How-To-Do-It

Would You Trust a Bryophyte for Directions?

A Field Exercise for Determining the Distribution of Moss on Trees

Lissa M. Leege

Every introductory biology course preaches the importance of scientific method, but often students do not have the opportunity to develop and test scientific questions in those very courses. For example, published lab manuals for the traditional "survey of the kingdoms" course rarely recommend little more than that students observe live and preserved materials and prepared slides in the lab. I designed the following field exercise both to illustrate the ecological requirements of a group of organisms (the mosses) and to allow students to test a hypothesis so popular that it has made its way into folklore: "Moss only grows on the north side of trees."

The bryophytes, plants such as mosses and liverworts that lack vascular tissue and depend upon water for fertilization, are an excellent subject for study in the field because they are abundant and they are present yearround. One might predict that mosses would be more abundant in moist, shady locations than in dry, sunny habitats because they are tied to water for survival and reproduction. The physiological dependence of mosses on water, coupled with the inclination of the sun in the northern hemisphere underlies the biological explanation for the folklore belief that moss grows only on the north side of trees. In the northern hemisphere, solar radiation strikes south-facing objects directly, while the north-facing objects are shaded from the sun throughout the day. This phenomenon results in hotter, drier microclimates on south-facing structures, and wetter, cooler microclimates on north-facing structures. It has consequences for everything from the location of ski slopes (north facing slopes to avoid snow melt) to the best windows for house plants (south facing because the sun shines on them all day). Does aspect (north or south-facing) also dictate the distribution of moss on trees? In other words, would you trust a bryophyte for directions?

Once students have been introduced to key characteristics of a particular group of organisms, it becomes possible to develop hypotheses about the ecological consequences of these characteristics. With rare exceptions, the distribution of a species in nature is inextricably tied to its physiological limitations. In order to train good scientists, we must teach our students to ask research questions and give them practice testing those questions and analyzing the results.

In this field exercise, students are challenged to test the hypothesis that moss grows preferentially on the north side of trees. The exercise clearly accomplishes two goals:

1. It involves students in the process of science: students ask a scientific question and test a hypothesis by collecting and analyzing data.
2. It illustrates how the key morphological and physiological characteristics of mosses result in ecological consequences that predict their distribution in the field.

For the university level introductory majors' course, I give the students the following information.

Background

Folk wisdom indicates that moss grows only on the north side of trees. Native Americans and North American pioneers are said to have found their way through deep forests by using the location of moss on tree trunks as a compass that pointed them north. In this exercise, we will be investigating this hypothesis using trees growing on our campus.

How does the north side of a tree differ from the south side? What do you know about the environmental requirements of moss that would restrict its distribution to the north side of trees? If you were in the southern hemisphere would your prediction change? Why or why not? What is your hypothesis for this study? Your prediction?

Suggested Protocol

Test your hypothesis by recording the location and abundance of moss on trees on the campus.

1. Split up into teams of four students and spread out across the campus. Each team will need a COMPASS, TAPE MEASURE, GRID (a transparency marked with 100—1 cm x 1 cm squares), and DATA SHEET.
2. In a systematic manner, sample a series of 10 trees (or as many as time allows).
3. Fill out the data sheet for each tree, indicating the species of tree and the number of squares in each grid with moss present at 0.5 m above the ground on the tree trunk on north and south sides of the tree. Include notes on observations you make on any abnormalities for each sample.
4. Calculate the percent cover of moss for each sample (100 * # squares with moss/total # of squares in the grid). Determine

Lissa M. Leege is an Assistant Professor in the Department of Biology at Georgia Southern University, Statesboro, GA 30460; e-mail: leege@gsaix2.cc.GaSoU.EDU.

the average percent cover of moss for the north side of the tree and the south side of the tree (add up all the samples and divide by the total # of trees sampled).

5. Use a Wilcoxon Signed Rank Test to analyze your moss distribution data.

Statistical Analysis: Wilcoxon Signed Rank Test

Statistics are used to tell us how convinced we should be that our results are not due to chance, but rather to some experimental treatment or other factors (i.e. location in relation to the sun) that we think are important. Without statistical support, our conclusions are merely speculative.

