Describing a population: leaf size of a plant at TSU wetland

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A. Overview Information

TITLE: Describing a population: leaf size of a plant at TSU wetland

ABSTRACT: Students will sample leaves from trees, shrubs or grasses, measure leaf size, and learn how to estimate mean, standard deviation, CV, and construct frequency table and histogram, the descriptive measures to describe a population. Students will be introduced to the concepts of population, sample, parameters, and statistics. Students will also learn different leaf structures of different plants, function of leaf. They will calculate mean, standard deviation, confidence interval, and write a lab report.

KEYWORD DESCRIPTORS

- **Ecological Topic Keywords:** leaf, foliage, photosynthesis, stomata, mesophyll cell, chloroplast
- **Science Methodological Skills Keywords:** data collection, statistical analysis, field work, formulating hypotheses, graphing data, scientific writing
- **Pedagogical Methods Keywords:** cooperative learning, group work assessment, guided inquiry, open-ended inquiry, project-based teaching

CLASS TIME: Three-hour lab sessions

OUTSIDE OF CLASS TIME: Students will spend 4 to 6 hours, primarily writing up the associated draft and final lab reports.

STUDENT PRODUCTS: Lab report (3-5 pages)

SETTING: This experiment is designed to measure plant leaves at TSU wetland, but can be used for plants on campus, or in other environmental conditions.

COURSE CONTEXT: This experiment can be used in an Ecology course.

INSTITUTION: Four-year, public, primarily undergraduate institution.

TRANSFERABILITY: This lab does not require instrument. Only rulers are needed.

ACKNOWLEDGEMENTS: This lab module was designed by Dr. Dafeng Hui. Funding for development and testing of the lab module was provided through awards from the NSF IUSE and TIP Program to D. Hui.

B. Synopsis of Lab Module

Principal Ecological Question Addressed: How to describe a population of leaf of a plant at TSU wetland?

What Happens: Before the lab meets, students read about the method to describe a population. During the lab session, students will go to wetland, select a plant species, develop a sampling method, and collect leaves of the plant. The leaves can be brought to lab and the length or width of leaves can be measured with rulers. Students will learn how to calculate mean, standard deviation, CV, 95% confidence interval, and construct a histogram, and write a lab report.

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

1. Understand the concept of population, sample, parameters and statistics
2. Learn how to calculate mean, variance, standard deviation, CV, confidence interval
3. Clearly communicate scientific results in writing and in the appropriate format

Equipment/ Logistics Required:

- No equipment is required
- A ruler to measure leaf length or width

Summary of What is Due:

- A formal, 3 to 5 page Lab Report written by individuals

C. Description of the Lab Activity

Introduction

Ecology is the ambitious attempt to understand life on a grand scale. Ecologists need to conduct measurements on different aspects of species. With measurement data, we can compare the growth rates of trees across a continent, under different conditions, or over a period of several years. Quantitative concepts such as average, variances, and probabilities reveal ecological patterns. In this lab, we will use a series of measurements and calculations to characterize a population. A **population** in biostatistics includes all of the elements from a set of data. A **sample** consists of a set of observations from the population. A measurable characteristic of a population, such as a mean or standard deviation, is called

a **parameter**; but a measurable characteristic of a sample is called a **statistic**. To better represent the population, a simple **random sample** is required. One random sample is that everyone in the population has equal opportunity for selection as a subject.

Descriptive statistics

Descriptive statistics describe, show or summarize data in a meaningful way such that patterns might emerge from the data. Descriptive statistics are very important because if we simply presented our raw data it would be hard to visulize what the data was showing, especially if there was a lot of it. Descriptive statistics therefore enables us to present the data in a more meaningful way, which allows simpler interpretation of the data.

Measures of central tendency: these are ways of describing the central position of a frequency distribution for a group of data. We can describe this central position using a number of statistics, including the mode, median, and mean.

