Using Microbial Ecology to Teach Experimental Design and Sampling Methods

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Exercise 1: Instructor Guide
Measuring Diversity

Materials needed

- A simulated "bag community" for each group, consisting of a lunch-size paper bag filled with different combinations of common objects such as beads, erasers, dry beans, etc. Hints for filling bags: include about 20 to 40 objects in each bag, use different proportions and numbers of selected components, include at least one bag with a large number of types of objects evenly distributed and another bag with only one type of object.
- Graph paper
- Computers (to allow use of Excel spreadsheets) or calculators

Part 1. Sampling a community: how many samples are enough?

The bag communities can be assembled from a wide variety of materials, depending upon the goals of the instructor. If an instructor wants to discuss the concept of operational taxonomic units for example, they might define "beads" as an operational taxonomic unit and include in the bag communities a variety of bead shapes that would all be grouped together. Alternatively beads of different shapes could be counted as separate species. It is also useful to vary the size and texture of different items to represent phenotypic diversity in a community. For example, by using pieces of string, small balloons, small pencil erasers, etc.

Bag communities should vary in their species richness and species evenness so that groups can compare different measures of diversity with one another. The number of individuals per community can be determined by the instructor, but it is recommended that there be at least 20 items in each bag. It is sometimes useful to add a very rare or very small member to a community to demonstrate how difficult it is to detect every type of organism in a community.

Graph paper for making the species sampling curves is available online. Alternatively students can use computers to make their graphs. Student groups can be asked to share their curves with the rest of the class (e.g., drawing them on a blackboard) to demonstrate how differently communities may appear. This also provides an opportunity for discussion of the questions in Step 4. The class should be able to determine that the only communities that have been adequately sampled are those with curves that have leveled off. In some cases it may be desirable for the students to resume sampling their communities and discussing the way the species sampling curve changes as the number of sampling events increases.

This process takes about 10 minutes, depending on how many times a group samples a community. It is important to sample at least 3 to 4 times so that students begin to see the effect of sampling effort on the conclusions about diversity.

Part II. Measuring diversity of a community

Graph paper for making the species sampling curves is available online. Alternatively students can use computers to make their graphs. Student groups should be given the opportunity to share their data with the rest of the class, for example making two big bar graphs on the blackboard that represent species richness and species evenness. Species richness, especially, is best understood when compared across different types of communities. This also provides an opportunity for discussion of the questions in Step 2.

A variety of diversity indexes can be calculated. Simpson's index of diversity is used in this exercise because of its simplicity. Simpson's index (D) is represented by the following equation:

$$D = 1-(\Sigma\ (n_i/N)^2)$$

where n_i is the number of individuals of species I, and N is the total number of individuals of all species. The calculation of n_i/N is referred to as proportional abundance (p) in the student version of the exercise, because it is a measure of the proportional representation of each species in the community. These values are squared and then subtracted from 1, resulting in values that range from 0 to 1, with higher numbers representing higher diversity.

See the example below. This part of the exercise takes approximately 20 minutes.

Sample calculations of Simpson's index of species diversity

Species	n	N	n/N	(n/N)2
n_1	6	36	0.17	0.03
n_2	6	36	0.17	0.03
n_3	6	36	0.17	0.03
n_4	6	36	0.17	0.03
n_5	6	36	0.17	0.03
n_6	6	36	0.17	0.03
				0.17
			Index:	0.83

Species	n	N	n/N	(n/N)2
n_1	6	36	0.17	0.03
n_2	8	36	0.22	0.05
n_3	4	36	0.11	0.01
n_4	0	36	0.00	0.00
n_5	12	36	0.33	0.11
n_6	10	36	0.28	0.08
				0.28
			Index:	0.72