Lab 4

Using Detritus to Determine Arthropod Biodiversity in Relation to Ecosystem Type

Author/School: LeeAnn Hutchison, Easton High School, Easton, MD

Correlation

Miller 16th edition Chapter 4 and Chapters 3, 5, and 14

Acorn Book—Topic Outline in the APES Course

I. Earth Systems and Resources
   D. Soil and Soil Dynamics
II. The Living World
   C. Ecosystem Diversity
   D. Natural Ecosystem Change
III. Population
   A. Population Biology Concepts
VII. Global Change
   C. Loss of Biodiversity

Purpose

By studying the biodiversity of arthropods located on the school campus, you will be able to recognize the relationship between organism type and number to specific habitat.

Objectives

At the end of this lab, students will be able to:

1. Employ a proper field collection technique, use appropriate sampling methods, and utilize field guides effectively.
2. Use measurement devices for evaluating climatic conditions.
3. Preserve organisms and use proper microscopic technique for observation.
4. Use quantitative methods for measuring arthropod populations and calculate biodiversity using an accepted statistical formula.
5. Compile data and present findings, with interpretations, in a formal lab report, research paper, and/or electronic presentation.

Background Information

This activity is designed to study the biodiversity of arthropods located on the school campus and to help the student recognize the relationship between organism type and number to specific habitat. Phylum Arthropoda, which includes more than one million species, is the largest in the animal kingdom and is represented by nine classes of segmented animals with paired, jointed appendages and a hard exoskeleton. This activity integrates several concepts and teaches a variety of field and laboratory skills in a short period of time. Work is conducted outdoors for one class period and in the lab for at least two class periods. Some of the concepts include taxonomy, population dynamics, habitat and niche, soil types, forestry, climatic conditions, seasonal variance, animal behavior, and developmental biology. The skills accomplished include proper field collection techniques, sampling methods, calculation of biodiversity, preservation of organisms, microscopy, quantitative technique, and field guide use.

Biodiversity can be defined as variability among or variety of biota and the ecological complexes in which they are found. The term has meaning at a genetic level, a species level, and at a level of large taxonomic groups. In general, a high biodiversity indicates a healthy, stable ecosystem. Sampling a small area helps students generate inferences regarding the organisms present in the entire area. Students write their own hypotheses; however, a sample hypothesis is something to the

effect that some sites will be more diverse than others due to certain environmental factors such as moisture, temperature, or vegetative type. Another possible hypothesis may be something to the effect that abiotic factors can affect the species diversity of a certain site. Most students will recognize the relationship between plant leaf type, moistness of leaf litter and/or soil, amount of sunlight received, and effects of other influences on arthropod biodiversity. In summary, students will conduct their study with the intention of determining the factors affecting both quantitative and qualitative results.

Materials

Field Component—Day One (per team)

4 flags
tape measure
field guides to trees and shrubs
one-gallon ziplock bag
index card
clipboard
pencil & paper (or journal)
poster board & masking tape (Berlese funnel)
(Optional: wind meter, air thermometer, soil thermometer, sling psychrometer)

Laboratory Component—Days Two and Three (per team)

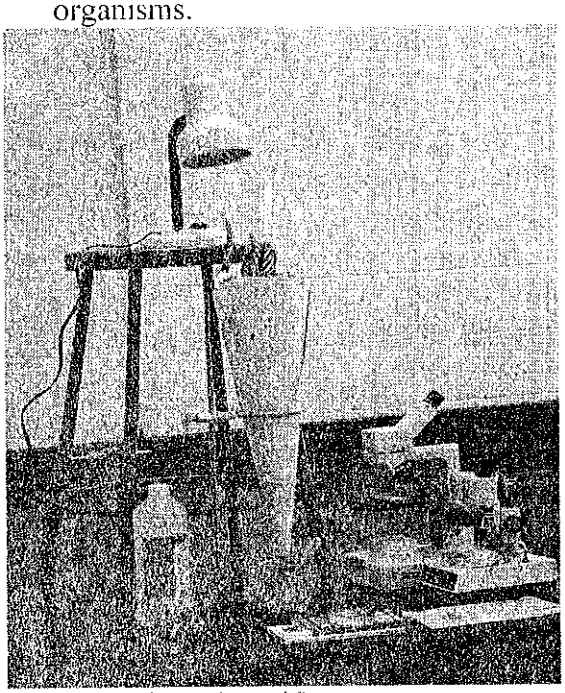
compound microscope
dissecting (binocular) microscope
depression slide
petri dish
pipet or dropper
forceps
isopropyl alcohol
Berlese funnel (constructed day one)
gooseneck lamp
ring stand
250 ml beaker
identification guides to arthropods

