The Impacts of a Dissolved Carbon Dioxide Barrier on Behavior of Aquatic Invasive Snails *Cipangopaludina chinensis* and *Physella acuta*

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Introduction

Invasive species are deleterious to ecosystems and may cause social and economic damage. The reduction of ecosystem services, loss of biodiversity, and disruption of trophic levels are just a few examples of what invasive species can do. Current efforts to deter aquatic invasive species include carbon dioxide (CO_2) barriers. CO_2 can be used as a barrier that acts to prevent the movement and abundance of invasive species within ponds and rivers. Studies show that fish can detect and will avoid water with 100-150mg/L of dissolved CO_2; however, it is unknown how they affect other invasive species including mollusks. Two invasive mollusk species, the Chinese Mystery snail *(Cipangopaludina chinensis)* and the Bladder snail (*Physella acuta),* are another threat to the Great Lakes and nearby bodies of water. Along with ecological damage and their introduction of parasites, they cause recreational and economic damage by reducing populations of sportfish.

Figure 1. The Chinese Mystery Snail, *Cipangopaludina chinensis*

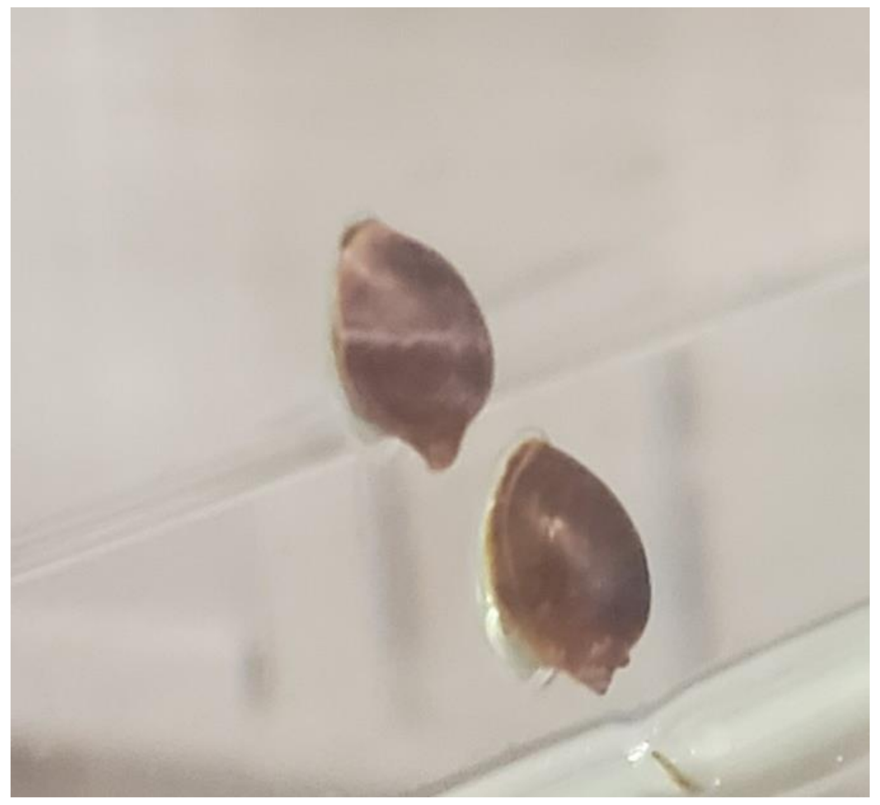

Figure 2. The Bladder Snail, *Physella acuta*

Methods and Results

EXPOSURE

- Snails were exposed to ambient (control), 70mg/L, 120mg/L, 300mg/L, and 500mg/L of dissolved CO2
- Timed treatment of either 30 or 60 minutes
- 10 snails per treatment
- Monitoring and recording of behavior changes were made every minute
- Snails were given 24 hours to recover after trial
- Recorded number of mortality after 24 hours

