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 (CO₂) barriers. CO₂ 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 CO₂; however, it is unknown how they affect other invasive species including mussels. 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.

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

AVOIDANCE
- Snails were placed in tanks filled with either ambient (control), 70mg/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

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 500mg/L, indicating that this level could be used for their deterrence (Table 1).

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Table 1. Narcotization limits and mortality observations after organism exposure to a range of CO₂ concentrations for 30 and 60 minutes.

<table>
<thead>
<tr>
<th>Species</th>
<th>Narcotization (mg/L)</th>
<th>Control 70mg/L</th>
<th>120mg/L</th>
<th>300mg/L</th>
<th>500mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. acuta</td>
<td>&gt;500</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>C. chinensis</td>
<td>500</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
</tbody>
</table>

* = 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.

Table 2. Observed Behavioral Categories of P. acuta

Table 3. Observed Behavioral Categories of C. chinensis

Figure 1. The Chinese Mystery Snail, Cipangopaludina chinensis

Figure 2. The Bladder Snail, Physella acuta

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.

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.