Predation Risk Impact on Snail Reproduction

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Abstract

In this research experiment, snails were exposed to different levels of predation, and data was collected on the reproductive output of the snails. Snails detect chemical cues from their predators and alter their behavior based on these cues. Thus, levels of predation were simulated by varying the amounts of predator chemical that was put into the snails' tanks. For this experiment, there were three different levels of predation: no predation, 50% exposure, and 100% exposure. For each level of predation, data was collected on the frequency of snail reproduction, clutch size, and the reproductive lifespan of the snails. Using this data, a statistical analysis comparing different reproductive variables was conducted. In the analysis, the reproductive intervals of the snails were compared with the ages, predation levels, and clutch sizes of the snails. Based on these findings, we were able to predict and simulate the final reproductive interval of the snails. The final reproductive interval gets interrupted by a period of no reproduction before the snails die. Thus, we were interested in trying to predict the post reproductive lifespan based on the data collected on reproductive intervals and the other factors that contributed to the reproductive intervals.

Objectives

- Prove the snails experience a period of no reproduction before dying.
- Show the effects that different levels of predation have on reproduction, survivability, and post reproductive lifespans.
- Predict the age at which the snails should begin the period of no reproduction and the length of the post reproductive lifespan.

Materials and Methods

Experimental

The population of snails was divided up into three groups based on predation level: no predation risk, 50% predation risk, and 100% predation risk. The level was determined by frequency at which the water in each group's tanks was treated with predator chemical. To simulate the presence of a predator, water was taken from a tank filled with crawfish and was cycled into the snails' tanks. The no predation risk group received no predator treatments, the 50% predation risk group received predator treatments every other day, and the 100% predation risk group received predator treatments every day. Each individual snail was labeled and data was collected on the ages at which the snails reproduced, their clutch sizes, and the age at which they died.

Numerical

Using the data collected on ages of final reproduction and death, survivability and fecundity plots were generated. The survivability and fecundity plots were created by plotting the ratios of total alive to starting population and total reproducing to starting population for each day.

$$\text{Survivability: } \frac{Total\ Alive}{Starting\ Population}$$

$$\text{Fecundity: } \frac{Total\ Reproducing}{Starting\ Population}$$

The average rate of reproduction plots were created by averaging the rates of reproduction for the population of snails over different bins for age and days since first reproduction.

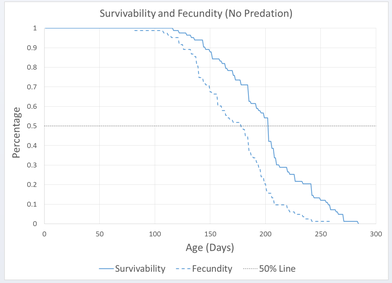
Hazard Ratios for survivability and fecundity were generated by taking the ratios of the total number of observed deaths or final reproductions to the expected number of deaths or final reproductions. The formula for expected events is listed below:

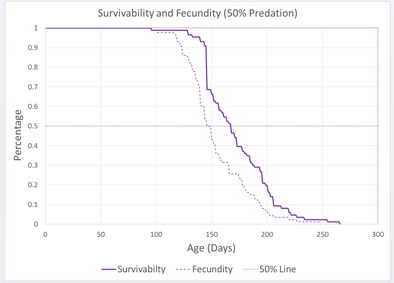
$$E_{j,t} = N_{j,t} * (\frac{O_t}{N_t})$$

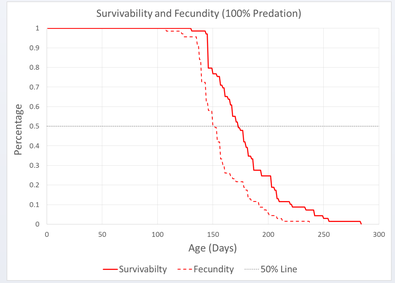
Where $E_{j,t}$ is the expected number of events for predation level j on day t, $N_{j,t}$ is the number of snails still alive or reproducing for predation level j on day t, O_t is the total number of observed events on day t, and N_t is the total number od snails still alive or reproducing on day t.

$$HR = \left(\frac{\sum O_{a,t}}{\sum E_{a,t}}\right) / \left(\frac{\sum O_{b,t}}{\sum E_{b,t}}\right)$$

