Plant-Pollinator Interactions

Grade Level: 10-12

Duration:

Prep time: 5 minutes
Activity duration: 1.5-2 hours

PA Standards:

- 4Bio.B.3.2. Analyze the sources for biological evolution.
- Bio.B.4.2.2. Describe biotic interactions in an ecosystem (e.g., competition, predation, and symbiosis).
- 3.1.10.C1. Explain the mechanisms of biological evolution.

NGSS Practices

The bolded practices below are included in these lessons:

1. **Asking questions**
2. Developing and using models
3. **Planning and carrying out investigations**
4. Analyzing and interpreting data
5. **Using mathematics and computational thinking**
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

OBJECTIVES

Students will be able to observe plant pollinator interactions.

Students will be able to ask questions about plant pollinator interactions based upon observations in the field.

Students will be able to test their hypothesis for statistical significance.

Students will be able to understand plant pollinator interactions and the mechanisms governing pollinator attraction to floral types

Students will be able to understand how plant-pollinator mutualisms may have contributed to species diversification through co-evolution

MATERIALS

Notebook

Writing Utensil

Timer

Garden or other outdoor space with flowering plants

Camera (students can use the camera on their phone for this activity)

Lamination sheet

Clippers/scissors

BACKGROUND

Plant-pollinator interactions often represent a classic mutualism whereby pollinators collect food in the form of nectar and pollen and in doing so transfer pollen grains between individual plants allowing for seed set and reproduction. These relationships are influenced by complex floral visual and chemical cues such as color, shape, and scent that help the pollinator locate and learn nutritional resources (Faegri & Van Der Pijl, 1971; Junker & Parachnowitsch, 2015; Willmer, 2011). Importantly, insect species differ in their attraction to and perception of floral cues based on natural history, nutritional requirement, anatomy, and physiology (Chittka & Raine, 2006). Because of this, pollinator groups are attracted to different plants in different degrees, and this non-random foraging behavior can increase the fitness of the plant by increasing the amount of pollen between individuals of the same species. Using this information, we can use observable flower characteristics to make hypotheses on which pollinators may visit certain plants.

PROCEDURES

Part 1.

Students will select two different flowering plant species from a preselected group of 6-10 (depending on class size), ideally that look very different from one another. **Recommendations for common garden plants in the Northeast to observe are listed at the end of this lesson plant.** For best success, this project should be done on sunny, moderately warm days with favorable weather conditions. They will begin by describing the characteristics of each plant in their notebook (ex. color, shape, smell, height, nectar/pollen reward). After writing their descriptions, they will observe each plant for 20 minutes, recording all pollinators that are visiting and noting any interesting behaviors that they see. This can also be done in small groups. At the end of the activity, they will take some time to synthesize their observations, look for patterns, and form hypotheses about why they may see what they do. Some sample questions to guide this process are:

- What types of insects do you see visiting your plants?
- Do you think they are collecting pollen, nectar, or both?
- How do the insects behave on the plant? *Do they stay for a long time or a short time? Do they walk all over the plant or stay in one place? When they leave, what plant do they go to next?*
- Do you think all of the insects visiting your plants were equally as effective at pollinating? Why or why not?
- Did you see a difference in how many types of pollinators your different plants attracted?

Each student should collect a sample of the flowers they observed and take pictures of the pollinators that visited it. They, they will record their natural history observations along with the photographs and flower collected during the activity.

At the end of this activity, all of the students will combine their data. Students will calculate the mean and standard deviation (explanations included at the end of this lesson plan) of visits to each plant type for each insect type. Depending on the students' experience, this data can also be analyzed using an F test in a one way ANOVA (see the end of the lesson plan for details)

- Do the plants appear to attract a different mean abundance of visitors (be sure to consider the standard deviation!)?
- Do plants appear to attract different mean abundance of visitors of a particular insect group (ex. flies, bees, butterflies?)

Part 2.

For the second part of this activity, students will have an opportunity to test their hypotheses developed in **part 1**. The structure of this can be very flexible, depending on the interest or ability of the students. Ideally, they will have developed hypotheses such as *"flies pollinate flowers that are white"* or *"Butterflies like to visit flowers that have long corollas"* and they will then select 2 new flowers (these do not have to be pre-determined) that have these characteristics to repeat their 20 minute observations.

Again, the class should pool their results. Students should develop methods of testing their hypothesis statistically (ex. is the mean fly abundance statistically comparable across white flowers (p value ≥ 0.05? Is it statistically different between white flowers and purple flowers (p value ≤ 0.05)? As with **part 1**, the depth of the statistical analysis can be adjusted depending on the students' level. Students can visually compare means to draw conclusions, or can perform the F test below)

QUANTITATIVE ANALYSIS

The mean is calculated by summing the values for each individual observation or data point and dividing the sum by the number of observations/ data points. This will give you the average value for the variable of interest in the data set (ex. the average number of bees visiting one plant species)

The standard deviation is a measure of the variation around the mean within the sample. This is calculated by subtracting the sample mean from the value of each data point (ex. counts of bees/ observation time to a plant species) and squaring the result for each data point. Average these values, and take the square root of this average.

There are many ways to process this sort of data statistically, and plenty of programs, including Excel and R that allow one to do so quickly. It is a bit trickier to do this analysis by hand, but is helpful for understanding the equations behind the values produced. An F test ANOVA is a way of seeing if you can reject the null hypothesis (which would be that there is no difference between the means with a confidence of alpha 0.05). A good resource for doing this step by step is: https://www.mathandstatistics.com/learn-stats/hypothesis-testing/one-way-anova-by-hand

SUGGESTED COMMON WILD AND GARDEN PLANTS IN THE NORTHEASTERN USA

Asteraceae
Golden Rod
Fleabane Daisy
New England Aster
Sunflower
Black Eyed Susan
Echinacea
Zinnia
Coreopsis
Dandelion
Thistle

Lamiaceae
Pycnanthemum (Mountain Mint)
Cat mint (Nepeta)
Hyssop (Agastache)
Dead-Nettle
Monarda (Bee Balm)
Lavender
Rosemary
Salvia

Brassicaceae
Mustard
Sweet Alyssum

Fabaceae
Hairy Vetch
Red Clover
Crownvetch

REFERENCES

Chittka, L., & Raine, N. E. (2006). Recognition of flowers by pollinators. *Current Opinion in Plant Biology,* 9(4), 428–435. doi: 10.1016/J.PBI.2006.05.002

Faegri, K., & Van Der Pijl, L. (1971). *Principles of Pollination Ecology*.

Junker, R. R., & Parachnowitsch, A. L. (2015). Working towards a holistic view on flower traits - how floral scents mediate plant-animal interactions in concert with other floral characters. *Journal of the Indian Institute of Science*, 95(1), 43–68.

Willmer, P. (2011). *Pollination and floral ecology*.