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Cooperate Influence of Water Hyacinth and Nile Tilapia on Freshwater Ecosystems: A Case from Pearl River

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Abstract. Invasive alien species already become significant threats to global ecosystems, freshwater ecosystem is on of the important ecosystem for human well-being and aquatic species, but they face severe threats from invasive alien species. This paper analyze the ecological impacts and biological trait of invasive alien species through case studies of nile tilapia(Oreochromis niloticus) and water hyacinth (Eichhornia crassipes). These invasive alien species thrive in non-native environments due to their strong adaptability, and devastates fresh water ecosystem through harming native species and influencing their environment. Moreover, this paper will also analyzed management that humans can take action to resist invasive alien species. And discussing accessibility for these management strategies.

Keywords: Freshwater Ecosystem, Invasive Alien Species, Oreochromis Niloticus, Eichhornia Crassipes

1. Introduction

Freshwater ecosystems are the basic foundation of the human community. With the development of technology, the problem of conserving freshwater ecosystems has become more and more serious, either for human well-being or natural habitat. Freshwater ecosystems are devastated mainly by human interaction including pollution and deforesting, caused by industry. And invasive alien species that came from other regions. This paper will focus on the impact of water invasive hyacinth and nile tilapia in freshwater ecosystems and provide theoretic solutions to overcome this problem.

Invasive alien species refers to species that not only survive but thrive in regions where they are not native to and have a harmful effect on the economy, environment, or heal). There are multiple ways non-native species invade new regions, primarily natural invasion and human-mediated introduction [1]. Natural invasion is mostly caused by factors such as habitat destruction, climate change, and population expansion. Human-mediated introduction, on the other hand, occurs when species are transported by humans, either accidentally or intentionally. As humans started trading globally, they unintentionally transported creatures to new regions, such as rats. On the other hand, some species are introduced by humans deliberately without considering the consequences. For instance, in China, foreign species such as snapping turtles were released into rivers and lakes by Buddhists without considering the ecological consequence, as they believe releasing animals could demonstrates benevolence [2]. Moreover, as invaders become established in a region, secondary

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invasions can also occur, where the success of one exotic species (the secondary invader) is completely contingent on the presence, influence, and impact of one or more other exotic species (primary invaders) [3].

Many countries around the globe are concerned about invasive alien species, take China as an example which is one of the world's most biodiverse nations, and a growing number of non-native species have been introduced into its ecosystems. Invasive alien species are now widespread across the country, with many already established. Examples include snapping turtles, red fire ants, wild cats, wild dogs, and golden apple snails. These invasive species have caused substantial economic losses, with the Chinese government spending 174.7 billion dollars to address these issues [4]. Additionally, these alien species have caused significant ecological damage.

This paper will use literature review to analyze water hyacinth and nile tilapia and their impact on ecosystems. Furthermore, based on these cases this paper will summarize impact of invasive species on ecosystems. In addition, this paper will also provide counter measures for these invasive alien species.

2. Literature review

Previous research shown that the invasion of Nile tilapia had caused a substantial impact on native ecosystem, typically in three dimensions. Canonico propose that Nile tilapia had made a decline of native species by compressing their habitat and scrambling food sources, for instance, in Lake Nicaragua, tilapia reduced native cichlid populations by 50% within a decade by monopolizing breeding sites and food. Moreover, the author suggested that nile tilapia may also cause eutrophication, process through which enrichment with nutrients such as nitrogen and phosphorus, leading to hypoxia and algae boom, which is a net effect of uneaten food in intensive tilapia farming [5]. Russel found that because Nile tilapia are bottom-feeding fish their behavior had increased turbidity, damaging submerged vegetation critical for other species, for instance Australian rivers, tilapia invasions correlated with a 30% drop in macroinvertebrate diversity. Moreover, they also act as host for parasites, harming native fish [6]. Shuai mentions that Nile tilapia invasion reduced the trophic status of native fish species, forcing herbivores and planktivores to seek new food sources. It also shortened food chains by decreasing the trophic levels of native invertivores, omnivores, and piscivores [7].

A series of studies had indicated that, spread of invasive water hyacinth has severely disrupted local marine ecosystems, which also caused enormous ecological damage. Water hyacinth invasion has had a huge impact on local biodiversity when a large amount of water hyacinth covers the water's surface, it blocks the sunlight, which causes submerged plants and algae to stop processing photosynthesis, which results in a reduction in oxygen level in water and causing hypoxia to occur, that leads to death of fish and submerged plant [8]. Additionally, decomposition of controlled or decaying water hyacinth releases nutrients and contaminants, facilitating eutrophication and further degrading in habitats [9]. Water hyacinth will also cause the phytoplankton productivity to decrease, following by disruptions in food chain, potentially harming fish who feed on phytoplankton [10]. Furthermore, Basaula suggested that invasive water hyacinth is one of the main factor that cause secondary invasion, as it alter the original environment which provide hospitalable environment for micro-invertebrate to thrive and made it suitable for exotic species like nile tilapia to thrive [11].

Water hyacinth and Nile tilapia , have cooperatively devastate fresh water ecosystem. Musa mentions that cage culture of nile tilapia aquaculture would increased phosphorus and nitrogen concentrations near the cage, because after fish were feed their will be uneaten food left in the water and release into rivers or lakes around it [12], leading to eutrophication. Meanwhile, Chen states that

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water hyacinth invasion is caused by especially water pollution such as eutrophication, because by the “enrichment” of nitrogen and phosphorus eutrophic waters will promotes photosynthesis and reproduction of water hyacinths by affecting the photosynthetic rate of plants, leading to a boost of water hyacinth population [13].Moreover, Gezie suggested that since water hyacinth is a kind of floating weed, large amount of it floating on water surface will block sunlight, and reduces the dissolved oxygen content of the water body by decreasing the rate of photosynthesis of aquatic plants. It my also cause lower ph in regions covered with water hyacinth due to decomposition [14]. Furthermore, Reboucas states that juveniles of nile tilapia have a high tolerant to acidic environment(up to 4 ph) [15].Thus, the condition that water hyacinths create will give them a competitive advantages when they are facing native species. In addition, Njiru mentions that water hyacinth, will provide habitats for invertebrate and vertebrates to thrive, such as insects, which creates continuously food source for nile tilapia [16].

