Smithsonian
National Zoological Park
Conservation and Research Center

BIODIVERSITY MONITORING PROJECT—QUICK LESSON #3
Insect Monitoring—A Classroom Model

Background

National education standards emphasize that science in schools should reflect “science as a process,” rather than sets of facts taught by memorization. “In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others”. National Standards highlight the inquiry-based approach to student learning at every grade level; students “develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world”.

However, recent research shows that teachers in the life science content areas are often uncomfortable about providing instruction about environmental issues and conducting field-based studies. This activity allows teachers to model a field activity in the classroom, either in preparation for conducting a field activity in the natural world, or as a stand-alone lesson that teaches important concepts and skills within science. By modeling field-techniques in a classroom-based activity, teachers and students together acquire both confidence and skills to take their project into the natural world.

This classroom lesson centers on using the scientific method to model an actual field experiment to census and monitor insect populations in the local ecosystem, using the same field techniques developed by Smithsonian scientists to census and monitor insect populations world-wide. Because the activity focuses on student teams clearly defining their own protocols as they explore insect diversity, they are engaged—just as Smithsonian research scientists—in science-as-process, using the scientific method. At the same time, this activity allows students to learn species classification skills, just as used by field-based para-taxonomists, even when they do not have the knowledge for specific species identification.

Objective

Students will understand the value of studying and monitoring biodiversity through an interactive lesson that teaches uses elements of the scientific method, including developing and implementing standard protocols, collecting and analyzing data. Skills learned include mathematical calculations and graphing techniques. By modeling an insect monitoring protocol in a classroom setting, students explore monitoring methods used by Smithsonian scientists, while sparking student inquiry.

Method

By using a simulation of a field research situation, students can practice the scientific method in the classroom, either in preparation or as a substitution for real-world field experience.

Students will examine a simulated biodiversity research situation, using a “mini-plot” or sampling square protocol, and will select their sampling parameters, collect data, and classify “species”. Additionally, they will graph their data for species richness and relative abundance, and will interpret their data, based on their protocol parameters.

Class discussion will point to the necessity of adhering to standard scientific protocols, like those used by Smithsonian scientists. Discussion will also reveal the variety of classification schemes and how methodology must also be consistent in order for data to be comparable. By being involved in every step of the scientific process, students will understand how all of the parts contribute to the overall picture of scientific research.

Materials

- Blank paper for observations and data collection
- Pencils for writing
- Buttons or bingo chips of various colors, some with small circular stickers, some without, representing the insect population within the sample size
- Sampling squares (can be made from 4 wire survey flagging stakes)
- Shredded paper of various colors and widths to simulate leaf litter

Procedure

1. **Divide the class into teams of four to five students each.** Each group needs a sampling square of approximately 30 centimeters that delineates the boundaries of the “sampling area”.

   To simulate layers of soil where ground-dwelling insects would be sampled (top-leaf litter, middle-decaying leaves and hummus, bottom-soil), layer inside the sampling square shredded paper by color. For example, brown paper on the bottom might represent soil, white paper as the middle layer might represent dead leaves/humus, while red paper on top might represent fresh leaf litter.

   Multi-colored bingo chips represent insects. To make it an additional challenge for classifying species, you can including bingo chips that have colored stickers placed on them, which can represent new species, or can represent same species, but male vs. female or young vs. adult. Bingo chips should be added in between each layer of paper.

2. **Design a protocol parameters and species classification system (10-15 minutes).**

