MICHIGAN STATE UNIVERSITY | W.K. Kellogg Biological Station

K-12 Partnership Lesson Plan

The Double Life of A Squirrel

Seed Disperser and Predator

Overview

Because they cannot move, plants have developed a diverse range of strategies to spread their genetic material: from producing tasty fruits to entice birds and mammals to encasing seeds in structures that can be carried off by the wind. Small mammals, like squirrels and mice, can be both beneficial and destructive for plant seeds – they serve as dispersal agents, moving seeds far from parent plants and into beneficial habitats, or as predators, consuming seeds before they have had a chance to germinate. Using squirrels as a study system, we will explore importance of squirrel behavior human disturbance influencing seed dispersal.

In this lesson, we discuss dispersal and predation as major forces determining the fate of a seed. We will conduct an experiment where we measure squirrel removal of seeds from a seed trap to determine their activity in a variety of habitats – including forest and open field. Using this data, we will go through the scientific method, from hypothesis generation to conclusion. Students will be introduced to Project Squirrel, a citizen science database where students can submit and explore data on squirrel behavior.

Objectives

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

- Understand how traits of a seed help it to disperse in its environment
- Discuss the tradeoffs between remaining need the parent plant or dispersing too far away
- Discuss the tradeoffs between attracting seed dispersers and being susceptible to seed predators
- Generate a hypothesis and prediction, and understand how the experimental design addresses their hypothesis
- Collect data from an experiment and put into a table
- Convert a data table into a figure and draw conclusions

Length of Lesson

This lesson will take two hour long class periods, spaced two days apart. In the first class period, students will watch the introductory PowerPoint and set out the experiment. In the second class period, students will collect data from their experiment, graph the data, and draw conclusions.

Grade Levels

This lesson is designed for middle school students, but could be easily tailored for elementary or high school classes (See Extensions and Modifications).

Standards covered

S.RS.01.12 Recognize that science investigations are done more than one time.
S.RS.02.15, S.RS.03.15 Use evidence when communicating scientific ideas.
S.IA.03.11 Summarize information from charts and graphs to answer scientific questions.
S.IA.03.12 Share ideas about science through purposeful conversation in collaborative groups.
S.IA.03.13 Communicate and present findings of observations and investigations.
S.RS.03.18 Describe effects of humans and other organisms on the balance of the natural world.
L.OL.02.14 Identify the needs of plants.
B1.1A Generate new questions that can be investigated in the laboratory or field.
B1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.
B1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).
B1.1D Identify patterns in data and relate them to theoretical models.
B1.1E Describe a reason for a given conclusion using evidence from an investigation.
B1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.
B1.1g Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.
B1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.
B1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.
L3.p2A Describe common relationships among organisms and provide examples of producer/consumer, predator/prey, or parasite/host relationship.
L3.p2B Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors).

Materials

- 8 large trays (such as lunch trays)
- 8 liters of play sand (small grain size, no pebbles)
- 800 sunflower seeds or corn kernels
- 8 sieves (to separate seeds from sand)
- PowerPoint Introduction
- Student Handout

Background to squirrels as seed predators and dispersers

A crucial challenge for a plant is to have as many seeds as possible survive and grow into healthy plants. To accomplish this, seeds must **disperse** away from the parent plant where natural enemies (like predators and disease) are abundant and competition with siblings and the parent plant is intense. Seeds must also end up in favorable conditions, meaning the right environment for the species of plant go grow. Many plants rely on seed dispersers to move their seeds into these new environments.

To attract seed dispersers, plants have evolved many unique adaptations to hitch a ride – for example hooks to snag the fur of animals or bright colored fruits to attract birds. However, attracting dispersers means potentially also attracting **predators**, so seeds are faced with a tradeoff. More complicated still is when the same species is both a seed predator and disperser, such as with squirrels.

Squirrels are voracious seed predators, so it is hard to imagine that they can also benefit seeds. Their interesting behavior of **caching**, or burying and storing seeds for a later date, results in many seeds being consumed, but some being forgotten or lost. These forgotten seeds are now buried below ground where they have a much higher chance of survival compared to their siblings left on the soil surface. They also have the chance to germinate the next season and grow into a new plant. In this lesson's experiment, students explore how squirrels can behaves more as dispersers than predators under certain habitat conditions.

