

## Teaching Heritability Using Butterfly Images: Real Organisms, Real Measurements

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### Introduction

We have developed a free, downloadable program [website for program download: [www.tinyurl.com/butterflygeneticslab](http://www.tinyurl.com/butterflygeneticslab)] that uses digitized images of butterfly wings (*Precis coenia*) from parent-offspring pairs as a platform that allows students to measure physical traits and calculate the heritability for that trait. Students are able to choose the trait they wish to measure, such as eyespot diameter or distance between wing bars, measure the trait using an on-screen data capture tool, and then export measurements into a spreadsheet or statistical package for analysis. The basic lab exercise is suitable for introductory majors biology and sophomore level genetics classes. Advanced genetics classes can perform more detailed analyses such as which categories of traits have higher heritabilities. Activities based on this program can be used as a lab activity to be completed in a 3-hour time block or as lecture supplements. Student handouts and instructor support materials, including pre-lab Powerpoint slides and formatted sample data sets are available from JRV.

### Program interface and brief methods

Students should be instructed on the number of families to measure – the program allows for selection of up to 40 families in 10-family intervals. We recommend measuring 20 families (80 individuals) per trait if the activity is to be done in a 3-hour lab section. Students can measure and analyze two or three traits for 20 families in a single lab period. Instructors should use 10 families for demonstration purposes. Presentation of individuals is randomized so members of a single family are not measured in succession. The program forces the user to measure wing size for each image prior to measuring the chosen trait. Beginning students do not need to correct for wing size to analyze the heritability of traits, but more advanced students with appropriate statistical background can. After data capture, students export data to Excel in a tab-delimited format, with columns for individual (mother,

father, son, and daughter), family ID, wing measure, and trait measure. Students will need to format data tables and calculate averages.

**Brief instructional suggestions:**

- Provide background in lecture or pre-lab on quantitative traits and heritability
- Pre-lab introduction to butterfly traits followed by demo of trait measurement using 10 families on a screen visible to students
- Demonstration by instructor on data formatting and analysis
- Materials necessary: Pre-loaded program (or on CD) on individual student computers (if using laptops, make sure they can be plugged in – it's a bit of a battery drain).
- Instructor posed question: Which traits have higher heritability? Let students brainstorm.  
Possible ideas: structural wing traits vs. color traits, etc.
- Other investigations: Even if students do not correct for wing size, they can investigate whether wing size and trait values are correlated. Is there evidence of assortative mating between males and females?
- More advanced uses: estimate sex-specific heritabilities, G-matrix. The program may even be used with a user's own images (see Hacking the System <http://www.treytronics.org/~paulsen/butterflyLab/hackTheSystem.html>)
- Background reading: Paulsen, S. M. 1996. Quantitative Genetics of the Wing Color Pattern in the Buckeye Butterfly (*Precis coenia* and *Precis evarete*): Evidence Against the Constancy of G. *Evolution*, 50: 1585-1597.