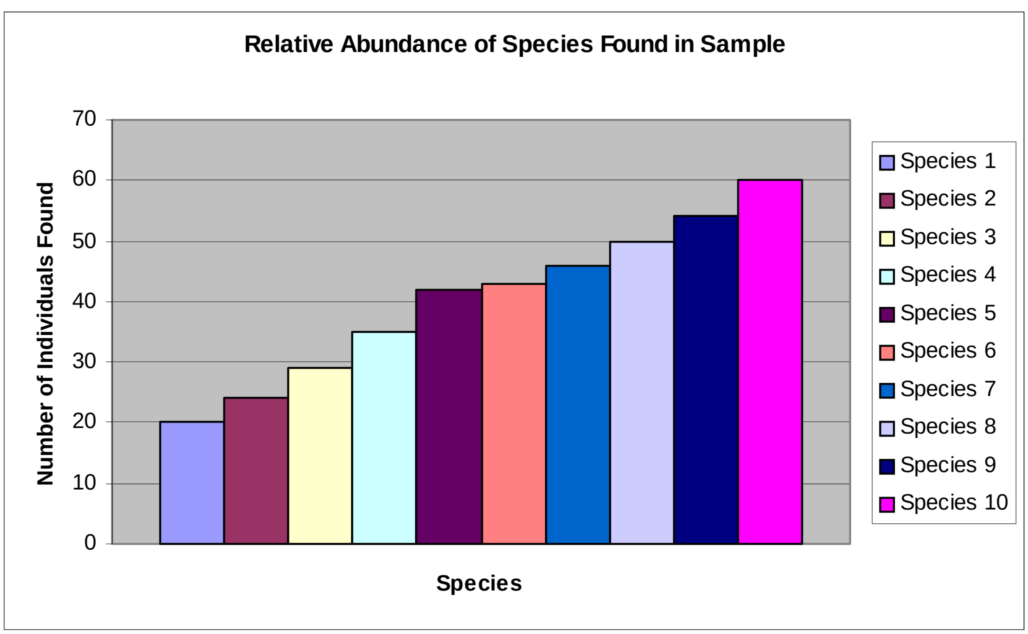
   <u>Protocol parameters</u>: Instruct the groups to determine their own protocol parameters for gathering data on the “insects” in their population. They should define their parameters, addressing issues such as how far into the leaf litter they want to go to monitor the insects in their sample, if they want to collect or observe the insects, and the research time frame (how long they have to conduct their census. Make sure everyone knows what each color layer represents so they know which layers they want to sample. Parameters include whether they will conduct a non-invasive census (top layer—leaf litter only), a moderately invasive census (top two layers—leaf litter and decaying matter), or a complete census (including all three layers).

Species classification system: The groups will also need to develop a classification system for counting species on their data sheets. For example, all blue bingo chips could represent a single species, regardless of whether or not they have a dot (perhaps male vs. female, young vs. adult, or subspecies of a single species). Or it could be that bingo chips with dots are all different species. This is actually a fairly critical step in the real world. In most parts of the world, scientists are still discovering new species (see student handout: "The Big, Big World of Insects). Para-taxonomists at remote field stations must sort insects that look alike or don't look alike without the benefit of field guides — since most of the insects have never been described or named by scientists. In this classroom model of an insect census, students will have the chance to debate within their team what constitutes a species — based on appearance alone (color, spot or no spot, etc.). On their data sheets, they will want to have a place to record the number of species a, species b, etc.

3. **Conduct census and reevaluate species classification system (20-30 minutes):** Teams collect data, following to their protocol parameters. Two students should do the collecting, with two students assisting with sorting. Teams will need to debate their classification system, and assign species designations as described above. The teams will perhaps need to reevaluate their species classification system.

4. **Record, calculate, graph, and analyze data (15-20 minutes):** Record keeper records species information using the data sheet. Total the species abundance (the number of individuals per species) in the right hand column. Calculate species richness (how many species are in your sample) at the bottom of the table.

   On a flip chart, student teams should create a bar graph showing relative abundance (a measure of biodiversity that compares how many individuals are in found for each species). The X-axis will represent the species in your census. The Y-axis will represent the number of individuals found for each species. Students should label their graph appropriately, and provide a legend. Following is an example of a graph for relative abundance:



5. **Present methods and results (5 minutes each).** Each team will be responsible for a short presentation that should include why they selected their protocol parameters, species classification system, and their results.