There are many species of squirrels in Southwest Michigan, and they each have key characteristics that can help you to tell them apart. Here are a few that you are likely to see in your schoolyard:

- Fox Squirrels – these are a little larger than the gray squirrel, but the easiest way to tell them apart is that instead of a white belly, this species has orange fur. Instead of frosted white on the tail, this species has black furs.
- Gray Squirrels – these squirrels are gray in color and have a white belly. Their tail looks frosted with white. There is also a completely black morph of this species.
- Chipmunks – yes, they are a type of squirrel! They can be distinguished by their black and white racing stripes down their backs.

Background to Project Squirrel

There is a unique opportunity for all of us to contribute to a nation-wide observational study that aims to answer some very big questions about squirrels. There are two wonderful observational experiments your classes can take part in that can be tailored to meet the level your students are at. By visiting the website for Project Squirrel, projectsquirrel.org, you can gain access to all of the information covered in this brief introduction.

The first experiment is a very simple experiment that involves taking your students into the school grounds and watching the squirrels in the area. You will want to introduce your students to the different types of squirrels that they may encounter. The grey squirrel will have a white belly with a frosted looking tail (tipped white). The fox squirrel will have a red/copper belly with a black tipped tail. The red squirrel may also be present, they are significantly smaller than the grey and

fox squirrels (appear to be juveniles), and will be red/copper in appearance. One thing to keep in mind, if you encounter any black squirrels they are simply a morph of a grey squirrel and should be counted as a grey. Students will need to keep a tally of the different squirrels they observe, and also the surroundings in which they are observing the squirrels (in particular the types of trees in the area). The green tab that is on the "Participate" page of the website will link you directly to the data entry form to submit your observations. This database has been used to write a publication on the dispersal of the grey and fox squirrels in the Chicago-land area, and is extending towards a nation-wide assessment.

The second experiment that students can take part in is certainly geared towards more advanced classes (8th-High School). There is an extremely in-depth, step-by-step experimental design that you can find here: http://www.projectsquirrel.org/Backe,Rabkin,Sullivan.Squirrels.pdf, and it is also attached found on the GK-12 Project website along with this lesson plan. This handout lays out how to set-up the experimental feeders that will be required, how to engage students with the topic, the introduction for the students, a data collection sheet, and even a set of follow-up questions to make the students apply the concepts they learned through the experiment to alternative situations. In summary, the experiment is designed to investigate how the squirrel foraging behavior responds to food sources that are set-up in "Safe" and "Unsafe" regions of the environment. Students will need to identify spots that are "Safe" and "Unsafe" such as locations near a tree and locations in the open respectively. Small feeders with an intact corncob will be placed in these locations and after a set period of time, students will collect the corn and compare the weight that was eaten throughout the feeding period.

Project Squirrel offers a wonderful opportunity for students to participate in a nation-wide observational study. Engaging students in such a unique opportunity to become Citizen Scientists is a perfect way to not only excite students about science but also contribute in a meaningful way.

Activities of the session

Day 1: Introduction and Experimental Setup

A. Introductory PowerPoint Presentation (35 minutes)
    1. Ask the students "Why is there so much diversity in seed shape and size?" Talk about how seeds evolved many traits to interact with other species such as dispersers and predators. A variety of habitats result in a variety of solutions to the same problems.
    2. Define **dispersal** and go through the examples of different dispersal strategy (e.g. stickiness, bright color and fruits)
    3. Ask students why dispersal is important. Dispersal allows seeds to escape **predators** and disease focused around the parent plant, and to escape competition with siblings.
    4. Talk about different types of predators: **pre-dispersal** vs. **post-dispersal** seed predators.
    5. Discuss how seed dispersers can also be predators. For example, squirrels can be vicious seed predators but they do not always eat the seeds right away. They store seeds in a safe location so that they can eat them later. This behavior is called **Caching**.
    6. Give an example of chocolate-chip cookie study conducted by scientists. In the classic behavior experiment, scientists studied the trade-off between foraging efficiency and predation risk using chocolate-chip cookies at a park in Rochester, New York. They placed different size of chocolate-chip cookies at different proximity from the closest tree (safe place) and looked at squirrel behavior. First they found that squirrels are more likely to carry larger cookies. This makes sense because if the cookie is small, it's faster and easier to eat it on the spot, rather than carrying it to a safe place. But if they eat a large cookie on an exposed area, it would take a longer time and the predation risk would also be higher. So it's better to carry a cookie to a safe place. Second, they found that squirrels are more likely to carry cookies over shorter distances. This is somewhat of a

counter intuitive result. However the scientists attributed to a trade-off between predation risk and energetic cost of carrying cookies around. In any case, squirrels seem to make foraging decision based on size of the food and distance from a safe spot.

