MASTER'S THESIS

# Impacts of Pomacea canaliculata on freshwater macrophytes and water quality, as well as its control with fish

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# Impacts of *Pomacea canaliculata* on Freshwater Macrophytes and Water Quality, as well as its Control with Fish

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## Abstract

The golden apple snail (*Pomacea canaliculata* Lamarck, 1819) is native to freshwater wetlands of South America, but has invaded many Asian countries and grazed heavily in agricultural and natural habitats. This species has become the focus of research in recent years, with the main targets of assessing its impact and reducing its grazing damage. However, several aspects of its trophic relationship remain understudied. Previous studies of the grazing of *P. canaliculata* have focused on its direct effects on macrophytes, but have neglected the indiect effects on water quality. Feeding preference of this invader on local wild macrophytes and plant traits that determine such preference are unknown. Besides, although common carp (*Cyprinus carpio*) has been proposed as a biological control agent against *Pomacea canaliculata*, its impact on non-target aquatic plants and animals has not been assessed.

This study aimed to provide information on the direct and indirect effects of the grazing by *P. canaliculata* on local wetlands, understand the plant traits that determine its feeding preference, and assess the effectiveness as well as the potential side effects of its biological control using common carp. To quantify the direct and indirect snail grazing effects, my colleagues and I confined a known amount of *Myriophyllum aquaticum* or *Eichhornia crassipes* with 0, 2, 4 or 8 apple snails in 1 x 1 x 1 m enclosures for approximately 1 month in a freshwater pond. Apple snails grazed heavily on both species of macrophytes, with higher overall weight losses at higher snail densities. The damage patterns differed between the two macrophytes. In *M. aquaticum*, both leaves and stems suffered from substantial herbivory, whereas in *E. crassipes*, only the roots suffered significant weight reduction. In addition to grazing on macrophytes, apple snails appeared to have controlled the growth of filamentous algae, as these did not develop in the snail treatments. The ability of *P. canaliculata* to control filamentous algae was supported by a laboratory experiment where the consumption was as high as 0.25 g $g^{-1}$ snail DW $d^{-1}$. Nitrogen and phosphorous concentrations remained low throughout both experiments, and were not correlated with apple snail

density. The treatment effects on chlorophyll *a* (Chl *a*) and phytoplankton composition varied in the two experiments. In the *M. aquaticum* experiment, with increasing snail density, Chl *a* increased and the phytoplankton community became dominated by Cryptophyceae. In the *E. crassipes* experiment, Chl *a* level was independent of snail density, but with increasing snail density, the phytoplankton community became co-dominated by Cryptophyceae, Chlorophyceae and Bacillariophyceae.

To study the palatability of local macrophytes to *P. canaliculata*, I offered 21 species of freshwater macrophytes to the snail in no-choice feeding assays. I also examined the plant traits that determine the food preference in apple snails. Snail daily feeding rate varied greatly with plant species, ranging from 1.1% to 22% of its body mass. Total nitrogen content was positively correlated, and C:N ratio and dry matter content (DMC) were negatively correlated with snail feeding rate. There was no significant correlation between snail feeding rates and plant phenolic content, but the feeding rate on *Myriophyllum aquaticum* (a plant with the highest phenolic content) was very low. Two macrophytes which bear the highest DMC, viz. *Phragmites australis* and *Vallisneria natans* were eaten much more as reconstituted plant than as fresh leaves, indicating structure (i.e. DMC) to be important in their defence against snail herbivory. The extracts from *M. aquaticum* and *Alternanthera philoxeroides* greatly reduced snail feeding rate, indicating chemical defense to be present in these two species. These results indicate that the apple snail's feeding decision is affected by multiple plants traits. The snail favours plants with high nitrogen and phosphorous contents. High DMC and secondary metabolite (i.e. phenolics and other plant defence chemicals) deter the feeding of the snail.

To examine the effects of common carp on *P. canaliculata* and local freshwater snails and macrophytes, I conducted a 2-month enclosure experiment with three species of aquatic macrophytes and nine species of snails, including the apple snail, in a shallow pond within a plot of freshwater wetland. The results showed that the apple snail or carp alone significantly reduced the

plant biomass, although the apple snail had a stronger herbivorous effect than the carp. The carp completely removed juvenile apple snails, had a weaker predatory effect on adult apple snails, but no effect on the adults' oviposition frequency. Furthermore, the carp significantly reduced the populations of most species of other gastropods that occurred naturally in the pond.

In summary, this study has identified some key plant traits that are useful to predict the direct impact on macrophytes. Given the multiple effects of *P. canaliculata* on wetland biodiversity and function, and the potential significant side effects of using common carp as a biological control agent for this invasive snail, management strategies should be developed to prevent its further spread. In invaded wetlands, strategies should be developed to eradicate the apple snail and re-introduce native snails that can control the development of filamentous algae.

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