

MASTER'S THESIS

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

Ip, Ka Lok Kelvin

Date of Award:
2013

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

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 gape 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 ± 3.3 mm; female: 29.8 ± 3.6 mm) 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.

Acknowledgements

I would like to take this opportunity to thank my principal supervisor Dr. Jianwen Qiu for his insightful guidance, generous sharing of knowledge, continuous support and patience throughout my course of study. I would like to thank whole-heartedly for his encouragement and support for me in pursuing this degree with such an inspiring topic that could provide practical management recommendations for wetlands in future. Special thanks to my co-supervisor Dr. Yan Liang who has provided vital comments for my study and manuscripts as well.

I must thank the Mass Transit Railway Corporation Ltd. for providing financial support for this research. I would like to deliver my thanks to Dr. Kam Foon Chan, Mr. Peter Choi, Ms. Catherine Leung, Ms. Ida Yu and Mr. John Allcock who has provided technical comments and all necessary on-site support for field experiments in Kam Tin compensation wetlands.

I would also like to thank Ms. Yingxuan Li for her kind assistance in handling the technical and financial problems for us throughout the study. I am thankful to my dear labmates, Dr. Jin Sun, Ms. Yanan Sun, Mr. Paul Fong, Mr. James Xie, Ms. Huawei Wu who have provided support in field work, encouragements, comfort and laughter whenever we chat. I am also grateful to receive useful comments from two previous students of my principal supervisor: Mr. King Lun Allan Kwok, Mr. Pak Ki Wong who conducted their in-depth studies and contributed to understanding in ecology of apple snails in Hong Kong. Special thanks to Mr. Mak who provided us with precious black carp specimens; Mr. Aaron Au and Dr. Dickey Lau for assistance in contacting local fish farmers;

Mr. Tim Chung, Ms. Phoebe Lam, Mr. Lam Ngo Lun Alan and Ms. Priscilla Li for their assistance to my tedious field work in summer.

I would like to extend my thanks to my parents. I am forever indebted to their love, care, encouragement and understanding in my current research and previous 25 years. Their support for my freedom in exploring personal academic interest and career pathway has always been the most precious gift of my lifetime. I would also like to thank Ms. Flora Leung for her love and encouragement for me in the last four years, whilst I hope that would last till ever.

Last but not least, thanks to all indigenous fauna and flora of Hong Kong. You have strived through the time where even few trees could ever survive after wartime. With your contribution, we are proud of being one of the wealthiest cities in the world with such huge biodiversity. Though we have deprived your rights to thrive within several decades by over-exploitation, habitat degradation, and introduction of invasive species, I hope our efforts and enthusiasm would finally bridge the knowledge gaps in biodiversity conservation and ecological consequences brought forth by rapid development.

Table of Contents

Declaration.....	i
Abstract.....	ii
Acknowledgements	vi
Table of Contents	viii
List of Tables	x
List of Figures	xi
Chapter 1 Introduction.....	1
1.1 Natural distribution range and pathway of introduction of apple snails ..	1
1.2 Distribution and identity of apple snails in Hong Kong	2
1.3 Impact of apple snails as invasive species to Chinese wetlands	4
1.4 Current control methods of apple snails in Hong Kong	8
1.5 Biological control and indigenous predators of apple snails in Hong Kong.....	10
1.6 Research objectives and general organization of thesis	13
Chapter 2 Predatory potential of indigenous fish as bio-control agent of apple snails.....	19
2.1 Background.....	19
2.2 Material and method.....	22
2.3 Results	24
2.4 Discussion.....	25
Chapter 3 Biological control of invasive apple snails in a freshwater wetland by two carp species: subtle differences matter	32
3.1 Background.....	32
3.2 Materials and methods.....	35
3.3 Results	39
3.4 Discussion.....	42
Chapter 4 Wetland scale application of biological control of apple snails using black carp: efficacies and subtle effect to ecosystem.....	51
4.1 Background.....	51
4.2 Study site	54
4.3 Method.....	55

4.4 Results	61
4.5 Discussion.....	67
5.1 Summary of information on local invasion history and possible indigenous predators of apple snails	94
5.2 Predatory potential of different local fish species on apple snails	96
5.3 Mesocosm studies on functional practicability of fish: testing efficacies and subtle effects in a nutshell.....	97
5.4 Wetland scale application of biological control of apple snails using black carp: efficacies and subtle effect to ecosystem.....	98
5.5 Implications on integrated pest management	99
Appendices	100
References	104
Curriculum Vitae.....	128