Parasite Driven Behavior Modifications of an Invasive Marine Snail, *Batillaria attramentaria*

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INTRODUCTION

***Batillaria attramentaria*, a highly invasive marine snail found in intertidal habitats along the North American west coast** (figure 8), frequently serves as a host to parasitic trematode worms. [1-3] (figure 2) Parasites are known to manipulate host behavior to improve their growth, reproduction, and access to hosts. [4-6] In the case of *B. attramentaria*, we predict that the parasite might increase its exposure to secondary hosts (fish and/or crabs) by altering the snails response to predators. The purpose of this study is to investigate whether the snail's antipredator responses vary depending on parasitic infection. Prior research has shown that *B. attramentaria* is responsive to chemical signals emitted by crabs and frequently burrows to defend against predation. [7] This established behavior provides a foundation upon which we can examine any potential modifications in behavior in relation to parasitic infection.

We hypothesize that snails infected with parasites will exhibit less burrowing and more crawling behavior when exposed to a predator, compared to uninfected snails.

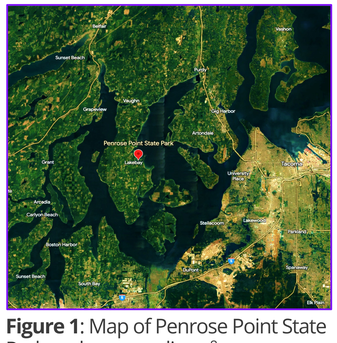


Figure 1: Map of Penrose Point State Park and surroundings [8]

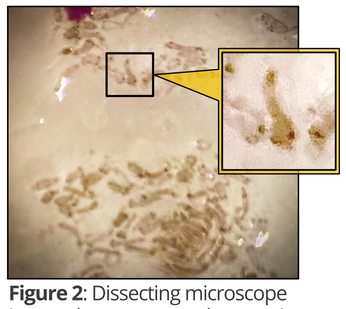


Figure 2: Dissecting microscope image shows trematode cercaria from an infected snail

EXPERIMENTAL SET UP

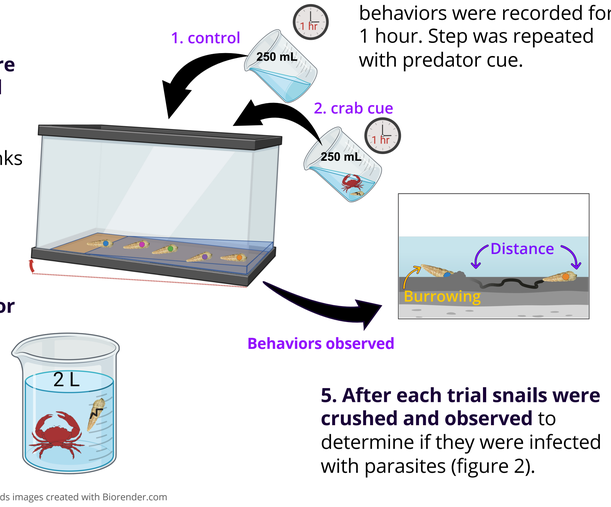
1. Snails were sampled from the intertidal zone at Penrose Point State Park, in Lakeview, WA (figure 1) and held in flowthrough tanks at the UW Tacoma.

2. snails were marked and placed in 10 gallon, pre-prepared tanks (figure 5, 6)

3. A predator cue was made just before each trial

4. 250 mL of control cue was added to each tank, behaviors were recorded for 1 hour. Step was repeated with predator cue.

5. After each trial snails were crushed and observed to determine if they were infected with parasites (figure 2).



Methods images created with Biorender.com

ANALYSIS & FINDINGS

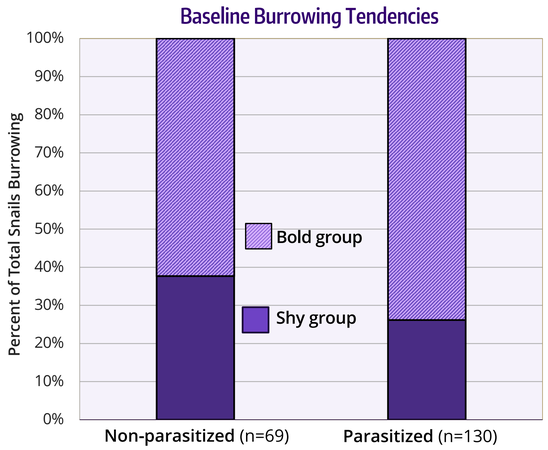


Figure 3: To control for differences in individual burrowing tendencies we categorized snails into burrowers (shy), or non-burrowers (bold) in the absence of predator cue.