The invasion of nile tilapia not only effected the ecosystem but also humans. Gu suggested that after Nile tilapia become abundant in Guang dong province the catch-per-unit-effort (CPUE) of native fish species and total fish biomass significantly decreased, leading to reduced fishermen's income due to its lower market price compared to native species, and exacerbating fishing pressure on declining native stocks. As a result, it caused economic loss for fisherman, as it displaced native fish that have higher value [17]. Water hyacinth had also effected livelihood.

Damtie suggested that in Ethiopia water hyacinth covered 33.4% of agricultural land, reducing yields and increasing labor for weed removal, since crops are especially cultivated around the lake like rice has been reduced. Additionally, fish catches declined by 45.7% (wet season) and 49.9% (dry season) due to water hyacinth blocking parts of river way, entanglement of nets, and reduced fish populations. Thus, many fishers abandoned the trade, leading to more expenditures on fish nets [18].

3. Discussion on the counter measures

Physical removal: physical removal can be split into 2 categories manual removal and mechanical removal. Manual removal of water hyacinths were often used in places where mechanical removal are not popular, such as regions around Lake Naivasha, during manual removal people use chopper to cut down water hyacinths, and chop them into pieces [10]. On the other hand, shredding boat and removal harvest system are used during mechanical removal, both of these machines are using featured surface-level knife cutters to slice through floating vegetation such as water hyacinth, which is powered by engines [19]. (2)Biological control: During biological control of water hyacinth the primary way to reduce the population of water hyacinths, is using micro-vertebrate and invertebrate to restrict its population. The water hyacinth weevil(Neochetina eichhorniae) a weevil that is the natural enemy of water hyacinth in Argentina. Adult water hyacinth weevil will feed on water hyacinth leaf and petiole, creating holes on the leaf and make it brittle, female weevils lay eggs in the petioles or leaf blades of the water hyacinth. After hatching, the larvae tunnel into the plant tissue, feeding on the inner parenchyma (soft tissue) of the petioles and rhizomes [20]. This internal damage disrupts nutrient and water transport within the plant causing a increase in it’s mortality rate.(3)Chemical control: Chemical control of water hyacinth involve using herbicides to kill the plant, which is usually used in places that boats or machines can not reach. By using Terbutryn, a relative slow acting herbicide, which disrupts the light-dependent reactions of photosynthesis, causing oxidative stress, leading to chlorosis and necrosis, as a result, water hyacinths will die in 4 to 5 weeks [21]. Unlike glyphosate, which rapidly kills water hyacinth but risks causing hypoxia, terbutryn is a far more suitable herbicide for this purpose. Moreover, the toxic

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residue that accumulated in other native fish will be temporary, so there won't be undue concerns [21].

Physical removal: Physical removal of nile tilapia include fishing, net fishing and electro-stunning.Between these three choices the most efficient way to remove nile tilapia is electro-stunning, electro-stunning can directly make the fish unconscious, thus, fisher can catch and kill the fish directly [22]. Whereas, net fishing and fishing will take longer duration time to catch them and there is a higher risk of the fish escaping from the net or breaking free from the hook. Chemical control: the most often used chemical pesticide for eradicating invasive nile tilapia is rotenone. Rotenone, a chemical pesticide targeting gill breathing organisms such as fish, amphibian, and aquatic invertebrates. When fish absorb it through their gills it will lead to oxygen deprivation and death. During an experiment conducted for effect of rotenone on nile tilapia, it exhibited neurological signs and respiratory distress before death [23]. (3) Biological control: Introducing their natural predator predation can effectively control their population. Natural predator predation, nile catfish (Clarias gariepinus) and nile perch (Lates niloticus) are two most effective predator that can eradicate nile tilapia, as the size of these two fish increase there predation rate will also increase. However, nile catfish are hard to manage and remove because it will burrow in the mud [24].

4. Conclusion

This paper examine impact of invasive species water hyacinth (Eichhornia crassipes) and nile tilapia (Oreochromis niloticus) on fresh water ecosystems, including decline in native species, habitat alternation such as eutrophication, reduce in biodiversity, and reduction in trophic level. The research objectives were to analyze their biological traits, and cooperative damage to freshwater ecosystems, and providing countermeasures to remove these invasive alien specie. Moreover, both species had lowered down fish catch and income for fisherman by increasing bycatch and causing obstacle during fish harvesting. Key findings revealed that both species thrive due to there rapid reproduction, environmental adaptability, and lacking of natural predator. The paper also discussed three primary modern control methods which are physical, biological, chemical and their accessibility for each species. Physical removal is immediate but requires a lot of labour force or machines which makes it expensive, biological control offers sustainable suppression but is slow-acting and might cause unpredictable consequence like invasion of other species, and chemical methods are efficient but environmentally risky, it might contaminate water source and harm native species. The whole paper is based on pure review of secondary data from existing articles.

Future research for this study will conduct field research for both species instead of only pure paper review. Furthermore, collecting data from experiment will also be included for future research such as testing adaptability of nile tilapia in different aquatic environment. Integrated management approaches could also be tested in future, for example, combining biological controls with physical or chemical interventions to enhance there effectiveness.

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