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Claw Waving for Sex: An Inquiry-Based Lab to Teach Sexual Dimorphism and Behavior in Fiddler Crabs †

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INTRODUCTION

Previous research has shown that engaging students in authentic research experiences contributes to their long-term learning (1) and furthers their interest in science (2, 3). As educators, we are responsible for fostering student experiences in gathering, condensing, and evaluating data to solve problems (4). Inquiry-based labs are one strategy we can use to immerse students in the science process. These allow for the development and refinement of conceptual understanding of the big ideas in science by giving students the opportunity to generate and test their own research questions and hypotheses (1). Here we share a three-week, guided inquiry–based lab with the main pedagogical goal of creating an interesting and relevant lab for non-biology majors enrolled at a large R1 Southeastern university. The inquiry process of experimental design and scientific thinking was deliberately scaffolded for students, to help them carry out their scientific investigation (Appendix 1) and can be modified and adapted for high school students to meet Next Generation and other state standards (5).

We chose to use fiddler crabs (*Uca pugilator*) for this lab because they are relatively inexpensive, they are easy to keep in the classroom, and it is easy for students to observe their behavior (Appendix 2). Fiddler crabs are sexually dimorphic, meaning that they exhibit characteristics that distinguish males and females. Here, both males and females possess front claws, but in males, the size of one claw is enlarged. The male's large claw is the result of sexual selection, as males must compete for and be chosen by females for mating (6). The claw is crucial for fighting off rival males and defending a male's burrow (7), as well as for attracting females (6, 8). For more information on mate attraction, please see Christy et al. (6).

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PROCEDURE

Preparing students prior to lab

Although the actual inquiry-based experiments are conducted by students in groups, each student is asked to complete the reading (Appendix 3), watch a video, and answer the pre-lab questions (see Appendix 1) in preparation for lab.

Activity in the lab

Week 1: Training students—Experimental design worksheet and ethogram (3 hours). During the first week in this lab sequence, students were introduced to fiddler crabs—their morphology, behavior, housing chambers, handling, and ethogram. The PowerPoint presentation that accompanied the lecture (Appendix 4) outlines an activity that was used to give students practice constructing and using an ethogram. Also included are discussion questions to introduce the idea of inter-observer reliability. After students observed the model organism for a few minutes, they were asked to complete the experimental design worksheet (Appendix 1). The purpose of this worksheet is three-fold: 1) to deliberately scaffold experimental design for students, 2) to give students targeted feedback, and 3) to outline the expectations for the oral communication of their work. The two main areas where students exhibited difficulties were in alignment (ensuring their research question, hypothesis, experimental procedures, data, and graphing tightly address the same phenomenon) and designing an ethogram (specifically, denoting observable behaviors within appropriate time increments). To help resolve the first difficulty, we had students use a published learning tool, "The step-by-step guide to data communication" (9). Using a reflective approach, with repeated practice and feedback, this guide makes the student aware of their learning and focuses their attention on relevant information from their experiment design, guiding them to a graphical representation that aligns with their research question and hypothesis. To resolve the second difficulty, we explicitly trained

students on animal observation, filling out an ethogram, and calculating inter-observer reliability. We first showed a short video clip from the Animal Planet TV show *Too Cute* ("Corgi Pups Learn to Climb," https://www.youtube.com/watch?v=hzeA2HqRgsE) without sound because we wanted students to form their own conclusions about the behavior. Students were asked to watch and take notes on behaviors that occurred over the two-minute timespan. After a short discussion on the behaviors students observed, we handed out an ethogram (Appendix 5) and asked students to fill it out while we played the video again. While the video was playing, the instructor yelled out "time!" every 10 seconds, prompting the students to write down an observation in their ethogram. Following this activity, we went over how to calculate the inter-observer reliability quotient and discussed how to achieve low inter-observer values and what should be done differently next time.

Week 2: Experimentation—Data collection and analysis (3 hours, plus time outside of class). Prior to starting their experiments, students were advised to address instructor comments on their experimental design worksheet. We also recapped calculating inter-observer reliability and presenting data using behavioral diagrams, since these were the main areas where students asked for further explanation (Appendix 6). We recommended that students make digital copies of their ethogram, using either Microsoft Excel or Google Sheets, to record their findings. Examples of research questions from student groups were: To what extent does the claw waving behavior of a male fiddler crab change when other males are introduced? How will the female fiddler crab react to various males with painted large claws? Are female fiddler crabs more attracted to claw size or claw waving behaviors by the male fiddler crabs? How will the presence of dead crabs in the mating chamber affect fiddler crab mating behaviors?

One common issue that students experienced was not observing any types of behaviors from their fiddler crabs. To help prevent this issue, the crabs should be visually isolated so that they are not frightened by observers or other crabs. Visual isolation can be achieved by simply covering the outside of the container in construction paper, and by encouraging students to glance at the fiddler crabs in the increments reported on their ethogram.

Week 3: Wrap-up—Oral presentation (10 minutes per group). During the first 30 to 60 minutes of the lab period, student groups summarized their findings in short PowerPoint presentations.

Safety

Fiddler crabs are not domesticated animals and exhibit a fear response to rapid movements. Please advise students to be considerate when handling fiddler crabs to avoid undue stress. Aggressive behavior towards humans is rare and does not pose a significant risk of injury. As a precaution, standard nitrile gloves are recommended when handling fiddler crabs.

CONCLUSIONS

Aligned with current best practices in undergraduate biology education, this three-week, guided inquiry–based lab immerses students in authentic research experiences around reproduction and sexual behavior. We have implemented this lab over two semesters, and student reactions have been positive. Compared with the other inquiry-based labs in the course, over half of the students rated the fiddler crab lab as one of their best laboratory experiences. Students said this lab helped them gain experience working with animals, connect concepts of sexual selection from lecture, and practice communicating findings using graphs and behavior diagrams.

SUPPLEMENTAL MATERIALS

Appendix 1: Fiddler crab experiment design worksheet
Appendix 2: Animal care
Appendix 3: Animal behavior: exploring sexual behavior in fiddler crabs
Appendix 4: Classroom PowerPoint presentation week 1
Appendix 5: Example of an ethogram
Appendix 6: Classroom PowerPoint presentation week 2

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