B. Experimental Setup (25 minutes)
    1. Break students into 8 groups, one per experimental replicate.
    2. Share the experimental design with students from the PowerPoint
        - 8 trays will be placed outside, each containing 100 seeds and 1 liter of sand.
        - Half the trays will be placed in one squirrel habitat, half another. Have a brief discussion about what qualities of a habitat would affect squirrels, and could influence them to behave more like a seed predator or disperser.
        - Choose two habitats, and assign groups to these habitats.
    3. Give each student group 1 tray, 1 liter of play sand, and have them count out 100 sunflower seeds or corn kernels, whichever you have chosen to use.
        - To assemble the seed trays, sprinkle seeds onto the tray and then cover with a fine layer of sand. If a few seeds are exposed, that is fine.
    4. Take the class outside to place the trays in each habitat. Sprinkle a few seeds around the trays to attract squirrels and help them find the seed trays.
    5. Observe any squirrels that you see outside. Record species and counts for each habitat.
    6. Leave the trays out for at least 48 hours, and no more than 96.

<u>Day 2: Data Collection and Interpretation (should occur 2-5 days after experimental setup)</u>

C. Data Collection and graphing (25 minutes)
    1. Bring students outside to collect the trays. (Optional – have students observe squirrels around the trays while journaling and sitting quietly. Look for squirrel species and behaviors).
    2. Have each student group record their data in the data table on the student worksheet
        - Record # empty seed coats – assemble fragments of seed coats to make the best estimate of a complete seed coat.
        - Record # of full seeds – seed coat + inside of seed in tact
    3. Students can then report out their findings to make a class set of data.
    4. Graph the data using class averages. Make a bar graph with one bar for each habitat. Discuss what should go on the x and y axis.

D. Class discussion of the data (20 minutes)
    1. Were there any interesting trends in the data?
    2. Did squirrels behave more like seed predators or dispersers in one environment? If students found many seed coats without the seed insides, these seeds were eaten while the squirrel was standing in the tray. If however, there are no seeds or coats left in the trays, squirrels may have cached the seeds and are acting as dispersal agents.
    3. Why do you think you saw differences in the habitats? How do you predict that they affected squirrel behavior?
    4. Are there any further hypotheses that students would want to test?

E. Project Squirrel (15 minutes) – See description in Background section.

Resources

- Lesson Plan “How Seeds Get Around”, which takes a closer look at modes of seed dispersal: http://kbsgk12project.kbs.msu.edu/blog/2012/03/20/how-seeds-get-around-inquiry-learning-about-seed-dispersal/
- Squirrels of Michigan: http://lansingwbu.blogspot.com/2009/02/question-of-week-how-many-species-of.html
- Project Squirrel: http://www.naturemuseum.org/Media/Default/Biology/Citizen%20Science/CitizenScienceResearchGuideAppendix.pdf

Extensions and Modifications

Elementary classes could focus more on squirrel observations and journaling outside, and the teacher could spend more time discussing the data. High school classes could turn this experiment into an independent project where students tested more complex hypotheses than the ones included in this lesson plan. For example, students cannot only study the squirrel behavior under different habitats, but they can also manipulate seed type and size, and distance from the "safe site". Using Project Squirrel, students could spend time learning about citizen science data and explore the vast dataset available through this website.

Assessment

Teachers can use the Student Worksheet for assessment. Students should have a hypothesis that contains both a prediction and a rationale for it. The table should be filled out with the class set of data, and the figure should be a representation of the class averages with axes labeled. For conclusions, students should state whether the date supported their hypothesis and use data from their figure to support it. Students should also state the implications of their findings – do squirrels behave more like seed dispersers or predators in different habitats?