Chapter 8

Developmental Plasticity in Oak Leaves

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Introduction

This exercise illustrates one aspect of how leaves in multilayered trees take advantage of light microenvironments. The exercise consistently yields good results and requires little equipment. The setup time is minimal, but the procedure requires two labs that are at least 1 day apart. In the first lab, leaves are collected on a field trip. The leaves are dried overnight or longer, and data are collected from them in a subsequent lab. Working in groups of four, students can complete the second lab within 3 hours.

Materials

For each group of four students:

Plant press (1)
Graph paper, 1-cm lined (20 sheets)
A computer with statistical analysis software (*t*-tests or Mann-Whitney U tests)

For the entire class:

An electronic balance accurate to 0.1 g

Student Outline

Many species of trees are adapted so that sunlight penetrates the interior of the canopy and shaded leaves maintain a high photosynthetic rate. The relationship between light intensity and photosynthesis is curvilinear (Figure 8.1); thus, a leaf does not have to be in full sunlight to photosynthesize at a maximal rate. Any leaf receiving about 250 w/m^2 of sunlight, even if partially shaded, will photosynthesize as well as leaves that are more exposed.

A tree with a large canopy should avoid excessive shading of the interior leaves. In some species, this is done by varying leaf shape according to location in the canopy. Leaves in exposed areas have larger sinuses (open spaces) that allow much of the light to penetrate to the interior; leaves in the deeper layers are shaped to intercept most of the light received (Figure 8.2). In addition, leaves on the canopy edge have thicker layers of photosynthesizing cells because intense sunlight penetrates the leaf to a greater depth (Chabot et al., 1979).

From these principles one can formulate two testable hypotheses: (1) The ratio of sinus area to leaf area should be significantly greater for exposed leaves than for leaves in the shaded interior a canopy.
(2) Specific leaf weight (g/m^2) should follow the same trend. Specific leaf weight is representative of leaf thickness.

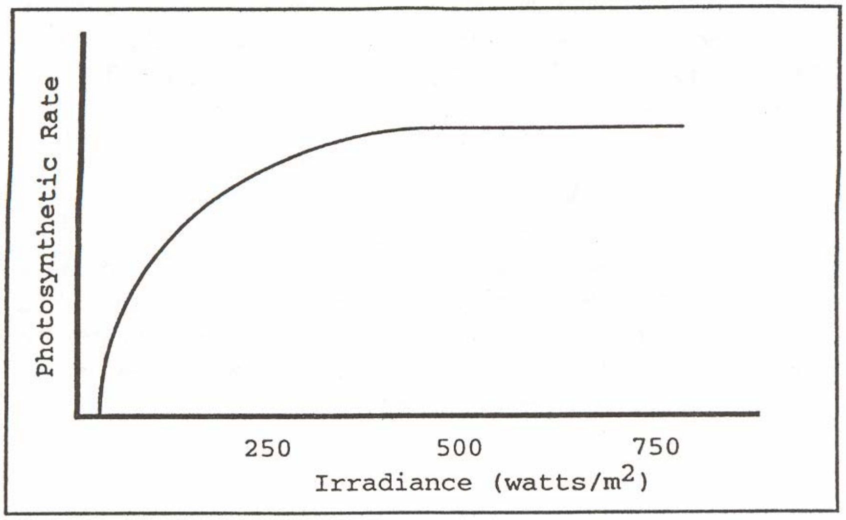

Figure 8.1. The rate of photosynthesis is affected by light intensity up to about 250 watts/m^2; from that point on, light intensity has no effect on photosynthesis.

