

A resampling-based approach to study variation in morphological modularity

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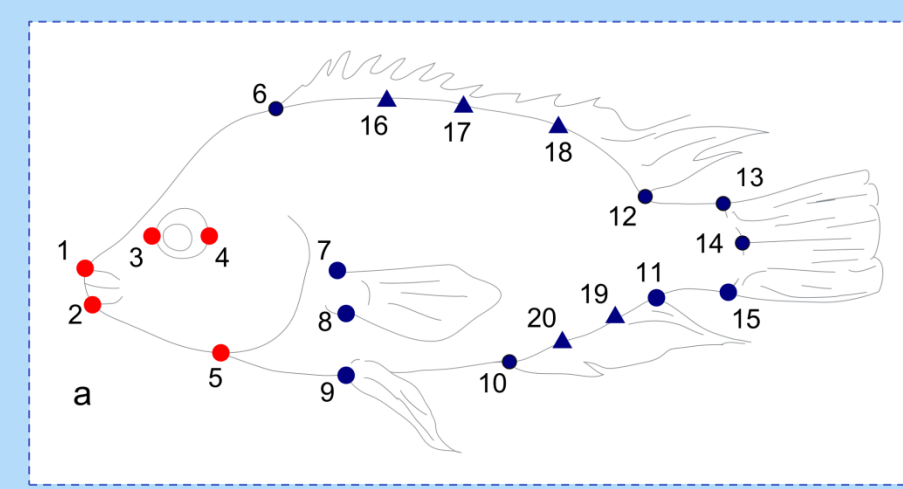
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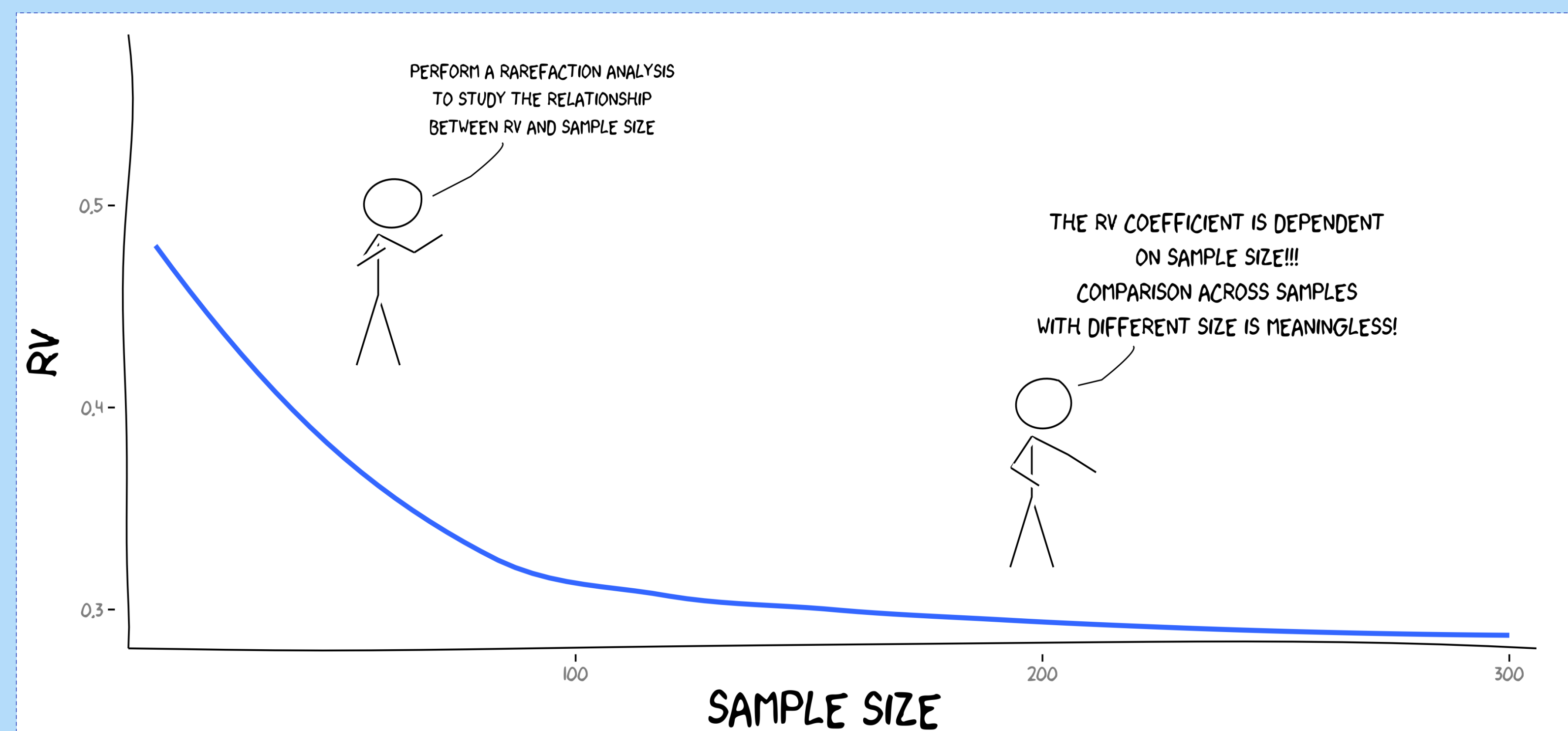
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Geometric morphometric studies of morphological modularity are very popular. This is partly due to the development of a permutation method (Klingenberg, 2009) based on the Escoufier RV coefficient (Escoufier, 1973) to test for the significance of modular organization hypotheses, implemented in the widely used software MorphoJ (Klingenberg, 2011). Researchers have, therefore, started computing the RV coefficients for different groups (species, for example) and comparing them.

