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# K-12 Partnership Lesson Plan

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# *Who’s the bravest of them all?*

# *Using inquiry to explore antipredator behavior in crickets*

## Overview

Inquiry based activities are one of the best ways to teach science to students. Students build a comprehension of the scientific method through exposure to the process of conducting research. Having students take an active role in collecting data and gathering evidence keeps them engaged while reinforcing the critical notion that claims be supported by evidence. This lesson plan provides teachers with a fun but relatively simple template for creating student research projects using antipredator behavior in crickets. Students will examine hiding behavior in crickets and determine how/whether certain variables of interest (e.g. sex, food availability, light level, etc.) influence hiding.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Understand the components of the scientific method
* Design experiments to test specific hypotheses
* Interpret data
* Use evidence to support claims
* Understand how predators can influence prey behavior
* Understand how organisms can face trade-off between safety and feeding, or safety and finding mates

**Length of Lesson**

Minimum of 4 class periods

**Grade Levels**

High school if students are conducting independent projects. The lesson can easily be appropriate for middle school as well if the teacher provides more direct supervision.

**Standards covered (NGSS)**

Disciplinary Core Ideas:

\*\*\*Note: the applicability of these disciplinary core ideas may vary depending on the specific research questions students choose to investigate and the level of classroom discussion throughout the project.

*Middle School*

* **MS-LS1-4**: use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively
* **MS-LS1-5**: construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
* **MS-LS4-4**: construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals’ probability of surviving and reproducing in a specific environment
* **MS-LS4-6**: use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time

*High School*

* **HS-LS3-3:** apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population
* **HS-LS4-4**: construct an explanation based on evidence for how natural selection leads to adaptation of populations

Cross Cutting Concepts:

* Patterns
* Cause and Effect

Science and Engineering Practices

* Asking questions and defining problems
* Planning and carrying out investigations
* Analyzing and interpreting data
* Using mathematics and computational thinking
* Engaging in argument from evidence

**Materials**

* House crickets (*Acheta domesticus*)
* Large plastic bin or similar container to store crickets
* Cricket food and water (see description below)
* Shoe boxes (one per group of students)
* Cardboard toilet paper tube
* Tape
* Stopwatch or other timing device
* Additional supplies may vary depending on the specific research question your students choose to investigate

**Background**

Inquiry based activities are a great way to engage students in real science. This lesson will provide a guide for setting up research experiments investigating cricket antipredator behavior. Predation is a strong selective force that influences numerous aspects of prey behavior. The acts of searching for food or mates often put many species at risk of predation. For example, in many species males produce elaborate signals such as bright coloration or loud calls to attract females with the added consequence of increasing their conspicuousness to predators. In these instances individuals face a trade-off between safety from predators and their ability to find food and attract mates. To cope with predation risk many species have evolved antipredator tactics that modify their behavior when predation risk is high. These tactics can include increased hiding behavior, reduced movement, reduced intensity of sexual displays, reduced courtship activity, and altered preferences and choosiness in mate selection. For example, in the Trinidad guppy males are brightly colored to attract females and females prefer to mate with brighter males. However, in populations with particularly high predation levels, female show a reduced preference for brighter males.

The degree of the antipredator response is likely to vary between individuals as some individuals take more risks than others. There are numerous factors that could potential influence the risk taking behavior of an organism both biotic and abiotic including: sex, age, size, physical condition, previous experience with predators, light level, presence of food.

For example, in a study of black gobies (*Gobius niger*) researchers found that older males were more willing to mate in the presence of a predator than younger males. This may be because older males are closer to the end of their lives and therefore have less to lose by taking risks (Magnhagen 1990).

Similarly, in a study of an acoustic moth, scientists found that older males were less likely to pause their mate attraction calls when they were exposed to a predator cue (Lafaille et al. 2010).

In another example researchers studying tungara frogs found that females were more likely to travel greater distance to seek out mates when light levels were low because predators would have a more difficult time visually locating females under darker conditions (Bonachea & Ryan 2011).

In this lesson students will examine the hiding behavior of the house cricket (*Acheta domesticus*). Students will choose one or several factors that they would like to test to examine the influence on antipredator hiding behavior.

