What is the cost of immune defense for snails infected with schistosome parasites?

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INTRODUCTION

Background:
Schistosomiasis is a chronic infection that is prevalent in communities without safe drinking water and adequate sanitation. In 2019, at least 236.6 million people required treatment for schistosomiasis.[1] In children, Schistosomiasis can lead to anemia, stunting, and reduced ability to learn. In adults, it results in reduced ability to work and sometimes death. Schistosomiasis is caused by parasitic trematodes of the genus *Schistosoma* and is vectored by an intermediate snail host (*Biomphalaria glabrata*) before infecting humans or other mammals. Schistosomiasis is primarily controlled via periodic, large-scale human population treatment with praziquantel. However, alternative control measures are needed.

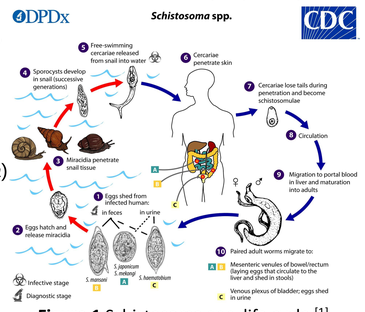

Figure 1 Schistosoma spp. life cycle [1]

OBJECTIVE

One possible mechanism for schistosomiasis control is to manipulate vector resistance in order to prevent transmission to humans. However, theory predicts that successful immune defense is costly, and thus such a trait may not be easily maintained in the population. Therefore:

- We tested the fitness costs of successful defense against schistosome infection.
- We hypothesize that snails with successful defense against *Schistosoma mansoni* infection is energetically costly and leads to reduced fitness in terms of survivorship, growth, and reproductivity. [2,3,4,5,6,7]

STUDY DESIGN

Five *Biomphalaria glabrata* inbred lines (105, 161, 36, 83, and M) were exposed to *Schistosoma mansoni*. Survival, growth and reproduction was measured for 42 weeks and compared to that of controls that were sham exposed.

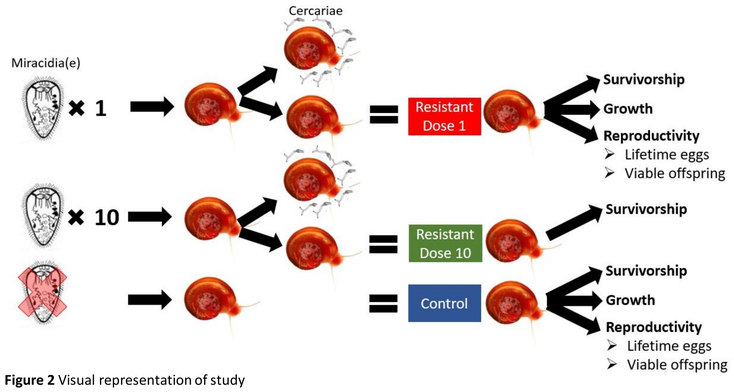

Figure 2 Visual representation of study

Survivorship: Each snails' survival time (in weeks) for the duration of the experiment (42 weeks). *Only analysis where data for all genetic lines were combined.*
Growth: Height (mm) of each snail's shell from top to base at the first signs of reproduction.
Reproduction: 1) The total number of egg clutches was counted across each snails' lifespan. 2) Total viable offspring was calculated as the sum of each snails weekly hatching success multiplied by the number of eggs produced during that week.

RESULTS

SURVIVORSHIP vs. Dosage in Resistant Snails

What are the costs of resisting infection on survivorship?

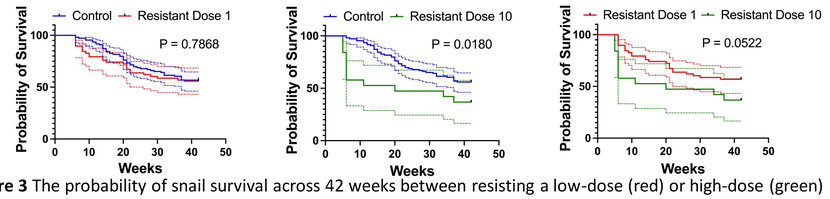

Figure 3 The probability of snail survival across 42 weeks between resisting a low-dose (red) or high-dose (green) infection and controls (blue).