6. **Group discussion and extensions.** Discuss as a group the differences in protocols and classification systems. Some questions you may want to ask:

    - How easy is it to classify species?
    - In what ways could we compare the data collected by different groups (using different protocols)?
    - What patterns do you notice in the data?
    - In what ways could conducting a census bias the data? (For example, disturbing the upper layers may cause insects typically found in the top layer to move to lower layers to escape. It doesn't mean they typically live in the bottom layer, but they may be found in that location because of the actions of the collector.)
    - Species accumulation curve. This type of graph would show how many species you find, based on the number sampling events are conducted. For example, one could predict that if you only put out one small sampling square in a habitat you might miss some (or if you only sampled insects in the top layer of leaf litter). The more sample you collect in a habitat (i.e., the number of sampling squares you collect data in), the more species you will find. You can graph this data with number of NEW species collected in each sample (column 1 has 4 species, column two you found two new species out of 3 collected, so column two has 6 species, and so on). When the curve flattens out, you are likely to have identified all the species present in a habitat. Do you find more if you sample the top through the bottom layer than you would find just sampling the top layer in different sites?
    - What research questions would you want to answer next, based on these results? Consider conducting an actual field census on or near your school grounds.

Additional Information

<u>Smithsonian's National Zoo biodiversity websites</u>

- http://nationalzoo.si.edu/education/classroompartnerships/biodivmonpro
- http://nationalzoo.si.edu/conservationandscience/MAB/whatisbio.cfm

<u>Smithsonian entomology websites</u>

- http://www.si.edu/resource/faq/nmnh/buginfo
- http://nationalzoo.si.edu/Animals/Invertebrates/News/monarchmigration.cfm
- http://nationalzoo.si.edu/Publications/ZooGoer/2004/4/antfarmers.cfm

<u>Booklets on biodiversity in adobe acrobat format</u>

- http://nationalzoo.si.edu/ConservationAndScience/MAB/publications/biotapestry.pdf
- http://nationalzoo.si.edu/ConservationAndScience/MAB/publications/workingforbiodiv.pdf

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STUDENT DATA SHEET
Ground Insect Census Protocol and Species Classification Data

Date: ________________________ Location: ____

Habitat type category (forest / field / flowerbed / other): ____________________________

Protocol Assignments:

Field data collector 1: ____

Field data collector 2: ____

Sorter (parataxonomist) 1: ____

Sorter (parataxonomist) 2: ____

Recorder: ____

Instructions:

1. Select a protocol, based on how many soil layers you wish to sample (check one):
   - ❑ Minimum disturbance: Fresh leaf litter only (top layer)
   - ❑ Moderate disturbance: Leaf litter and humus (top and middle layers)
   - ❑ Full census / maximum disturbance: All three layers sampled: leaf, humus, soil

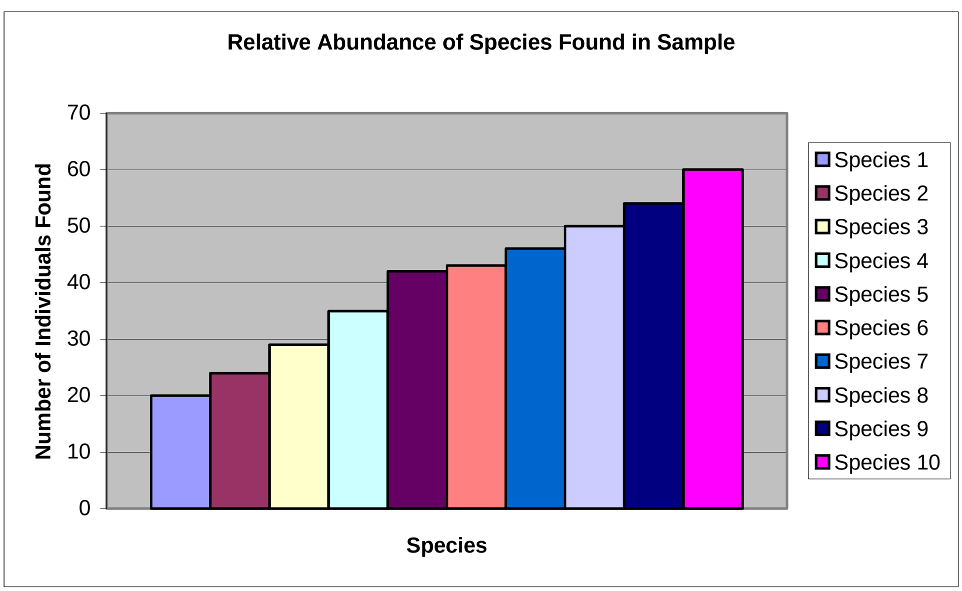
2. Field data collector(s) collect insects from each layer, keeping layers separate from one another.

