Introduction to the Scientific Method

What habitat at your school has the highest insect biodiversity?

Overview

This lesson serves as a good introduction to the scientific method, or as a review to start off the school year. Students will develop their own hypotheses and experimental design, as well as analyze data as a class in order to draw conclusions. The lesson covers all the steps of the scientific method and allows students to think like scientists and answer the question "In what habitat do we find the highest insect diversity?" Unlike many classroom experiments where teachers have an idea of the "correct" results, in this lesson each student or class might come up with his or her own design and all data is meaningful.

Objectives

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

- Describe the steps of the scientific method
- Understand how scientists use the scientific method
- State a hypothesis and how it differs from a question or prediction
- Design an experiment to test their hypothesis
- Collect data and organize into a table and graph
- Draw conclusions from data and support claims with evidence
- Define biodiversity and its two components
- Classify common insects to Order

Length of Lesson

This lesson will require 3 class periods of an hour each. Class 1 and 2 must occur one week apart. **Class 1:** Students will review the scientific method as the teacher presents a PowerPoint. Students will develop a hypothesis and experimental design, and place sticky traps around their school. **Class 2:** The class will collect the sticky traps, count and classify the insects, and pool the classroom data for all habitats. **Class 3:** Graph data, and make conclusions.

Grade Levels

This lesson is appropriate for middle and high school classes. It can be done at the beginning of the school year to introduce or review the scientific method.

Standards covered

B1.1 Scientific Inquiry

Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.

- **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.

Materials

- Introduction to the Scientific Method PowerPoint (included)
- Invertebrate Guide PowerPoint (included) and field ID books
- Worksheets (included)
- Graph paper
- Sticky Traps
- 1-meter high stakes
- Plastic wrap or large Ziplocs
- Labels for the plastic bags (sharpies and masking tape)
- Camera to photograph unknown invertebrates
- School habitats (grassy lawn, BEST Bioenergy Plots, woods, pavement…)
- Randomization Procedure (found in BEST Binders or on the website)

Background

Insects and other invertebrates are essential for any healthy ecosystem. Invertebrates aerate the soil, eat plant pests, pollinate flowers, and provide food for other organisms such as birds and small mammals. Ecosystems with high invertebrate diversity may be more stable over time and able to support a greater diversity of plants and animals. High diversity in an ecosystem can also affect ecosystem services. <u>Ecosystem services</u> are resources and processes generated by ecosystems that benefit humans. For example, food, water, energy, air quality, water purification, disease control, nutrient cycling, seed dispersal, and recreation are all ecosystem services.

Activities of the session

- **Class 1:**
  1. Go through the PowerPoint to introduce the steps of the scientific method (15 minutes).
  2. Present the question that the students will be addressing: "In what habitat do we find the highest insect diversity?" and show the slide to reveal what materials they'll have for their experiment.
  3. In small groups, have students develop their own hypotheses that they want to test, predictions about what they'll see, and what experimental designs they would need to accomplish this (7 minutes).
     i. Two choices for how to structure your prediction and hypothesis:

        I predict that habitat 1 will have higher insect diversity than habitat 2 because (description of what is different about that habitat).

        - The **first part of this statement is the prediction** – what are the students' expected results?
        - The **second part is the hypothesis** – the mechanism that students think is behind this pattern. In this case, what determines insect abundance? Why do you think a particular habitat will have higher insect diversity?

        If feature of a habitat drives insect diversity, then we will measure the highest insect diversity in habitat 1.

        - The **first part in this case is the hypothesis** – what is it about a habitat that drives higher insect diversity?
        - The **second part is the prediction** – choose the habitat that has the most of the factor in your hypothesis. *For example, students might predict the wetland will have the highest diversity because they hypothesize that insects are attracted to water.*