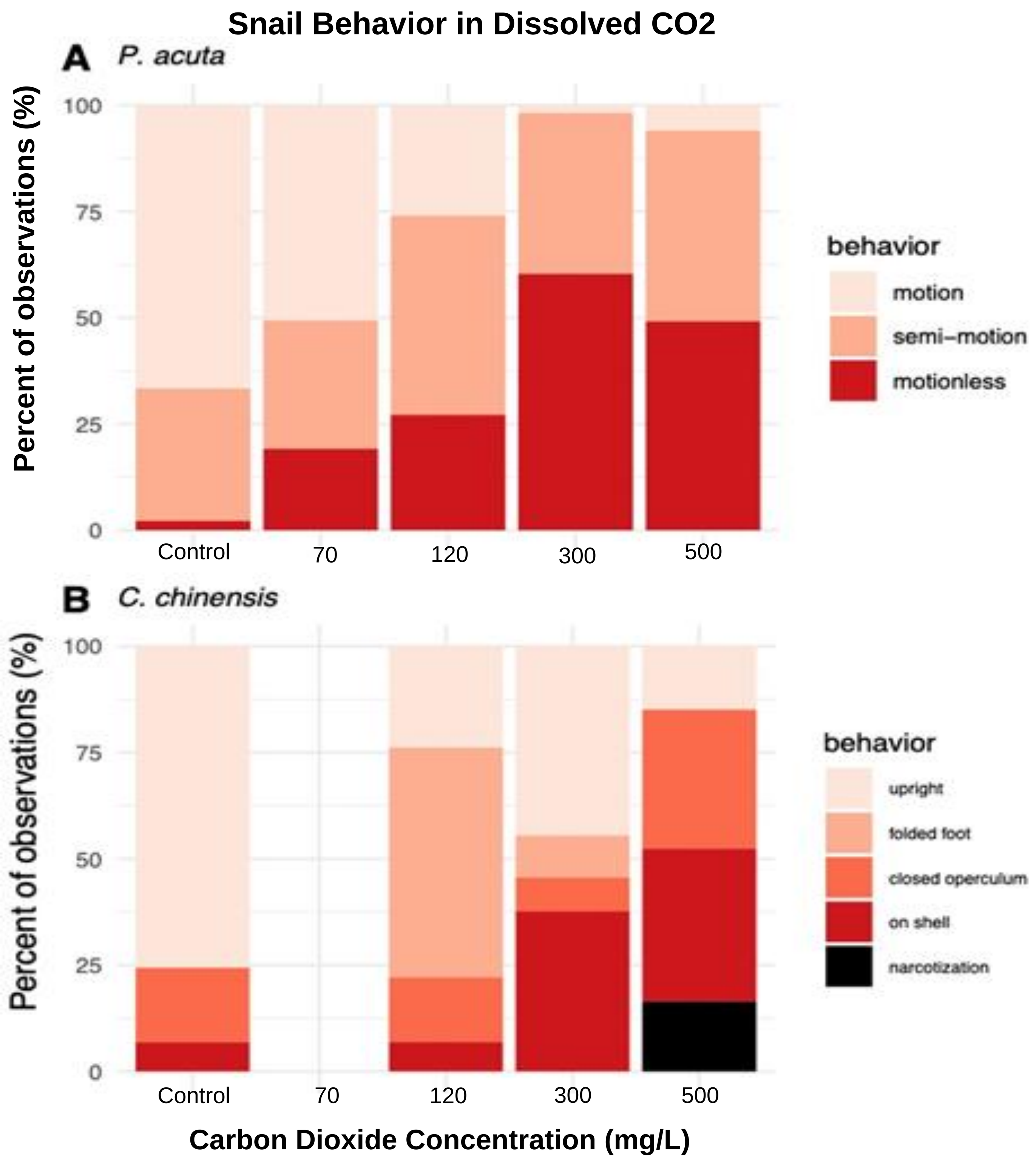

Figure 3A. *P. acuta* behavior recorded every minute in control, 70mg/L, 120mg/L, 300mg/L, and 500mg/L CO2 exposure for 60 minutes.
Figure 3B. *C. chinensis* behavior recorded every minute in control, 120mg/L, 300mg/L, and 500mg/L CO2 exposure for 60 minutes.

AVOIDANCE

- Snails were placed in tanks filled with either ambient (control), 70 mg/L, 120mg/L, 300mg/L, or 500mg/L of dissolved CO2
- 20 *P. acuta* per treatment
- 25 *C. chinensis* per treatment
- Monitoring and recording of observations were made throughout 24 hours
- Observed whether *P. acuta* actively avoided the water by crawling above waterline
- Observed whether *C. chinensis* avoided the water by closing operculum