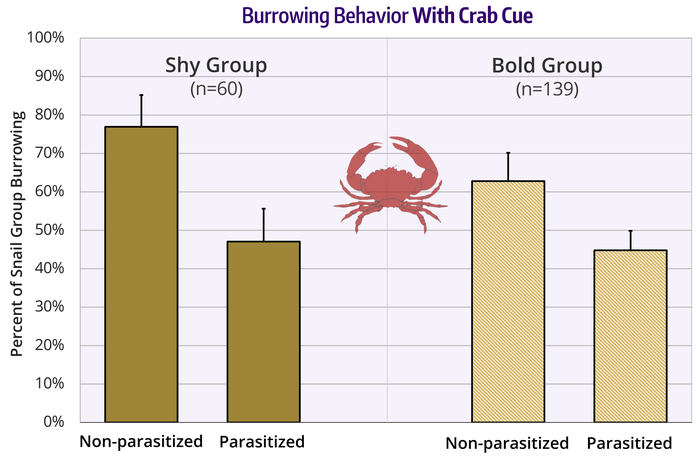


Figure 4: Shy and bold groups were analyzed [9] separately for burrowing behaviors after crab cue was added. Standard error is shown.

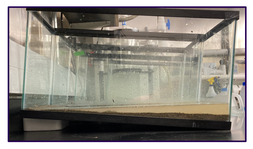


Figure 5: Tank set up with thin layer of play sand and seawater, tilted to simulate shore

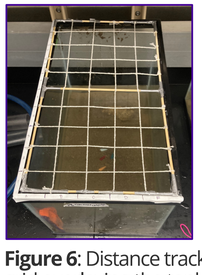


Figure 6: Distance tracking grid overlaying the tank

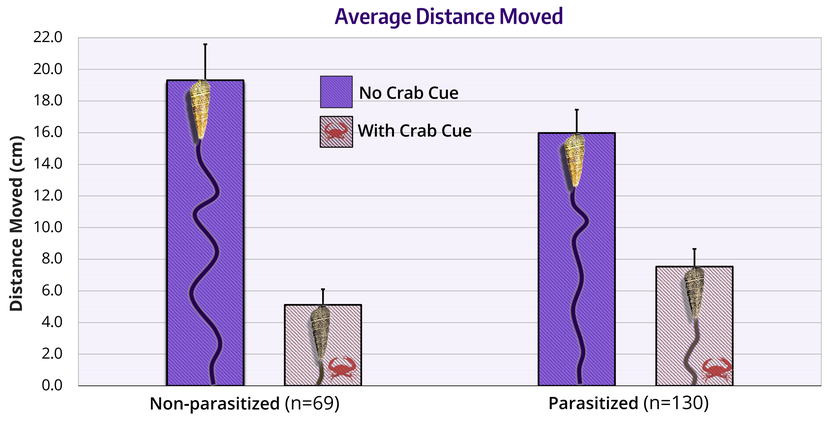


Figure 7: Distance analysis was done using a linear mixed effects model [9,10] to compare effects of parasite, crab cue and their interaction on distance. We controlled for the random variables of day and individual snails. Model selection was based on AIC test [11] for best fit, indicated by lowest AIC value. Graph shows average distance moved by snails before and after the crab cue was added. Standard error is shown.

Burrowing

> **In the absence of the crab cue, there was a non-significant trend for parasitized snails to be categorized as bold** (χ^2 =2.844, df = 1, p=0.0917) (figure 3).

> **When exposed to the crab cue the frequency of burrowing in non-parasitized snails was significantly higher compared to parasitized snails** for both shy group (χ^2 =5.475, df = 1, p=0.0193) and bold group (χ^2 =3.849, df = 1, p=0.0498) (figure 4).

Distance

> **The addition of crab cue resulted in a highly significant decrease in distance travelled by both parasitized and non-parasitized snails** (estimate = -14.21, SE = 2.20, df = 197, t = 2.12, p < 0.0001).

> **There is a significant interaction between parasitism and crab cue** (estimate = 5.76, SE = 2.72, df = 197, t = 2.12, p = 0.035) . **Non-parasitized snails moved more than parasitized snails before the crab cue, and less afterwards** (figure 7).

DISCUSSION & FUTURE DIRECTION

> **Our findings suggest that parasite infection may drive modifications of some antipredator behaviors in *B. attramentaria*.**

> **Larger snails are infected at much higher rates than smaller snails.** [6,12] We were unable to separate the potential effects of size and parasitism. Future studies might seek to do so by sampling snails within a narrow size range or by lab rearing non-parasitized snails.

> **In the absence of predator cues we observed no significant differences between** parasitized and non-parasitized snails. Whether or not a snail was infected had significant effects on behavior after introduction of the predator cue, influencing both the decision to burrow and the amount of movement exhibited.

> **Snails that are less responsive to predators spend less time hiding** and perhaps more time feeding, this could make them a strong competitor for food in intertidal habitats and potentially enhance their success and impact as an invasive species.

> **Enhanced understanding of the parasite-host interaction can give further context** to future and existing studies on the success of *B. attramentaria*, and inform models seeking to explain the influence of this invasive species on native intertidal ecosystems.

ACKNOWLEDGEMENTS

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Figure 8: *Batillaria attramentaria*

REFERENCES