MASTER'S THESIS

Biological control of golden apple snails (Pomacea canaliculata) in freshwater wetland using black carp (Mylopharyngodon piceus)

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Abstract

The apple snail *Pomacea canaliculata* Lamarck is a native of South America but has invaded Hong Kong since early 1980s. Its feeding has resulted in a tremendous loss in semi-aquatic agriculture, especially rice (*Oryza sativa* L.) and other aquatic crops such as taro (*Colocasia esculenta* L.) and water spinach (*Ipomoea aquatica* Forssk). While spreading to freshwater wetlands, its feeding threatens macrophyte diversity. Owing to its voracious appetite, this invasive snail has also become a competitor of lowland indigenous mollusks. On ecosystem level, over-grazing by high density of apple snails could also induce excessive release of nutrients from macrophytes to water bodies, thus promoting phytoplankton growth and primary production.

Measures to control invasive apple snails fall into three categories: mechanical / cultural, chemical, and biological. Among them, biological control methods are appealing because they are usually considered relatively less labor-intensive and more cost-effective. However, both the control efficacy and potential non-target effects should be carefully evaluated before adopting a species in biological control. Although various fish species have been proposed as biological control agents for apple snails, their effectiveness and non-target effects on wetland flora and fauna are largely unknown.

This study investigated the feasibility of black carp (*Mylopharyngodon piceus* Richardson) as bio-control agent for apple snails in both laboratory and field experiments.

The laboratory experiment compared the feeding of black carp, common carp (*Cyprinus carpio* L.) and white-spotted catfish (*Clarias fuscus* Lacepède) on apple snails. These three species are indigenous and widely aquacultured in southern China. The three species of fish of comparable body length were each offered apple snails of various sizes *ad libitum* in aquaria. Black carp (fork length: 165 mm; maximum gap width: 16 mm) was the most effective predator, with a predatory rate of 70.5 apple snails in 48 hours. Common carp and white-spotted catfish of similar fork lengths consumed only 58.6 and 15.7 apple snails on average within the same experimental period. Apple snails preyed upon by black carp and common carp were juveniles, with their respective shell length ranged from 3 - 16mm and 3 - 17mm, while that for white-spotted catfish ranged from 3 - 21mm.

An 8-week mesocosm experiment was conducted in a constructed wetland during the dry season of 2011 to determine whether black carp (fork length: 170 - 185 mm) is as effective as common carp (fork length: 170 - 195 mm) as a bio-control agent for apple snails, but causes less herbivory to macrophytes and predation to non-*Pomacea* snails. Both species of carp preyed effectively on *P. canaliculata*, removing almost all apple snail individuals (~ 200 per enclosure) that were small enough to fit into their mouths. The effects of the two fish species on macrophytes were different. Black carp reduced herbivory on macrophytes through reducing apple snail density. However, common carp reduced apple snail density but did not result in a lower level of herbivory because it also grazed on macrophytes. Non-target mollusk density was reduced by both fish species.

A one-year whole-pond experiment was also conducted in June 2012 to June 2013 to investigate the applicability of black carp as a biological control agent of apple snails in constructed freshwater wetlands. Three separate constructed freshwater wetlands were used as replicates of the experiment. Each wetland was divided into a control side without black carp and a treatment side with black carp. Four individuals of black carp (fork length 260 - 310 mm) were released to the side of wetland assigned as treatment. Prior to starting the experiment and every three months, density of apple snails and other macro-invertebrates, apple snail egg clutch size and abundance, water quality parameters (total nitrogen, ammonia nitrogen, total phosphorus and reactive phosphorus) were recorded. Black carp was highly tolerant to the low dissolved oxygen in the shallow stagnant waters. It was an effective predator of juvenile apple snails (<5 – 25mm), but it did not result in significant reduction of adult apple snails (shell length >25mm) nor affected their reproduction. In addition, black carp preyed on non-apple snail macro-invertebrates, especially mollusks.

In conclusion, our study has shown that juvenile black carp (minimum total length: 300mm) is a suitable bio-control agent of apple snails in shallow water wetlands as it is tolerant of stagnant poor water quality and is an effective predator of apple snails. A major decline of 89.2% in average overall density of apple snail has been recorded in the treatment plots of the three experimental sites after one year. Juvenile snails would be eradicated before they get to mature minimum size (male SL: 25.2 ± 3.3mm; female: 29.8 ± 3.6mm) for reproduction. Given the longevity of black carp, a low stocking density (80-89 individuals ha^{-1}) is sufficient to control apple snail populations. However, black carp reduces the

abundance and diversity of non-target macro-invertebrates. Therefore the benefits of the biological control must be weighed against the potential undesirable effects on wetland diversity before adopting in the pest management. To maximize the control efficacy, mechanical methods to eradicate adult snails, for instance hand-picking in the shallow water, should be implemented with biological control effort in an integrated apple snail management program.

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