The Wilcoxon Signed Rank Test is a statistical analysis that can be used to compare differences between paired samples. For example, you might want to know if people improved their test scores after taking a class, or if the IQs of first and second born twins are similar. The statistical null hypothesis of this test is that there is no difference between the pairs (taking a class did not improve test scores, first and second born twins do not have different IQs).

The statistical procedure (based on Sokal & Rohlf 1995) follows:

1. Calculate the differences between the n pairs of observations and record in a third column: (e.g. Percent moss cover on north side of Tree #1 − cover on south side of Tree #1.).
2. Rank the numbers from low to high, beginning with 1 and IGNORING THE SIGN. If there is a tie (observations having the same value), each of the values is assigned the average value of the rank. For example, north and south both have zero values that would normally receive the rank of 1. Instead of 1, however, each is assigned the average between 1 and 2, which is 1.5. The rank of 2 is skipped over (because you have already ranked two samples) and you proceed with the rank of 3.
3. Assign to the ranks the original signs of the differences.
4. Add the positive and negative ranks separately. The sum that is smaller in absolute value, T_s, is compared with the values for your sample size of trees (n) in a Table of Critical values of the Wilcoxon rank sum (See Table V: Critical values of the Wilcoxon rank sum: Rohlf & Sokal 1995, or a similar table in any other compendium of statistical tables). For example:

Tree	*North*	*South*	*Difference*	*Rank*
1	0	1.5	−1.5	−1
2	35	18	+17	+3
3	67	27	+40	+6
4	68	38	+30	+5
5	30	20	+10	+2
6	40	20	+20	+4

Sum of + ranks = 20;
Sum of − ranks = 1
T_s = 1; n = 6 trees

5. If your T_s value is equal to or less than the value in the table for the corresponding sample size, the pairs are different at the α level listed. This indicates that the differences between the pairs are too great to be attributed reasonably to chance. If the T_s value is greater than the value in the table, the pairs do not differ statistically and the differences can be attributed to chance.
6. The alpha (α) value tells you the probability of obtaining the T_s value by chance alone. Therefore, if $\alpha = .05$, then there is only a 5% chance that the difference is due to chance alone; or you can state with 95% confidence that the paired values differ from each other. Generally in biological studies, $\alpha \leq 0.05$ is the value used to determine if the differences are statistically significant.

   For example: $T_s = 1$; $n = 6$

   T_s is equal to 1, the value in the table for $n = 6$. Since $\alpha = .0312$, there is a 3.12% probability that these differences are due to chance. Therefore the pairs differ (at $\alpha \leq 0.05$) and one side of the tree has less moss than the other.

Interpretation of Results

The following questions can be used to help students understand the outcome of this experiment and to prepare them to write up their results.

- How do mosses transport water? How do they reproduce? Explain why you might expect moss to grow on the north side of a tree and not on the south.
- Did moss abundance differ between north and south sides of the trees? On which side of the tree was moss most abundant? Least abundant?
- Show your Wilcoxon rank sum test results (differences for each pair, ranks for each difference, calculation of T_s values, critical value from the table, whether you accept or reject the null hypothesis that moss is equally abundant on the north and south sides of trees on campus).
- Interpret your results. Is the experimental hypothesis supported or rejected by your data? What does this mean in terms of where moss is distributed on tree trunks?
- Why is it important to analyze your data statistically?
- Do you see any difference in the ability of moss to colonize different tree species? If so, what might be the cause of this?
- Do you expect that the outcome of this investigation would have been different if the study was done in a much more densely forested site? Why or why not?
- If you were to get lost in a forest without a compass, would you depend upon the distribution of moss to find out which direction is north? Why or why not?