### Activities of the session

1. Acquire house crickets. Because house crickets are commonly used as pet food for reptiles and amphibians you can purchase house crickets from numerous pet stores, or you can order them online at site such as: <http://www.flukerfarms.com/crickets.aspx>

\*Note: If you think your students may want to investigate any differences between males and females I recommend ordering older crickets (if using the website above) because it is easier to identify male from female in older individuals.

1. Set up a storage container to house your crickets. We recommend using a large plastic tub such as the image below:



Other containers can be used to house your crickets but we highly recommend testing any container with a few crickets before adding them all to make sure that they are unable to climb up the walls and escape! Add egg cartons and scraps of cardboard to serve as refuge for the crickets.

1. Provide food and water for your crickets. You can purchase special cricket food and water from numerous pet stores and websites: <http://www.flukerfarms.com/feedersupplies.aspx>  
   For a less expensive alternative you can feed your crickets with slices of apple, potato, banana peels, and raw vegetable scraps. You can provide water by adding cotton balls that have been soaked in water.
2. Introduce the project to the students. Talk about the scientific method and tell your students that they will be conducting their own research experiments. Discuss the interactions between predators and prey and how predators can influence prey behavior. Tell your students that they are going to be investigating the factors influencing hiding behavior in crickets.
3. Split your class up into groups (the number and size of groups will depend on class size). Have groups brainstorm ideas for what they would like to test. Some suggestions for variables they may want to test include: size (length or weight), sex, light levels, hunger level, age.
4. When a group has decided what variable they want to investigate have them write down a hypothesis and predictions for how they think the variable will influence hiding behavior (e.g. male crickets will spend more time hiding than female crickets). Be sure that students also include an explanation for why they think that way.
5. Set up the testing chambers: Test chambers consist of a shoebox or other comparably sized container. In addition to this box each chamber will also need a cardboard toilet paper tube. Tape a piece of paper over one end of the tube so that the tube only has one opening.

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1. Experimental procedure: The general experimental methods will time how long it takes a cricket to emerge from hiding (the toilet paper tube) when placed in a new environment (the shoebox).

### Select a cricket from the housing container and place it in the toilet paper tube

### Using your hand or another piece of paper cover the opening of the tube to ensure the cricket remains inside

### Give the cricket a full minute to become acclimated to the tube

### After one minute place the tube inside the shoebox and uncover the opening

### Time how long it takes for the cricket to fully emerge from the tube

### Remove the cricket and repeat the steps above until you have collected sufficient data. \*Note: to ensure you do not accidentally retest the same crickets it is recommend that you keep the crickets you have finished testing separated from the main colony until data collection is complete (for example you can store then in a separate Tupperware container).

### General tips and hints for investigating several potential variables of interest:

### Handling crickets: Crickets are fairly easy to handle by hand however many students may be squeamish about touching the crickets. You can use a pair of tweezers (preferably soft tweezers to minimize the risk of accidentally hurting the cricket) to pick up crickets.

### If you want to gather a large group of crickets at once (perhaps to separate off a group for testing) place a long paper towel cardboard tube inside the housing container and wait several minutes. Crickets will move inside the tube making the transfer of groups of crickets very easy.

### Sample size: Obviously the larger the sample size the better! We recommend students test at least 25 crickets per level of the variable of interest. For example if a group of students were investigating the differences between males and females we recommend testing 25 males and 25 females.

### Having multiple students/groups collect data on the same variable will allow you to pool data and increase the sample size while reducing the time required to collect all of the data.

### Hunger levels: To manipulate the hunger level of crickets you can separate a group of crickets into a different container and deprive them of food for between 48-72 hours (crickets can be food deprived for up to a week before experiencing any increase in mortality so the time suggested here will not cause any major harm to the crickets).

### Age: The simplest way to investigate the influence of age would be to order crickets from different age groups. The Fluker Farms website provided above allows you to select the age of the crickets you are ordering. Obviously however, this would involve additional purchases which may not be an option for your class. As an alternative students can test the crickets you ordered and then wait a set period (1-2 weeks) before testing another group of crickets.

### Sex: If you are investigating the difference between males and females you obviously first need to be able to identify the sex of individual crickets. You can tell the sex of your crickets by looking at their rear. Male crickets will have two extrusions coming off their rear (these are called cerci). Females will have these two extrusions and an additional third long extrusion coming off the center of her rear. This is the ovipositor and it is used for laying eggs.