3. Sorters (para-taxonomists) sort insects using a visual examination. Group works with sorters to determine "what is a species" (i.e., is "blue" a different species than "blue with yellow dot").

4. Record keeper records species information using the data sheet on page two of this protocol sheet.

5. Total the species abundance (the number of individuals per species) in the right hand column. Calculate species richness (how many species are in your sample) at the bottom of the table.

6. On a flip chart, create a bar graph showing relative abundance (a measure of biodiversity that compares how many individuals are in found for each species). The X-axis will represent the species in your census. The Y-axis will represent the number of individuals found for each species. Label your graph appropriately, and provide a legend. Following is an example of a graph for relative abundance:



7. Present your graph to the class.

DATA SHEET—Leaf Litter Insects

SPECIES Describe in detail. Example: 1. blue insects; 2. blue with yellow dots	**Top layer** Leaf litter	**Middle layer** Humus / decomposing leaves	**Lowest layer** Soil	**TOTAL INDIVIDUALS FOUND**
1:				
2:				
3:				
4:				
5:				
6:				
7:				
8:				
9:				
10:				
11:				
12:				
13:				
14:				
15:				
16:				
17:				
18:				

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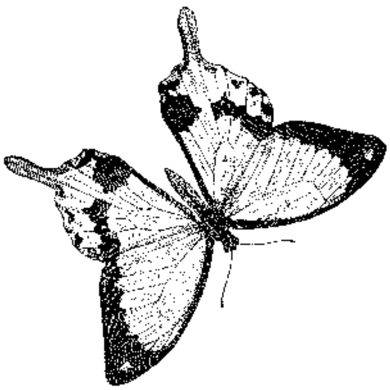
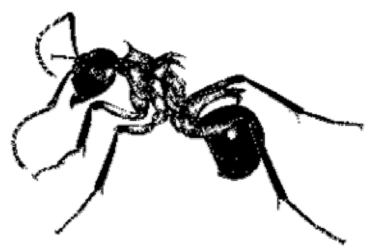
THE BIG, BIG WORLD OF INSECTS!

In the world today, we know that there are about 1.5 million species of living insects. However, even though that seems like a huge number, most scientists agree that there are more insect species that have not been discovered yet. A Smithsonian entomologist (an insect scientist) named Terry Erwin was discovering so many new species of insects every single day at his research site in Latin America that he estimated that there might be as many as 30 million species of living insects in the world today—most of them not discovered yet.



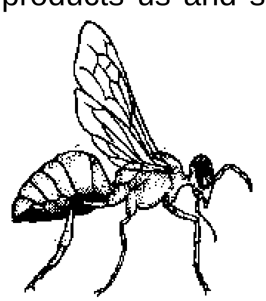
Insects probably have the largest biomass of all terrestrial animals (meaning that if you put all the bugs of the world on a huge scale, and compared their mass with that of all other terrestrial animals, insects would weigh more). It is estimated that there are 10 quintillion (10,000,000,000,000,000,000) insects alive right now on our planet. Another way to think of it is that there are 200 million insects for every human being on the planet. If you still don't get the picture, *The New York Times* recently claimed that the world holds 300 pounds of insects for every pound of humans. That's a lot of insects!

Insects are found almost everywhere on the planet — from the tropical rainforests, to the harsh dry deserts, to the frozen tundra. Insects exist just about everywhere expect in the ocean. They are successful because they can adapt to almost any environment. Some insects are adapted to be herbivores (plant eaters) while some are carnivores (meat eaters). Some live in the ground or under leaf litter, while some live in the forest canopy. Some insects are solitary, and some live in huge colonies (like ants and termites).



