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A Laboratory Experiment that Demonstrates the “Ratio Problem” for an Undergraduate Introductory Biology Laboratory

Scientists regularly use ratios, but they should be interpreted carefully. Comparing ratios is appropriate, only if the plot of the denominator vs. the numerator is linear with a zero intercept. If not true, ratios depend on denominator size, making a ratio-based evaluation misleading. The purpose of this project is to develop a simple laboratory experiment, using cowpea (*Vigna unguiculata*) plants, that freshmen Biology majors can conduct to demonstrate ratio problems. We hypothesized that students will misinterpret results, if unaware of ratio difficulties.

Cotyledons are the first leaves (within seeds) and provide developing plants with stored nutrients required for early growth. We evaluated how cotyledon removal and additions of phosphorus (P) and nitrogen (N) alter dry-matter partitioning between plants' roots and shoots. Students will hypothesize that plants with cotyledons left intact will have smaller root-shoot ratios because more reserves are available for shoot development, adding P would produce lower root-shoot ratios, and that N addition would have no effect. Results of this experiment would confirm most of the students' hypotheses. However, reanalysis of the data would suggest the hypotheses confirmation is an artifact due to a mathematical quirk.

For example, in this study, removing cotyledons increased root-shoot ratios. However, when evaluating plants of similar size, plants without cotyledons had smaller roots. Students will learn the importance of careful data interpretation, as they will realize that their final conclusion is the opposite of what they originally proposed. This data will be used in the UOG introductory biology lab (BI 158L) this fall.

Key Words: covariance, ratio alternatives, regression, spurious relationships, statistics