INVESTIGATION

18

Shannon-Weiner Diversity Index

Lab

PURPOSE

- Collect and count organisms and species in several habitats
- Analyze and apply data to biodiversity problems using the Shannon-Weiner Diversity Index

BACKGROUND

A central theme in ecology is **biodiversity**, which often serves as a measure of the overall health of an ecosystem. Declining biodiversity can indicate that the ecosystem is undergoing some type of environmental stress. Further study can then help to pinpoint that stress.

There are many methods that ecologists use to calculate species diversity. The Shannon-Weiner Diversity Index is a common way of showing that diversity involves not only numbers of different species, but also how well each of these species is represented in different "habitats." The Shannon-Weiner value "H" can range from no diversity at 0.0 to a maximum diversity at 4.0. These values have no real meaning by themselves, but can be used to compare two communities or the same community at different times. The index was based on information theory developed some time ago by communication engineers. A large value of H indicates that if you randomly pick two organisms in your test area, the odds are the second individual will be different from the first. In this field investigation, your group will collect data and make calculations from the data. If you are unable to go outdoors to collect data as directed, ask your teacher for alternatives.

Materials

- index cards
- honey or other sweet bait
- tuna or cat food
- sealable bags
- hand lens
- table of natural logarithms

Optional (see **Extension***):*

- plywood
- saw

Procedure

Step 1 Place the names of the students in your group on the bottom of ten 6 × 9-in. index cards.

Step 2 Bait five index cards by smearing the named side with something sweet like honey. Bait the other five cards with tuna or cat food. Divide the cards into 5 pairs of the two bait types.

Step 3 Place the pairs of cards near each other, bait side down, in five different locations (in the grass, near trees or a building foundation, etc.). Pin the cards as close to the ground as possible to attract organisms to the food and prevent them from blowing away.

Step 4 Number each site for identification purposes. Draw a map of the area that includes your sites and label the map with the ID numbers.

Step 5 Make a table of data to record the biotic and abiotic conditions. Approximate the moisture level or wetness of your areas and determine the temperature of each site. Also record any other differences in the habitats, biotic or abiotic, that you can measure or describe and that may aid in your analysis at the end of the experiment.

Step 6 Leave the cards in place for at least 24 hours.

Step 7 Collect the cards by carefully slipping each into its own zip-lock or other air-sealed bag with the proper ID number on it. The bags can then be placed in the refrigerator or freezer until you are ready to make your counts.

Step 8 For each card, count the number of organism types, and the number of individuals of each type, and record them on your data table. It is not necessary to identify the organisms to the species level, but you must agree among yourselves on what different types there appear to be. A hand lens will help in making distinctions.

Calculations

The most common equation for the Shannon-Weiner Index is:

$$H = -\text{sum}\ (p_i \ln p_i)$$

where H = Shannon-Weiner Diversity Index
p_i = the ratio of the number of organisms of a species to the total number of organisms
$\ln p_i$ = the natural log of p_i

For each index card you used, complete a copy of the chart in **Fig. 18-1** to calculate an Index value.

Fig. 18-1

Index Calculation Chart

Species Name ($_i$) (or other ID type)	Number of that species in sample	p_i	$\ln(p_i)$	$(p_i)\ln(p_i)$
	$\frac{\quad}{\text{Total number from all species on card}}$	This column should add up to 1.00	Refer to natural log table	$H = \frac{\quad}{-\text{Sum of all } (p_i)\ln(p_i)}$

Analysis

1. Compare the same species at different sites.
   a. How do the biotic and abiotic factors seem to affect the number of species?

   b. How do the data suggest that there are species preferences for one type of food over the other? Evaluate the preference for one food compared to another.

2. Determine the differences in the Index values from one location to another.
   a. Describe what is different between the habitats.
   b. How do you think the moisture, temperature, and any other biotic or abiotic factors influenced your results?
   c. How do the data suggest that there may be a general preference for one type of food over the other? Evaluate the preference for one food compared to another.
   d. Describe how the Index values support your conclusions.

3. Describe how the Shannon-Weiner Diversity Index could be used to evaluate dinosaur and plant diversity in a Jurassic fossil bed from 150 million years ago and then also be compared to a fossil bed from the Cretaceous of 90 million years ago. Comment on the reliability of proposing theories based on such data.

4. Design an experiment by which you could evaluate the effect of an invasive plant species, such as purple loosestrife, on songbird diversity, using the Shannon-Weiner Diversity Index.

Analysis

Extension

Further develop your study of diversity with the following activity.

Step 1 Cut five different-sized squares of plywood to the following lengths per side:

15 cm 50 cm 1.0 m 1.5 m 2.0 m

Plywood is very durable when it rains and can be used year after year.

Step 2 Calculate the surface area of each plywood sheet in square meters and record it on a data table.

Step 3 Set the plywood out in similar locations in close contact with the ground for 5 to seven days.

Step 4 A week later collect all of the invertebrates that you find under each board. (*Lab Hint:* If possible take a digital picture as soon as you turn the board over, as some creatures will scurry away before they can be counted or collected.)

Calculation

Calculate the Diversity Index for the life forms on each different-sized board. Then describe the apparent effect of habitat size on diversity.

Analysis

1. Graph your data with the surface area plotted on the x-axis and the values of H plotted on the y-axis.
   - **a.** If you can take advantage of Excel, use the Chart Wizard to plot the data as a scatterplot.
   - **b.** Plot a regression line by clicking on your graph and then going to the Chart menu and selecting Add Trendline.
   - **c.** Look at your graph to determine what type of Trendline or regression you need and select it.
   - **d.** Use Options for displaying the equation for the Trendline and R-squared value, which is a reliability measure.
2. Conduct research on actual data for islands or long peninsulas. Compare your information as graphed to those data. Describe any similar patterns.