Possible Extensions

I have used this field exercise most often in an introductory majors' Biology of Organisms course, but have also modified it for use in an upper level Biology of Plants course. In the upper level course, the focus on bryophyte characteristics is secondary to the act of investigating interesting questions. Students are asked to observe the patterns of moss distribution on trees and to formulate a group question for which they will then design a test. Students have generated questions about the effects of host tree species (deciduous vs. evergreen), aspect (the four cardinal directions), location relative to the ground (low vs. high), and many more factors on the abundance of moss. We have used two- and three-way ANOVAs to determine the relationship between these factors and the distribution of moss on trees.

Conclusions

This is an enjoyable field exercise that always produces interesting results and stimulates student interest. The data collection can be completed in under 45 minutes and the explanation of the statistical procedure in about 15 to 20 minutes. The exercise gets the students into the field to ask some biological questions and to actually participate in the process of science. Not only do students have an opportunity to see live moss in its natural habitat where often both the sporophyte and gametophyte generations are present, they also get a chance to learn some common tree species. More importantly, they gain some experience testing a hypothesis and finally make the connection between physiology and its ecological consequences as illustrated by the distribution of mosses.

Acknowledgments

I would like to thank Ann Pratt, Sophie George, Janice Grumbles and Don Drapalik for their comments on earlier versions of this field exercise, and thanks to Ray Chandler for his statistical advice.

References

Rohlf, F.J. & Sokal, R.R. (1995). *Statistical Tables, 3rd ed.* New York: W.H. Freeman and Co.

Sokal, R.R. & Rohlf, F.J. (1995). *Biometry: the Principles and Practice of Statistics in Biological Research, 3rd ed.* New York: W.H. Freeman and Co.

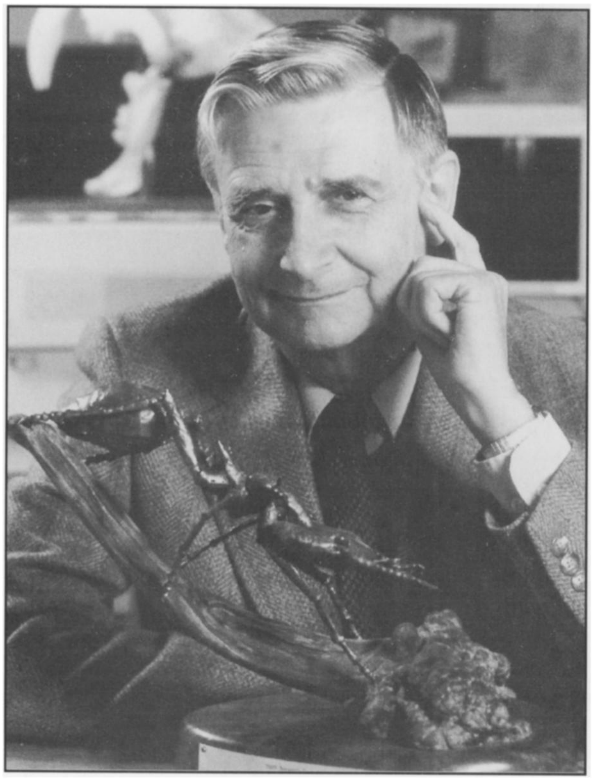

Photo by John Chase

An Evening with E. O. Wilson . . .

Come to NABT's 2001 Montréal Meeting and have dinner with Edward O. Wilson. Wilson will be the guest speaker at the Annual Banquet, Saturday, November 10, as well as NABT's Distinguished Service Award Recipient.

Edward O. Wilson is University Research Professor and Honorary Curator in Entomology of the Museum of Comparative Zoology at Harvard University. He is the author of two Pulitzer Prize-winning books, *On Human Nature* (1978) and *The Ants* (1990, with Bert Höldobler), as well as the recipient of many fellowships, honors, and awards, including the 1977 National Medal of Science, the Crafoord Prize from the Royal Swedish Academy of Sciences (1990), the International Prize for Biology from Japan (1993), and, for his conservation efforts, the Gold Medal of the World-wide Fund for Nature (1990) and the Audubon Medal of the National Audubon Society (1995).

He is on the Board of Directors of The Nature Conservancy, Conservation International, and the American Museum of Natural History, and gives many lectures throughout the world. His most recent book is *Consilience* (1998).