

## MONARCH BUTTERFLIES: MALE FEMALE COMPARISON

### RELEVANT JMP PLATFORMS AND STATISTICAL TECHNIQUES

Graph Builder :	Comparative Dotplots and Boxplots.
Fit Y by X :	Two-Sample t-test, Two-Sample variance test, Normality assumption
Multivariate :	Scatterplot Matrix, Correlation,

### PROBLEM STATEMENT

To better understand how differences in morphological features in monarch butterflies might explain higher migratory success of females over males, a study was conducted by ecologists at University of Georgia [1].

47 male and 45 female monarch specimens were selected for the study. 11 different morphological features such as the size and weight of various body parts, and color of wings were measured. (Figures 1A and 1B).



Figure 1A



Figure 1B

## DATA MONARCH\_BUTTERFLIES\_MALE\_FEMALE\_COMPARISON.JMP

Sex	Sex (Male , Female)
Total Wing Area	Area (mm <sup>2</sup> ) of forewings and hindwings
Live Weight	Weight (mg) of butterfly live after eclosion
Dry Weight	Total Weight (mg) of butterfly after drying
Thorax Weight	Weight (mg) of thorax after drying
Relative Thorax Size	(Thorax Weight)/(Dry Weight)*100
Abdomen Weight	Weight (mg) of Abdomen after drying
Forewing Weight	Weight (mg) of forewing after drying
Relative Forewing Weight	(Forewing Weight)/(Total Wing Area) (mg/mm <sup>2</sup> )
Wing loading	(Live Weight)/(Total Wing Area) (mg/mm <sup>2</sup> )
Orange Hue	Hue of the orange portion of the wings (measured in degrees on a color wheel with lower values being more red and higher values indicating more yellow)
Black Density	Measure of the darkness of the black portion of the wings (measured in units relative to light reflectance with 0 corresponding to no light reflectance [i.e., completely black] and 255 corresponding to full light reflectance [i.e., completely white]).

## EXERCISES

1. Create comparative dotplots for each of the 11 morphological features vs. Gender. Describe differences observed in these features between males and females?
2. Perform a 2-sample t-test comparing the average for each feature between the males and females. Summarize the results by indicating those features that show a statistically significant difference from those that do not. Does this change any of the conclusions you reached when doing the comparison via. only a graph?
3. Perform a statistical test for each feature comparing the variability between males and females? Is statistical significant evidence produced to conclude a difference in variability for any of the features? If so, examine the Welch's Test comparing means assuming variances are not equal. Does this change any of the conclusion you reached regarding differences in the means in the analyses from Exercise 2 where the assumption of equal variances was made? *Tip: Select "Unequal Variances" under the red triangle.*
4. Evaluate each feature within each sex to assess normality which is an assumption in the two inference procedures performed in Excerise 2 and 3 above. Are there any concerns? *Tip: Select "Normal Quantile Plot > Plot Actual by Quantile" under the red triangle.*

5. Calculate the correlation between all pairs of variables and create a scatterplot matrix. Identify the pairs of variables that have the strongest and weakest correlation. Examine the Scatterplot Matrix. Do these plots provide any additional insights into differences between the males and females that the analyses comparing each variable individually did not identify? *Tip: Analyze > Multivariate Methods > Multivariate.*

## COMPLIMENTARY MATERIALS

1. Davis, Andrew K. ; Holden, Michael T. "Measuring Intraspecific Variation in Flight-Related Morphology of Monarch Butterflies (*Danaus plexippus*): Which Sex Has the Best Flying Gear?" *Journal of Insects*, vol. 2015, Article ID 591705, 6 pages, 2015.  
<https://doi.org/10.1155/2015/591705>

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