. Tilapia usually feed on microalgae, insects and aquatic plants, but are highly adaptable to a variety of food items (Esmaeili *et al*. 2015) [3]. They are opportunistic feeders, often competing for food resources with native fish. Tilapia (Oreochromis spp.) exhibit higher feeding rates compared to Indian major carp (Cyprinidae), primarily due to their greater population density and heightened feeding activity. Under optimal culture conditions, tilapia can attain marketable size within approximately six months. Additionally, the presence of robust spines on their dorsal fins serves as a morphological defence mechanism, deterring predation by other fish species. Tilapia is seen as a major ecological threat in many countries. They spread easily through floods, canals, and water supplies, reaching natural ecosystems and even drinking water sources. Their fast reproduction, heavy feeding, and aggressive behaviour harm native fish and aquatic plants. This leads to competition for food and nesting sites, reducing native fish production. Tilapia possesses the potential to hybridize with closely related endemic species, posing a threat to native genetic integrity. This interbreeding can lead to genetic introgression and loss of biodiversity in indigenous fish populations. Given this ecological risk, it is essential to implement integrated management strategies. Such approaches should focus on containment, monitoring, and control of invasive populations. Preventing further spread is critical to safeguarding native aquatic ecosystems.

Conclusion

This review presents a systematic examination of the subject, emphasizing the significance of understanding the biology and ecological implications of exotic Tilapia species on indigenous fish populations. Continued research and the implementation of comprehensive management strategies are critical for effectively mitigating the associated ecological and economic impacts. Tilapia, particularly Nile tilapia (*Oreochromis niloticus*), has considerable impacts on native fish populations across multiple regions. The expansion of Tilapia aquaculture and subsequent escape of individuals into natural aquatic ecosystems can result in interspecific competition for resources such as food and habitat, thereby contributing to the decline in abundance and catch of native fishes. Dietary and habitat overlap between Tilapia and indigenous fish species results in interspecific competition, leading to resource depletion and potential declines in native fish populations. Reduction of native species has been reported in many places globally, such as India, Australia, Southeast Asia, and Papua New Guinea. The natural ecosystems of many regions have been severely damaged in recent years due to the introduction of exotic and invasive species. Non-native species are introduced to nature, and after becoming problematic. Many countries have experienced the severe experience of tilapia introduction and their experiences should be used in Iran as well. Rearing tilapia in Iran has no environmental justification and threatens aquatic ecosystems and biodiversity. In addition, the expansion of tilapia farming increases the possibility of their escape to natural waters that have great diversity with more than 100 endemic species, which certainly have negative effects on them, in some cases, tilapia hybridisation, e.g. Hormuz and Persis cichlids due to hybridisation.

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