Mean (Arithmetic)

The mean (or average) is the most popular and well known measure of central tendency. The mean is equal to the sum of all the values in the data set divided by the number of values in the data set. If we have n values in a data set and they have values x1, x2, ..., xn, the sample mean, usually denoted by $\bar{x}$ (pronounced x bar), is:

$$\bar{x} = \frac{(x_1 + x_2 + \cdots + x_n)}{n}$$

Or

$$\bar{x} = \frac{\sum x}{n}$$

This is for sample mean. For population mean, we use the Greek lower case letter "mu", denoted as μ:

$$\mu = \frac{\sum x}{n}$$

The mean is essentially a model of your data set. It is the value that is most common. You will notice, however, that the mean is not often one of the actual values that you have observed in your data set. However, one of its important properties is that it minimises error in the prediction of any one value in your data set. That is, it is the value that produces the lowest amount of error from all other values in the data set.

The Median is the score found at the exact middle of the set of values. One way to compute the median is to list all scores in numerical order, and then locate the score in the center of the sample. For example, if there are 500 scores in the list, score #250 would be the median. If we order the 8 scores shown above, we would get:

15,15,15,20,20,21,25,36

There are 8 scores and score #4 and #5 represent the halfway point. Since both of these scores are 20, the median is 20. If the two middle scores had different values, you would have to interpolate to determine the median.

The mode is the most frequently occurring value in the set of scores. To determine the mode, you might again order the scores as shown above, and then count each one. The most frequently occurring value is the mode. In our example, the value 15 occurs three times and is the model. In some distributions there is more than one modal value. For instance, in a bimodal distribution there are two values that occur most frequently.

Measures of dispersion: Dispersion refers to the spread of the values around the central tendency. There are several common measures of dispersion, the range, variance, standard deviation, and coefficient of variance. Variance for a small population is defined and calculated as:

$$variance = \frac{\sum(X-\mu)^2}{N}$$

$$= \frac{21188.75}{100}$$

$$= 211.89$$

Where μ = mean, X = score, ∑= the sum of, N = number of scores, ∑X = "add up all the scores"

The population standard deviation formula is:

$$\sigma = \sqrt{\frac{\sum(X-\mu)^2}{n}}$$

where,
σ = population standard deviation
$\sum$ = sum of...
μ = population mean
n = number of scores in population.

The sample standard deviation formula is:

$$s = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$

where,
s = sample standard deviation
$\sum$ = sum of...
$\bar{X}$ = sample mean
n = number of scores in sample.

Coefficient of variation (CV). The coefficient of variation, or CV is calculated as follows:

$$CV\% = (SD/Xbar)*100$$

CV is mostly used when comparing samples with large differences in means.

Leaf size

Leaves are a plant's main photosynthesis organ, the most one of most vascular plants. Leaf structure is closely associated with its photosynthesis function. Plants are autotrophic, and they can use carbon dioxide, water and light energy to create their own organic matter through photosynthesis to produce simple sugars, such as glucose and sucrose. These are then further processed by chemical synthesis into more complex organic molecules such as cellulose, the basic structural material in plant cell walls. To perform photosynthesis, plant must bring these three ingredients (CO2, light and water) together in the leaf.

The leaves draw water from the ground in the transpiration process through xylem and obtain carbon dioxide from the atmosphere by diffusion through stomata, while leaves are orientated to maximize their exposure to sunlight. The synthesized carbonhydrates are transported to plant shorts and roots for their growths through phloem. The phloem and xylem are parallel to each other but the transport of materials is usually in opposite directions.

Leaves have different sizes and shapes. Typically leaves are broad, flat and thin, thereby maximizing the surface area directly exposed to light and enabling the light to penetrate the tissues and reach the chloroplasts, thus promoting photosynthesis. They are arranged on the plant so as to expose their surfaces to light as efficiently as possible without shading each other, but there are many exceptions and complications. For instance plants adapted to windy conditions may have pendent leaves, such as in many willows and eucalyptss. The flat, or laminar, shape also maximises thermal contact with the surrounding air, promoting cooling. Functionally, in addition to photosynthesis the leaf is the principal site of transpiration and guttation.

Coniferous plants have thin needle-like leaves that can be advantageous in cold climates with frequent snow and frost. These are interpreted as reduced from megaphyllous leaves of their ancestors. Some leaf forms are adapted to modulate the amount of light they absorb to avoid or mitigate excessive heat, ultraviolet damage, or desiccation, or to sacrifice light-absorption efficiency in favour of protection from herbivory.