Procedure

Field Component & Lab Setup—Day One (See photo of experimental set-up on the next page.)

1. Students should be assigned to one of five sites on school grounds. Each site will have certain characteristics. If you require assessment of climatic conditions, have students measure the relative humidity with a sling psychrometer, the wind speed with a wind meter, and the temperature of air and soil using the appropriate thermometers.
2. Students should mark off their sites using an agreed upon method of sampling. If sampled properly, the diversity of organisms in one grid will be representative of the entire site and data can be extrapolated properly. A ten-meter square area works nicely. Steps 3 - 5 below can be time consuming—be sure they share the workload and give each team member a job!
3. Students should place flags at each of the four corners of the quadrat. Once the site is marked off, they should use field guides to identify the vegetation in their assigned sites. They should also map out the area, so that relation to varying vegetative types in the area can be verified later. See Student Page "Quadrat Data Collection Sheet." If time permits, have students categorize the trees into canopy, understory, and seedling.
4. On the index card, each team should name its site (i.e. East Campus Woods, Parking Lot Median, or Picnic Area) for purposes of discussion later. They should also give a description of the site which includes general observations such as predominant vegetative species, weather conditions, soil appearance, proximity to streams, rivers, or other natural area, anthropogenic influences adjacent to site (i.e. football field, road, parking lot), and any other descriptive words which make their site unique. Although anthropogenic influences are not the focus of this study, they may influence natural conditions.
5. Using a random method, leaf litter should be collected within the site and placed in a gallon ziplock bag, and identified with indelible marker as to group name/number, site name, date, and time.

6. Students will need about 10 minutes at the end of the class period to set up the lab apparatus inside. At your instruction, students should gather all field equipment and materials, as well as their leaf litter sample and return to the lab.
7. Once inside, each team should construct a Berlese Funnel out of poster board and masking tape. The paper is shaped into a funnel with a small enough bottom opening to trap all leaf litter inside, yet allow tiny arthropods to drop out. It is taped securely and then placed in a ring stand to hold it upright.
8. A gooseneck lamp is shined directly on the leaf litter for approximately two days to take advantage of negative phototaxis (the tendency to move away from light) exhibited by the leaf litter inhabitants. To get the lamp high enough above the funnel, you may need to stack several books or use a stool or some other stackable device.
9. A 250 ml beaker with 100 ml isopropyl alcohol is placed below the funnel to "catch" the organisms.



Berlese Funnel Experimental Setup

Note: Your teacher must turn off the lamps overnight and turn them back on the next morning. Organisms will begin dropping into alcohol within about 30 minutes; however, quantitative analysis is best postponed until the next day.

Lab Component—Days Two and Three

1. Retrieve organisms from the alcohol by forceps and/or pipet and place on slides, in culture dishes, or in Petri dishes to be identified and counted under the compound and/or dissecting microscope. Choice of microscope depends upon size of organisms collected. Hand lenses may also prove useful.
2. You should use arthropod identification guides, or if your teacher feels that specific identification is not necessary, descriptive names can be assigned and agreed upon prior to quantitative analysis.
3. Samples of each organism type can be mounted with glue on an index card for class display and ease of further identification.
4. Once all counts have been completed, biodiversity can be calculated by using the Shannon-Weiner Diversity Index (see reference section—Stiling. Also see formula and sample student data results below).
5. Your team should share its findings with the rest of the class by writing data on the board or by entering onto a desired computer format such as EXCEL and printing a copy for each of you to analyze, make interpretations, and write conclusions.

6. You should write a formal research paper, lab report, or give an electronic presentation as instructed by your teacher.