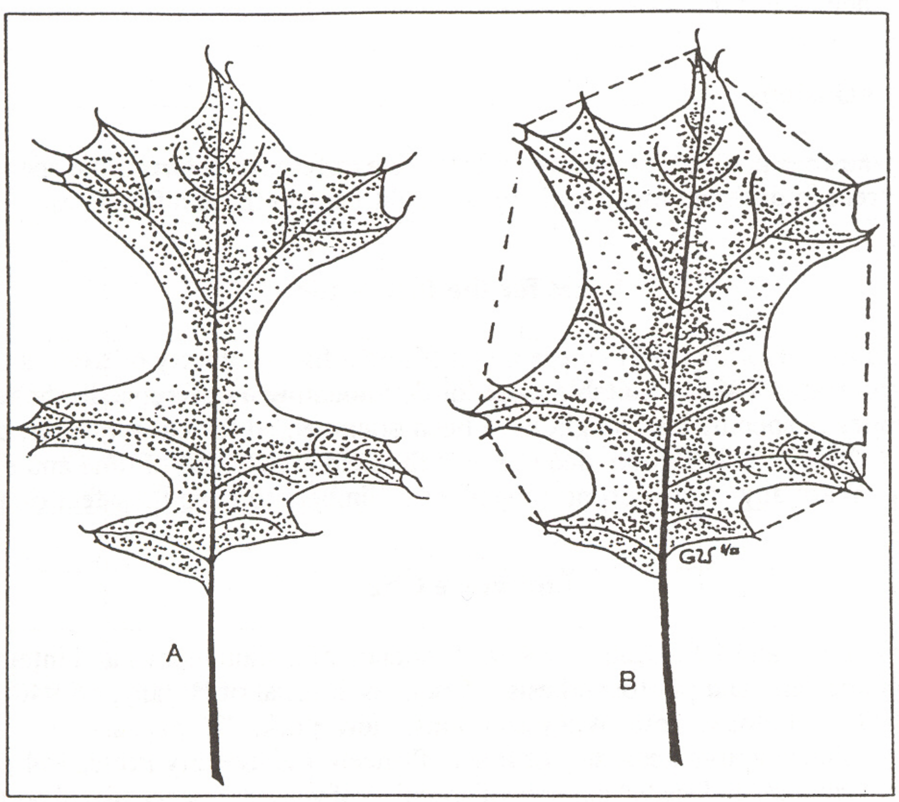

Figure 8.2. Change in leaf shape associated with the position in the canopy. (A) A sun leaf tends to have deeper sinuses; (B) a shade leaf has large lobes and shallow sinuses.

Step 1: Collect the Leaves

Choose a tree with a full crown that can be reached from the ground. Collect 10 sun leaves from the outside edge of the canopy, and 10 shade leaves from darkest part of the interior. Avoid leaves that have been partially eaten by insects. Label the leaves “Sun” or “Shade”. Then, put the leaves into a plant press to be dried overnight.

Step 2: Quantify Leaf Shape and Weight

To calculate leaf area, trace the leaves on centimeter-lined graph paper. Count the squares to calculate the leaf area. Record the data in Table 8.1. Calculate the sinus area by connecting the leaf lobes with a straight line and summing the inscribed areas (Figure 8.2). Divide sinus area by leaf area to get the shape ratio. A high number represents a leaf with deep sinuses and narrow lobes.

Weigh each leaf to 0.1 g and divide the weight by leaf area.

Step 3: Data Analysis

Enter the data into a computer program, creating separate columns for the type of leaf, the shape ratio, and specific leaf weight (Table 8.1). Use boxplots to compare the shape ratios and specific leaf weights between sun and shade leaves. Then, follow with *t*-tests or Mann-Whitney U-tests to determine whether the differences are statistically significant.

Step 4: Draw Conclusions

Were the hypotheses supported, or rejected? Is there a difference between the species of trees you used, or between trees in different locations? What might explain these differences?

Notes for the Instructor

The exercise follows Horn’s (1971) ideas about the adaptive geometry of trees; a useful summary is presented in Collinveaux (1986). Suitable trees for documenting a difference in shape ratio are oaks and maples. Changes in specific leaf weight have been documented for oaks, maples, birches, aspens, and beeches (Jurik, 1986). It is a good idea to scout the field area ahead of time and select trees with full, low canopies. Warn any “testosterone-driven” tree climbers to keep their feet on the ground.

Literature Cited

Chabot, B. F., T. W. Jurik, and J. F. Chabot. 1979. Influence of instantaneous and integrated light-flux density on leaf anatomy and photosynthesis. American Journal of Botany, 66:940–945.

Collinveaux, P. 1986. Ecology. John Wiley and Sons, New York, 725 pages.

Horn, H. D. 1971. The adaptive geometry of trees. Princeton University Press, 144 pages.

Jurik, T. W. 1986. Temporal and spatial patterns of specific leaf weight in successional northern hardwood tree species. American Journal of Botany, 73:1083–1092.

Table 8.1. One datasheet is completed by each group, then entered into a computer program. The complete data file should include the data from all groups.

	A	B	C	D	E	F
1	Leaf type	Leaf area	Sinus area	Shape ratio	Leaf weight	Weight/cm^2
2		(sq. cm)	(sq. cm)		(g)	
3	Sun					
4	Sun					
5	Sun					
6	Sun					
7	Sun					
8	Sun					
9	Sun					
10	Sun					
11	Sun					
12	Sun					
13	Shade					
14	Shade					
15	Shade					
16	Shade					
17	Shade					
18	Shade					
19	Shade					
20	Shade					
21	Shade					
22	Shade					