Interpretation: Combined survivorship data among genetic lines (due to no significant differences among snail genetic lines) did not alter host lifespan when resisting a low-dose infection but did for the higher-dose infection.

Statistical analysis: Mantel-Cox survival test

GROWTH: Size at First Reproduction

What are the cost of resisting infection on growth (measured as size at first reproduction)?

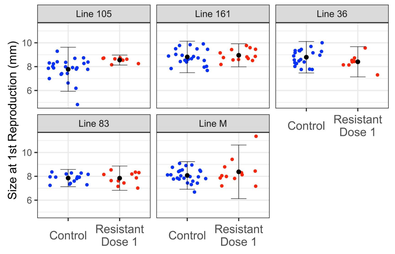

Figure 4 Each snail's diameter (mm) at time of first reproduction between resisting a low-dose infection (red dots) and controls (blue dots) across all genetic lines.

Interpretation: Resisting low-dose infection did not significantly alter size at first reproduction.

Statistical analysis: Linear regression model accounting for genetic lines due to variation.

REPRODUCTION:

1) Total Lifetime Reproduction

What are the cost of resisting infection on total lifetime reproduction?

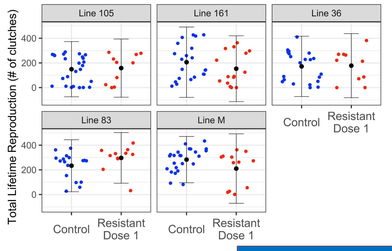

Figure 5 The total number of clutches produced over a snails' lifespan between resisting a low-dose infection (red dots) and controls (blue dots) across all genetic lines.

Interpretation: Resisting low-dose infection did not significantly alter lifetime egg reproduction.

2) Total Viable Offspring

What are the cost of resisting infection on total viable offspring?

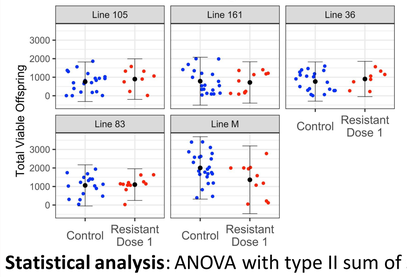

Figure 6 The total viable offspring produced during a snails' lifespan between resisting a low-dose infection (red dots) and controls (blue dots) across all genetic lines.

Interpretation: Resisting low-dose infection did not significantly alter viable offspring reproduction.

Statistical analysis: ANOVA with type II sum of squares (SS) and negative binomial regression model due to over dispersed count data.

DISCUSSION

Snails with resistance to one dosage of *S. mansoni* infection appeared to show limited significance in fitness costs as a result of the immune defense. This indicates the possibility that there is a low energy cost for the snails to defend against *S. mansoni* infections within the experimental design or that the laboratory environment with food provided *ad libitum* allowed the snails to easily compensate for the defense costs. It also leaves a question unanswered if there is a dependence on an immune mechanism that allows the snails to maintains low energy costs with resistance.

Most snails that were exposed to 10 parasites either became infected or died leaving limited data to determine how costly resisting a higher dose might be.

CONCLUSION

While our experiment did not support our hypothesis of immune defenses providing a significant cost to hosts, the initial experiment and the analysis of the collected data set is the first step in evaluating the cost of natural immunity within *Biomphalaria glabrata* against *Schistosoma mansoni* infections.

FUTURE DIRECTION

The future direction of our research lies in focusing on recreating more natural environments with increase extrinsic stressors through reduction of available nutrient resources. An additional evaluation into the cost of resistance in comparison to increased parasitic dosage is also warranted to discover if a limitation exists when immune resistance becomes overly exorbitant to maintain.

Further investigation into the significance of resistance cost between inbred lines can divulge valuable knowledge into if genetic manipulation is a worthwhile endeavor as a clinical application of this research towards a treatment option of schistosomiasis.

ACKNOWLEDGEMENTS

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References

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