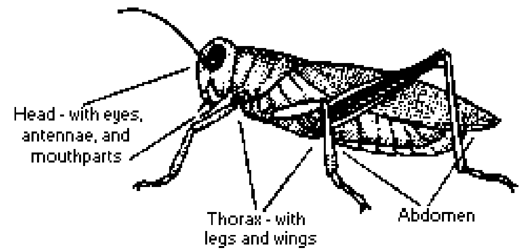
Insects often have a bad reputation and the interactions between humans and insects have not always been positive. Although some insects allow crops to grow, insects are responsible for their destruction. And in many parts of the world, a mosquito bite can be more than just annoying. Malaria, carried by a species of mosquito, kills an estimated two million people a year.

But in spite of all that, it is amazing to think how much humans actually rely on insects for the products us and services they provide. So many of the things we use in our lives rely on insects. Almost everyone knows that bees make honey, but did you know that almost all of the crops we grow are pollinated by insects? Without insects flying from plant to plant and transferring pollen, most of our flowering plants, including the fruits and vegetables that we eat every day, could not survive without this insect-related activity.

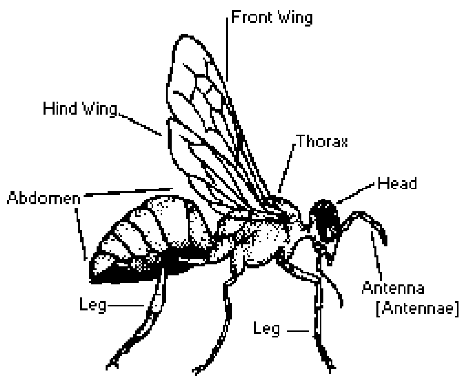


There is so much that we don't know about insects that scientists are working hard to study them around the globe. Because they exist in just about every ecosystem, it is possible to start an insect study on or near your school by using the same protocols (methods) that scientists used to document their numbers, behaviors, and diversity.

Insect parts



Even though insects are the most diverse creatures on earth, they all share certain features. Their bodies are made up of segments, which in the adult into three parts: head, thorax, and abdomen. (Spiders, by comparison, have only two main body segments.)



Insect heads have two compound eyes and two antennae, or "feelers". The thorax is where the legs and wings are attached. Adult insects have three pairs of legs, and most have two pairs of wings. Although there are many similar and related organisms—like spiders and scorpions and millipedes—none have all of the same traits that insects share.

Fun Facts about Bugs

- Flies find sugar with their feet, which are 10 million times more sensitive than human tongues.
- Ticks can grow from the size of a grain of rice to the size of a marble.
- Approximately 2,000 silkworm cocoons are needed to produce one pound of silk.
- While gathering food, a bee may fly up to 60 miles in one day.
- Ants can lift and carry more than 50 times their own weight.
- Mexican Jumping Beans actually have a caterpillar of a bean moth inside.
- It takes about one hundred Monarch Butterflies to weigh an ounce.
- A queen of a certain termite can lay 40,000 eggs per day.
- Honeybees make about ten million trips to collect enough nectar to make one pound of honey.
- Insects have been present on earth for 350 million years, humans for only 130,000 years.
- Beetles account for one quarter of all known species of plants and animals. There are more kinds of beetles than all plants.
- The term "honeymoon" comes from the Middle Ages, when a newly married couple was given enough honey wine to last for the first month of their marriage.
- To survive the cold winter months, many insects replace their body water with a chemical called glycerol, which acts as an "antifreeze" against the temperatures.
- There are as many species of ants (8,800) as there are species of birds (9,000).
- About one-third of all insect species are carnivorous, and most hunt for their food rather than eating decaying meat or dung.
- The oldest known fossil of an insect dates back 400 million years ago, and is a springtail.
- There are about 91,000 different kinds (species) of insects in the United States, and maybe another 73,000 that we haven't discovered, yet. In the world, there are 1.5 million kinds of insects known, and maybe 3 to 30 million that haven't been discovered.
- TEXAS INSECT—The State insect is the Monarch Butterfly (which is also the State insect for Alabama, Idaho, Illinois, Minnesota, and West Virginia). The Monarch is known to migrate huge distances, spending their winters in the southern United States and Mexico.

For more information about insects and Smithsonian science, check out:

www.si.edu/resource/faq/nmnh/buginfo