Figure 1. A leaf shed in autumn.

Deciduous plants in frigid or cold temperate regions typically shed their leaves in autumn, whereas in areas with a severe dry season, some plants may shed their leaves until the dry season ends. In contrast, many other non-seasonal plants, such as palms and conifers, retain their leaves for long periods; Welwitschia retains its two main leaves throughout a lifetime that may exceed a thousand years.

Materials and Methods

Study Site:

TSU wetland at the Agricultural Research and Demonstration Center (Latitude 36.12'N, Longitude 86.89'W, Elevation 127.6 m) in Nashville, Tennessee provides variety of plant species students can choose. Students may either select broad-leaf species, or needle-leaf plants.

Overview of Data Collection and Analysis Methods

1. Learn the structure of leaf
2. Understand sampling method and random sample
3. Learn how to calculate descriptive statistics such as mean, variance, standard deviation, and CV
4. Measure the width of leaf or length of leaf for needle leaf.

Homework:
Write a lab report using the proper format. Your Instructor will assign a due date for the lab report.

Questions for Further Thought and Discussion

1. Why are there different type of leaves?
2. Which factors influence the shape of leaf? How ages and canopy layers would influence leaf structure and size?

References

Betts RA, Cox PM, Lee SE, Woodward FI. 1997. Contrasting physiological and structural vegetation feedbacks in climate change simulations. Nature 387: 796–799.

Chuck G, Lincoln C, Hake S. 1996. KNAT1 induces lobed leaves with ectopic meristems when overexpressed in Arabidopsis. Plant Cell 3: 801–807.

Davidson DW, McKey D. 1993. Ant–plant symbioses : stalking the Chuyachaqui. Trends in Ecology and Evolution 8: 326–332.

Evans JR. 1999. Leaf anatomy enables more equal access to light and CO2 between chloroplasts. New Phytologist 143: 93–104.

Parkhurst DF, Loucks OL. 1972. Optimal leaf size in relation to environment. Journal of Ecology 60: 505–537.

Poorter H, de Jong R. 1999. A comparison of specific leaf area, chemical composition and leaf construction costs of field plants from 15 habitats differing in productivity. New Phytologist 143:163–176.

Tools for Assessment of Student Learning Outcomes:

Assessment

Students will be assessed through the written lab report. The lab report will be used to test your comprehension of the principles behind soil respiration and your ability to communicate in writing in proper scientific format.

Experimental Design Guidelines
Lab Report Guidelines

Sample Exam Questions

Q. Dispersion of data can be described using measures such as _____ and _____.

A. *Range, variance, standard deviation, CV (any two of them)*

D. Comments to Faculty Users

Descriptive Statistics

Introducing the Descriptive Statistics to Your Students

Typically the introductory material can be covered in Biostat course, but most of students in ecology class did not take Biostat before the lab activity, thus, the basic description of definition and calculations need to be provided before the lab. In lab we begin indoors where the concepts can be reviewed briefly. Students will discuss the leaf and develop a sampling plan before we move to outdoor. After data collection, they need to do calculations and write a lab report.

Data Collection and Analysis Methods Used in the Experiment

Data collection is relatively simple. But students need to identify plant species, and collect at least 80 leaves.
Weather is an important consideration. If rain, leaves may be collected before class form wetland.

Questions for Further Thought

1. Instructors may need to help students by design a table for data collection and calculation. This will help them organize data collected.
2. Depending on resource availability, some statistical analysis software may be introduced. Students may also use Excel for data calculation and construction of frequency distribution and chart.

Comments on Formative Evaluation of this Experiment

The formative evaluation is a Quiz/Survey given at the beginning of Lab. It is intended to assess the degree to which they have achieved learning objective and also to identify any problem areas. The quiz portion contains five objective questions to assess content knowledge. The survey portion contains two questions asking students about 1) anything that is not clear, 2) the hardest part of the activity so far. No grade was associated with the quiz in my courses but an instructor could use it as a graded assignment.

Comments on Translating the Activity to Other Institutional Scales or Locations:

The experiment can be adapted for indoors when the weather does not cooperate.

E. Appendix