



Predators and Pollinators: Smells of Danger

An Experiment for High School Students

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Objective: this lesson plan lays out an idea for an experimental module that can be conducted by high school students over several months. While based on previous work, the experiment is novel and thus would allow high school students to participate in cutting-edge research. At the same time, the experiment would be an opportunity for students to learn basic concepts in the scientific method, experimental design, statistical analysis, and scientific writing.

Learning Outcomes: After completion of the module, students will

- 1) Be able to discuss why pollinators are important, and factors behind their recent decline.
- 2) Better understand how animals other than humans sense the world.
- 3) Be able to classify arthropods into broad categories.



Figure 1. Crab spider attacking and killing a honey bee. Note the camouflaged color of the spider.



Figure 2. Crab spider killing a bumble bee. The spider's body colors match very well with the flowers it is hunting from.

- 4) Be able to construct hypotheses and predictions for an experiment.
- 5) Be able to discuss issues involved in planning an experiment, such as designing a control, minimizing bias and using replication.
- 6) Understand how probability underlies statistics, and interpret the result of a statistical test.
- 7) Be able to write up a full scientific article, describing the result of an experiment.

Background: Pollinator declines are a serious cause for concern the world over, as Colony Collapse Disorder has affected honeybees, and many species of native bees such as bumblebees have also been shown to be in decline. One aspect of mortality for pollinators is from predators, yet little is known about which predators capture pollinators, or how bees avoid predators. In this exercise, we will investigate whether bees can sense the olfactory cues given off by predators and use it to avoid areas where predators are present.

Lecture I: The introductory lecture will cover why pollinators are important, and how significantly they are declining, while laying out the basic schedule and expectations of the module.

Lecture II: A lecture will cover classification and identification of arthropods into broad categories.

Activity I: Search for Predators in the Environment

Students will use nets to sample bushes and grasses near the UCSD field station, where the honeybee colonies are located. Of particular interest are 'sit-and-wait' predators such as crab spiders, jumping spiders, assassin bugs, and praying mantis. The survey will indicate which type of sit-and-wait predator is most



Figure 3. Crab spider attacking a bumble bee. In some cases, crab spiders do not match the color of the flower. Did you know that spiders, because of their fast-acting venom, can kill bees 10 times their size?



Figure 4. Ambush bug killing a solitary bee on a flower bud.

common in the environment. Students will also be encouraged to continue the survey in areas near their homes, in so doing starting the first bee predator survey conducted for the San Diego region.

Activity II: Testing the Effectiveness of Predators in an Artificial Environment.

Students, working in groups of four, will learn how to take care of the common predator that they found in Step I above, in a laboratory environment. They will then test how effective the predator is in capturing both honeybees and native bees, such as bumblebees, by introducing the bees into small flight chambers with the predator present.



Figure 5. Praying mantis killing a bumble bee. Did you know that praying mantises are sometimes used in biological pest control?

Lecture III: A lecture will then cover how pollinators such as honeybees sense the world, comparing their vision and their olfactory senses.

Activity III: Choosing Predator Stimuli.

Student groups will choose how they want to test whether bees can detect the predator or its activities. Examples of the kinds of treatments that can be tested include: bee carcasses that have been attacked by the predator in question; bodily fluids of bees that have been attacked, leaked onto filter paper; cuticular footprints of the predator, obtained when the predator walks over filter paper; a full, dead mount of a predator, with a control of the same mount covered by a resin that restricts olfactory cues; bodily fluids of a predator. Some of these stimuli will require vision, others olfaction.

Lecture IV: A lecture will introduce how to construct a hypothesis and will cover aspects of experimental design including minimizing bias and replication.

Activity IV: Preference Tests to Measure Avoidance of the Stimuli

The student groups will then design an experiment to measure whether honeybees can detect the predator stimuli chosen in step III above. Bee colonies maintained at the UCSD field station will be used. Bees will be trained to come to a feeder approximately 10 meters from the hive, and then that feeder will be replaced by two feeders that contain the experimental treatment (predator stimulus) and the control, respectively. In designing the experiment, students will be asked to: a) determine an appropriate control, b) think of confounding variables and how to minimize them (e.g., could one position, the right or the left feeder, be more attractive to bees? If so, we might want to switch the position of

the experimental treatment between right and left positions every five minutes), c) consider replication (how many bees from one colony? how many colonies?). Before the experiment starts, students will be asked to make a general hypothesis about the experiment, and a specific prediction following from the hypothesis about how the results will turn out. Data collection will require several sessions, incorporating the choices of several colonies.

Lecture V: A lecture will explain statistics from a simple probability perspective.

Activity V: Analysis of the Results.

Students will analyze the results of the preference tests described in Step IV by using a binomial test to measure whether bees avoided the experimental stimulus more than expected by chance.

Lecture VI: A lecture will explore how to write a laboratory report, covering what is expected in each segment of a scientific article (introduction, methods, results and discussion).

Activity VI: Individual write-up

Students will be evaluated on the quality of their report, in which they used the groups' data, but wrote up the report individually.

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