     ii. For the experimental design, have students choose the habitats around the school that they would want to use to address their hypothesis.
  4. Have the class share their hypotheses and experimental designs.
  5. Decide as a class 2 habitats to place the sticky traps in (7 minutes).
  6. Go outside to place the sticky traps (30 minutes)
     i. Place 1 meter stake into the ground
     ii. Pull apart the two sticky traps, exposing the sticky side
     iii. Fold over one sticky trap, and fold around the post
     iv. Push the arrows through the holes to secure the stick trap to the pole, and make sure the trap goes into one of the grips along the pole
     v. Make sure not to touch the sticky side of the traps!
     vi. Use the *Randomization Procedure* found in the BEST Binders or website if you are placing the traps into the BEST Plots.
- **Class 2:**
  1. Take the class outside and collect the stick traps (1 week after placement)
     i. Wrap each sticky trap in plastic wrap or in a Ziploc
     ii. Label the plastic to show where the trap was located
  2. Bring class back to classroom to count insects found on the traps.
  3. Show the Invertebrate Guide PowerPoint and have students key out their insects to Order.
  4. Record data for each trap, and pool to get classroom data. Make sure you record the average number of insects per stick trap (divide class total for each habitat by how many traps you placed out in that habitat).

- **Class 3:**
  1. Review with students the scientific method and how their experiment followed each of the steps. Have students restate their hypothesis. Make sure they still have their worksheets from Class 1 and 2 where they recorded everything.
  2. Put the classroom data up in a table on the board. Hand out graph paper and tell the students you will all run through making a graph together.
  3. Go through the steps of making a graph together as a class (students will make 2 graphs – one for total # of insects and one for # of types of insects in each habitat).
     i. Draw axes of graph
     ii. Decide what type of graph to draw (in this case, where we are plotting averages, a bar graph would be best)
     iii. Label the x-axis with the categories (habitats sampled at your school)
     iv. Label the y-axis with the response variable (depending on the graph, the total # of insects per sticky trap or the # of types of insect per sticky trap)
     v. Make a scale for the y-axis. Guide students through making sure the intervals on the axis are even and that they make their numbers go from 0 to the highest number.
     vi. Decide on a title, describing to students that it should be descriptive enough that if someone was looking at the graph for the first time it would be clear. Acceptable titles include restating the question addressed by the experiment or "Insect Biodiversity in School District Habitats
     vii. Have the students plot their data
  4. Once the graphs are complete, the students will use them to write their conclusion. The parts of the conclusion include:
     i. Restate hypothesis and prediction
     ii. Does the data support your hypothesis? Where your predictions correct?
     iii. What habitat does the data say has the highest insect diversity? (use numbers from the graphs!)
     iv. Would you change anything about the experiment if you could do it again? Would you conduct a follow up experiment? Do you think the data is reliable or do you think there was some error in the experiment?
  5. Have a class discussion about what the data shows and what future experiments students might want to conduct. Ideas include using more habitats, using different colored sticky traps, attaching lights to the traps to attract more bugs, using pitfall traps instead of sticky traps…

Resources

BEST Plot Website where you can find the Randomization Procedure, Invertebrate Biodiversity Protocol, and Invertebrate Guide PowerPoint:

http://kbsgk12project.kbs.msu.edu/best-research-network/

To work more with supporting conclusions with data and the scientific method, check out the Data Nuggets Website:

http://kbsgk12project.kbs.msu.edu/data-nuggets/

This and other lesson plans relevant to the BEST Plots can be found at:

http://kbsgk12project.kbs.msu.edu/blog/2011/09/14/best-plots-lesson-plans/

Extensions and Modifications

This lesson plan can be applied to any experiment you conduct in your classroom. The steps of the scientific method should apply to any classroom inquiry and can be used with any data. A follow up to this lesson could be letting students have more freedom in their question and experimental design and ask follow up questions in a future experiment.

Though this lesson plan emphasized all parts of the scientific method, you may want to delve into each section in more detail in future experiments. For example, provide the students with the hypothesis and experimental design, and focus more on data interpretation and graphing.

Assessment

To assess student understanding the graphs and conclusions will be most helpful. Below is a grading rubric to make sure students have included all parts of the graph and conclusion. In future classroom inquiry, allowing students to be more independent when making graphs will show if they understood walking through it this time.

GRAPH	**Points**			
X-axis label	5			
Y-axis label	5			
Scale & number interval	5			
Plot data	5			
Title	5			
CONCLUSION				
Restates hypothesis	5			
Indicates whether or not data agrees with prediction	5			
Indicates precisely what data says	5			
What could be changed/Experimental error/Ideas for new experiment/Positive statement regarding experiment	5			
	45			