Data Analysis

Analyze your data by answering the following questions:

1. Can you find differences and similarities of the various quadrats (sites) studied by your class? For example, you may see some correlations between climatic conditions and vegetative type and the biodiversity of the sites.
2. Do arthropods seem to have a preference for certain conditions? These may or may not be evident. Specific comparisons of vegetation and associated organisms at different sites may help you make inferences. (i.e. termites in large quantities on a site with fallen logs might indicate that these organisms had a plentiful food source and thus reproduced prolifically....)
3. Do the biodiversity values give you a general idea of which sites were supposedly more stable and healthy? You should explore variables and factors which may or may not account for differences in results. This includes an analysis of team error.

Evaluation

Write a formal lab report or research paper as instructed by your teacher. Be certain you document evidence of your field component, including site descriptions, mapping, and measurements taken within each site. For the lab component, counts should be recorded in an organized format, and biodiversity calculations using the Shannon-Weiner Diversity Index should be shown. Interpretations should be discussed effectively in your formal research paper after sharing site data with your class and after making comparisons regarding the different site characteristics and respective biodiversity indices found.

Important Terms

Arthropod	Metamorphosis	Quantitative
Biodiversity	Negative Phototaxis	Shannon-Weiner Diversity Index
Detritus	Qualitative	Taxonomy

Additional Resources and References

Background Research Links

An introduction to the Arthropoda can be found at
www.ucmp.berkeley.edu/arthropoda/arthropoda.html

Information on biological communities, particularly microscopic soil arthropods can be found at
www.blm.gov/nstc/soil.arthropods

Information on biodiversity among arthropods can be found at
www.animaldiversity.ummz.umich.edu/arthropoda.html
www.werc.usgs.gov/socal/abstra.html
www.soils.usda.gov/squ/files/biodivers.pdf

A full color interactive dichotomous key to the common tree species can be found at
www.fw.vt.edu/dendro/forsite/Idtree.htm

Additional Resources

1. Leahy, C., R. White. 1987. *Peterson First Guide to Insects of North America.* Houghton Mifflin Co., Boston.
2. Levi, W., L. Levi, H. Zim. 1968. *Spiders and Their Kin.* Golden Press, NY.
3. Martin, Alexander C. 1987. *Weeds.* Golden Press, NY.
4. Milne, Lorus and Margery. 1980. *The Audubon Society Field Guide to North American Insects and Spiders.* Alfred A. Knopf, NY
5. Petrides, George A. 1988. *Peterson Field Guide to Eastern Trees.* Houghton Mifflin Co., NY

6. Stiling, Peter D. 1996. *Ecology: Theories and Practice*. Upper Saddle River, NJ: Prentice Hall. Pages 279-280.
7. Weisgerber, Robert A. 1995. *Science Success for Students With Disabilities*. Addison-Wesley Publishing Co., Ca.
8. Zim, H. and C. Cottam. 1987. *Insects*. Golden Press, NY

Calculating Shannon-Weiner Diversity Index

$$H' = -\sum p_i \times \ln p_i$$

Where

H' = The Shannon Index

$\sum$ = the sum of

p_i = frequency rating = n_i/N (ratio is how many of each kind divided by total count)

$\ln p_i$ = natural log of the frequency rating

Sample Student Data

Shannon-Weiner Diversity Index: Site #1 Windmill Branch Forest

Organism	n_i	p_i	$\ln p_i$	$p_i \times \ln p_i$
Subterranean Termite	5	5/24	–1.568	–0.3267
Thrip	3	3/24	–2.079	–0.259
Ground Beetle	1	1/24	–3.18	–0.132
Phalangidae	1	1/24	–3.18	–0.132
Swallowtail	1	1/24	–3.18	–0.132
Springtail	12	12/24	–0.693	–0.3465
Caddisfly	1	1/24	–3.18	–0.132
	$N = 24$			$H' = 1.4602$

Remember that the Shannon Index has a minus sign in the calculation, so the index actually becomes 1.4602, not –1.4602.

Values of the Shannon Diversity Index for real communities are often found to fall between 1.0 and 6.0.