Predator sense and prey defense: a lab exercise in evolutionary hypothesis formulation and experimentation

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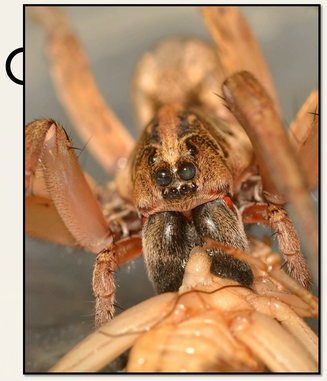

Question
How to design a laboratory experience, using live organisms, to measure the strength of natural selection.

Background

Lab exercises designed to complement course content in evolutionary biology are difficult to conduct in "real time." While simulations, both physical and virtual, allow students to gain a better understanding of the process of natural selection, they do not allow students to interact with real organisms or observe natural forces of selection.

We designed a lab exercise driven by student inquiry that allowed students to measure the force of natural selection using a model invertebrate predator-prey system (wolf spiders and crickets). After using the exercise in two lab sections of a sophomore-level course (Ecology and Evolution) required for Biology majors, we recommend its implementation in similar courses with similar learning objectives.

Learning Objectives

- Introduce students to evolutionary hypothesis formulation and experimental design,
- Provide a dynamic experimental test of natural selection
- Instill student responsibility for:
  - Specimen collection and care
  - Hypothesis formulation
  - Experimental design and data collection

Acknowledgments
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Laboratory Exercise

Week One

Students worked in small groups to complete three main tasks:

- Development of IF…THEN… statements for a variety of biological questions as a way of identifying and formulating testable scientific hypotheses.
- Reading of a "mini-journal" article (Witzig et al), written by us, that described a small experiment we conducted to test whether bitter taste would increase cricket survival when exposed to wolf spiders.

  This article provided:

  - Background information about prey defense mechanisms and spider predation (**Introduction**)
  - Methodology that could be modified by students in the design of their own experiment (**Method**s)
  - Data summary (**Results**)
  - Interpretation of the results, with pointed statements about unanswered questions intended to prompt students to think about the direction of their own experiment (**Discussion**)
- Each student group was asked to develop an IF…THEN prediction that built on the knowledge they gained from the mini-journal article. The entire class discussed each group's idea and then agreed on a single hypothesis to test in the following week.

Week Two

Students conducted the experiment they had designed the previous week.

- Entire class worked on the same experiment
- Groups specialized in individual tasks (e.g., weighing spiders and crickets, applying experimental treatments, transporting animals from scale to experimental arenas, observing/timing spider-cricket interactions, entering data).

Week Three

Students worked in groups to analyze data and summarize the results for the report due the following week.

Outcomes

Student Perceptions

Students completed a short survey soliciting their opinions about the exercise at the end of the three week period.

- 96% of students (n=25) agreed or strongly agreed that the exercise increased their:
  - *"understanding of experimental design"*
  - *"ability to generate predictions about evolutionary hypotheses"*
- Several students found the open-ended nature of the exercise disconcerting. One student responded that he/she felt like the exercise was a "shot in the dark" since he/she didn't know in advance how the spiders would behave toward their treatments.
- A few students expressed a dislike for spiders that made it difficult for them to fully engage in the lab.

Future Improvements

Based on our observations and student comments, we plan several improvements for future classes:

- Provide a sample data sheet to allow students to consider, in advance of the experiment, how they will collect and record data.
- Collect a larger number of spiders earlier. We found that roughly half of the spiders did not eat a cricket, regardless of the treatment.
- Provide the mini-journal article to students in advance, and allow them to spend more time in small groups discussing what they learned from the article.

Hypotheses

Examples of hypotheses developed by student groups:

IF bright colors serve as a warning to predators, THEN crickets painted red will have higher survival than those painted black when exposed to wolf spiders.

IF bitter tasting prey are avoided by predators, THEN crickets dipped in a quinine solution will have higher survival than those dipped in water when exposed to wolf spiders.

Literature Cited

Witzig,SB., N. Zhao, S.K. Abell, J.C. Weaver, J.E. Adams, and F.J. Schmidt. 2010. Achievable Inquiry in the college laboratory: The mini-journal. Journal of College Science Teaching 14-23.