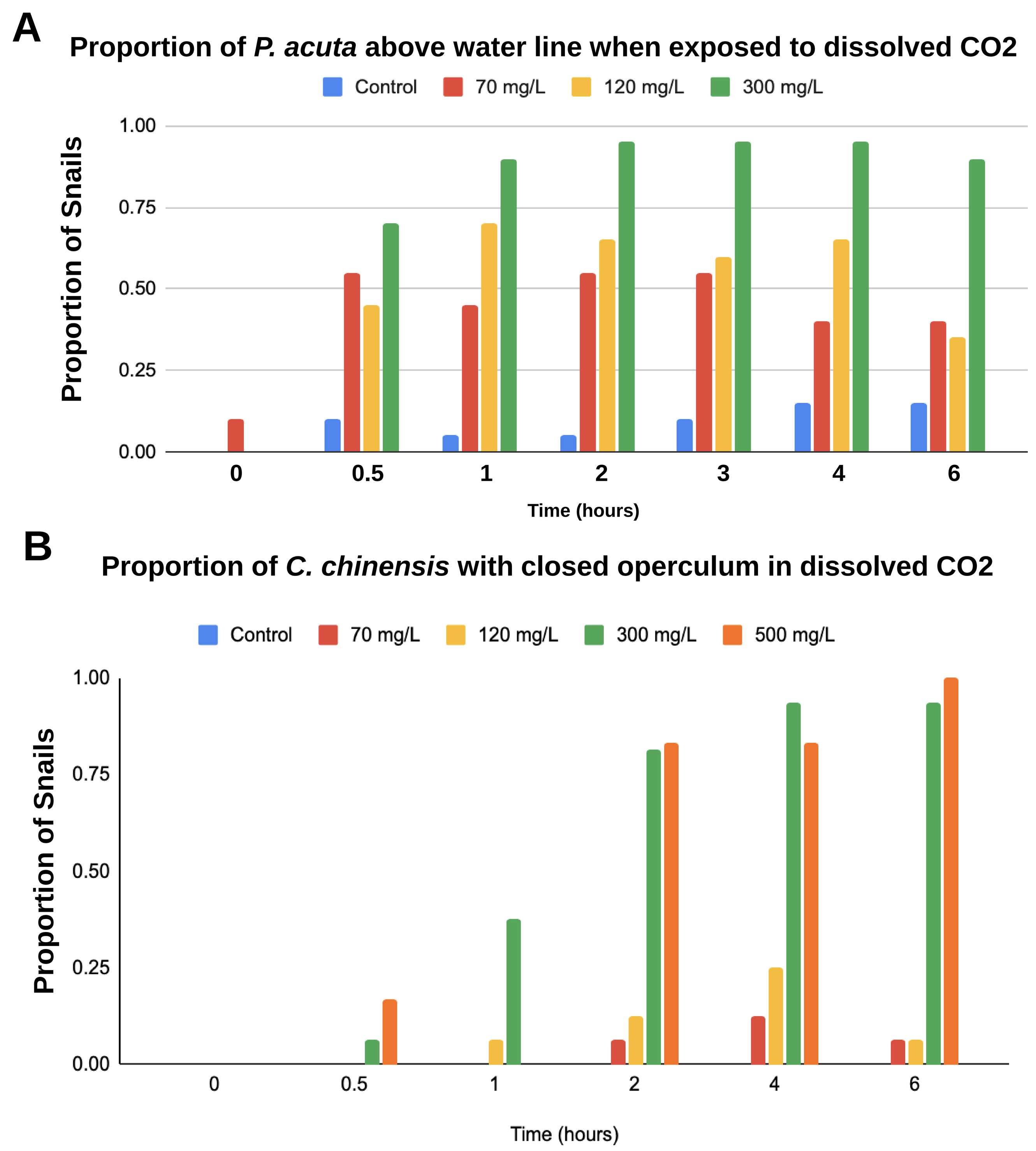

Figure 4A. Proportion of *P. acuta* observed above the water line. 20 snails for each treatment.
Figure 4B. Proportion of *C. chinensis* with closed operculum across time and a range of CO2 concentrations. 25 snails per treatment were used. None were seen crawling above waterline.

		% Mortality (30 min./ 60 min.)				
Species	**Narcotization* (mg/L)**	**Control**	**70 mg/L**	**120 mg/L**	**300 mg/L**	**500 mg/L**
P. acuta	>500	0/0	0/0	20/0	0/10	0/0
C. chinensis	500	0/0	-	0/0	0/0	0/0

Table 1. Narcotization limits and mortality observations after organism exposure to a range of CO2 concentrations for 30 and 60 minutes.
*= minimum at which ≥ 50% of individuals were rigid, on back, and unresponsive to stimulus for at least 10 minutes.
- = Not enough individuals available for testing.

Conclusion

P. acuta

- *P. acuta* displayed a decrease of motion behaviors with increasing levels of CO2 (**Figure 3A**), indicating that CO2 may contribute to their deterrence.
- CO2 had a significant affect on their avoidance, as they were seen choosing to stay above the waterline (**Figure 4A**) during the avoidance experiment.
- Narcotization was not present in any level (**Table 1**).

C. chinensis

- Counts of stress behaviors for *C. chinensis* were observed with higher levels of CO2 (**Figure 3B**).
- There was no significant effect of CO2 on crawling above the waterline; however, there was an effect on closed operculum (**Figure 4B**), indicating that this behavior may be used to help avoid CO2.
- Narcotization was not present until 500 mg/L, indicating that this level could be used for their deterrence (**Table 1**).

Table 2. Observed Behavioral Categories of *P. acuta*

Category	Behavior
Motion	**Crawling** Outside of shell*, there is motion, and is moving in a direction **Swimming** On back, moving on water's surface with direction **Flicking**** Swinging shell from side-to-side
Semi-motion	**Observing- inactive** Outside of shell*, not moving and attached to a surface
Motionless	**Stagnant** Inside of shell* and attached to a surface **Sinking, inside shell** On back, not attached to any surface, antennae hidden **Sinking, outside shell** On back, antennae stretched out, stiffness **Floating** Stiffness while on water's surface, not moving in any direction, on back or right side up

Table 3. Observed Behavioral Categories of *C. chinensis*

Category	**Behavior**
Upright	Normal behavior: out of shell, responds to stimulus by closing operculum
Folded Foot	Altered Movement: upright, partially out of shell, folded foot
Closed Operculum	Protective stress response: trap door all the way closed
On Shell	Impeded movement with loss of equilibrium: on back, operculum open, still moving, responding to stimulus
Narcotization	On back, operculum open, not moving, not responding to stimulus

*Snails were observed outside shells when antennae were stretched out, and inside shell when antennae hidden.
**Flicking only observed during snail-on-snail interaction for space.

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