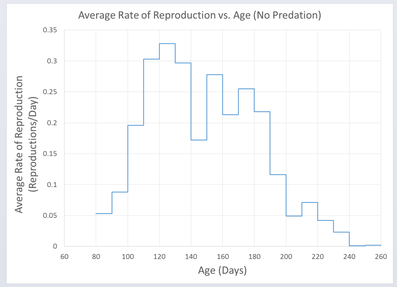
Results

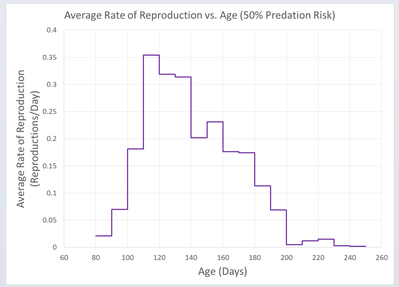


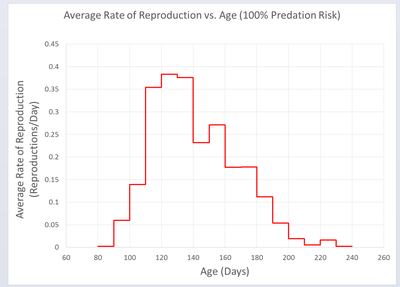




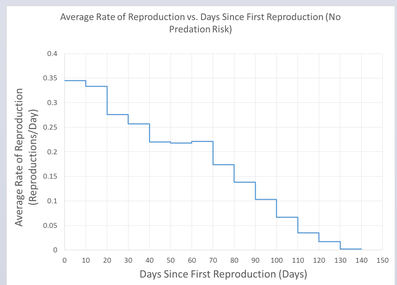
- As shown in the above charts, there is a clear gap between the expected age at which reproduction ceases and the expected age at which death occurs.
- Approximately 50% of snails exposed to predation risk are expected to die within 175 days of their birth. On the other hand, approximately 50% of snails not exposed to predation risk are expected to die within 210 days of their birth.
- The presence of any predation risk (50% or 100%) causes a decrease in the expected ages at which reproduction cease and death occur.

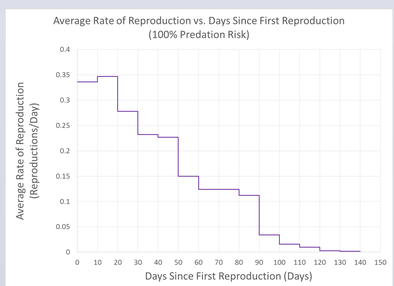


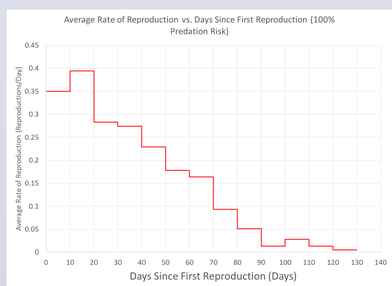




- The above charts show the average rate of reproduction, measured in reproductions per day, for the snail populations at different age bins.
- These charts provide an estimate to when it would be expected for the snail populations to cease reproduction (Average Rate of Reproduction ≈ 0).







- The above charts show the average rate of reproduction, measured in reproductions per day, for the snail populations at different age bins, starting from the first time the individual snails reproduced. A snail's first reproduction was used as a marker that the snail reached maturity.
- These charts provide another estimate to when it would be expected for the snail populations to cease reproduction (Average Rate of Reproduction ≈ 0).

Results Continued

Survival Hazard Ratios		
Level of Predation Risk	Comapred With	Hazard Ratio
No Predation	50% Predation	2.20
No Predation	100% Predation	1.77
50% Predation	100% Predation	1.24

Fecundity Hazard Ratios		
Level of Predation Risk	Comapred With	Hazard Ratio
No Predation	50% Predation	1.76
No Predation	100% Predation	1.78
50% Predation	100% Predation	1.05

- A Hazard Ratio of approximately 1 indicates that there is no significant difference between the two predation levels being compared.
- The above tables show that any presence of predation produces a difference in survivability and fecundity. However, increasing the predation level from 50% to 100% did not seem to have much of an effect on the snails.

Percentage of Life in Period of No Reproduction			
Level of Predation Risk	AVG	STDEV	AVG ± 1 s
No Predation	12.46%	9.87%	(2.59%, 22.33%)
50% Predation	9.50%	7.10%	(2.40%, 16.60%)
100% Predation	11.47%	7.62%	(3.85%, 19.09%)

Conclusions

- As shown in the survivability and fecundity plots, the snails clearly experience a period of no reproduction before they die.
- Assuming that the data is normally distributed, The Empirical Rule states that approximately 68% of values lie within one standard deviation from the mean. Thus, the Percentage of Life in Period of No Reproduction table shows that approximately 68% of the snails across all three levels of predation experience a period of no production that accounts for at least 2% of their lifespan.
- As shown in the Hazard Ratio tables, the presence of predation causes a significant difference in the survivability and fecundity of the snails.
- The Survivability and Fecundity plots show that it should be expected that at approximately 50% of the snails exposed to some predation risk will stop reproducing approximately 150 days after birth, whereas approximately 50% of snails not exposed to predation risk will stop reproducing approximately 180 days after birth. Thus, a lack of exposure to predation risk seems to be correlated with an elongated period of reproduction.
- The Average Rate of Reproduction plots also support the previously mentioned correlation between the lack of predation risk and an elongated period of reproduction.

References

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- Gage, T. (2001). Age-specific fecundity of mammalian populations: A test of three mathematical models. Zoo Biology, 20(6), 487-499.

Acknowledgements

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