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### Size: There are several ways you could test for the influence of size. If you have accurate enough scales you could weigh the crickets. Length can be roughly measured with a ruler while gripping a cricket in a pair of tweezers. A simpler alternative could involve students characterizing size into two levels (big vs small). Students could separate out a group of big crickets and a group of small crickets just using visual approximation and then test the two groups. This method is obviously the least precise but it will also be the least difficult to measure.

### Light level: The simplest approach to testing this variable is to control the room lights or have the group work in a closet or other space where they can minimize the amount of light. If this is not an option students can use a folder to place on top of the shoebox testing arena leaving only a slight crack through which I student can watch for the cricket to emerge from hiding.

### After students have collected all of the data have them begin working on analyzing what they have collected. At a minimum students should calculate averages, standard deviations, and graph their data. More advanced students should conduct simple statistical tests to determine if the variable they have tested has a statistically significant effect on hiding behavior.

### Most of the suggestions in this lesson plan involve comparing the average hiding times between two groups (e.g. male vs. female, light vs. dark, hungry vs not hungry). In these cases a simple t-test is appropriate to determine if the averages are significantly different. You can use the online t-test calculator here: <http://www.socscistatistics.com/tests/studentttest/>

### Be sure to select the 0.05 significance level and a two-tailed hypothesis. If the p-value produced using the calculator is less than 0.05, this indicates that the two groups are significantly different.

### Additional online statistics calculators can be found here:

### ANOVA (for comparing more than two groups): <http://vassarstats.net/anova1u.html>

### Linear regression (for analyzing continuous variables such as length or weight): <https://www.easycalculation.com/statistics/r-squared.php> <http://stattrek.com/regression/slope-test.aspx?Tutorial=AP>

### Optional: Have students write up a paper and/or put together a poster to present their findings to the rest of the class. Be sure to have students discuss whether their hypotheses and predictions were supported or not and come up with some conclusions about what they learned about cricket behavior, what they would change if they could redo the experiment, and any future experiments they think may be interesting.

### At the completion of this experiments crickets can be used as feeder crickets for any pets that eat crickets. Alternatively you can keep the colony of crickets until all individuals die off naturally (amount of time will take will depend on the age at which you ordered your crickets). You can also humanly euthanize the crickets by dumping them into a sealable bag and placing the bag in a freezer for 24 hours.

### \*\*\*DO NOT release these crickets into the wild. These crickets are shipped from other locations and you do not want to risk disrupting the local wildlife by introducing new predators, spreading disease, or introducing competition for food sources.

### Resources

* Website with information on antipredator behavior: <https://en.wikipedia.org/wiki/Anti-predator_adaptation>
* Article on cricket hiding behavior: <http://www.sciencedirect.com/science/article/pii/S000334720600306X>
* References for examples of factors influencing antipredator responses:
  + Magnhagen C (1990). Reproduction under predation risk in the sand goby, *Pomatoschistus minutes*, and the black goby, *Gobius niger*: the effect of age and longevity. Behav Ecol Sociobiol 26:331-335.
  + Lafaille M, Bimbard G, Greenfield MD (2010). Risk trading in mating behavior: forgoing anti-predator responses reduces the likelihood of missing terminal mating opportunities. Behav Ecol Sociobiol 64:1485-1494.
  + Bonachea LA, Ryan MJ (2011). Simulated predation risk influences female choice in tungara frogs, *Physalaemus pustulosus*. Ethology 117:400-407.
* Fluker farms website for ordering crickets: <http://www.flukerfarms.com/crickets.aspx>
* Tips for raising crickets: <http://www.wikihow.com/Raise-Your-Own-Crickets>
* Online statistics calculators
  + T-test: <http://www.socscistatistics.com/tests/studentttest/>
  + ANOVA: <http://vassarstats.net/anova1u.html>
  + Regression: <https://www.easycalculation.com/statistics/r-squared.php>  
    <https://www.easycalculation.com/statistics/r-squared.php>

**Extensions and Modifications**

1. Students can use these crickets to test other biologically meaningful behaviors. Students can experiment with aggression by examining male fights (just be sure to isolate individual males for several days before testing to increase the likelihood that fights will occur).
2. Students can investigate mating behavior by monitoring how females interact with males or how females respond to the sound of male calls (students can use speakers to play cricket calls for females).

**Assessment**

Students will be assessed at the end of the experiment through the graphs they produce and a poster and/or paper write up.