However...



308 specimens, 2 modules
Figure from Fruciano *et al.* (2013)



Data from Fruciano *et al.* (2013). Plot obtained with the xkcd R package (Torres Manzanera, 2013)

The rarefaction analysis was carried out by resampling with replacement the full dataset at a smaller sample size and computing the RV coefficient. Variation in the RV coefficient was explored at all the sample sizes between 10 and 300.

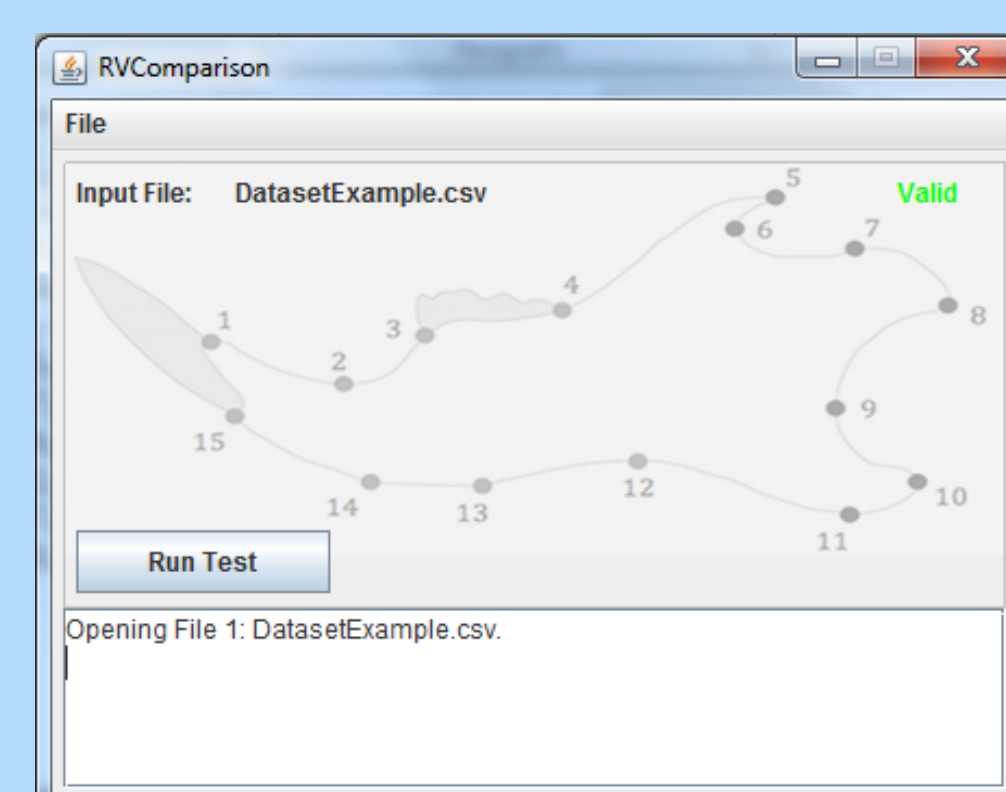
Extension 1

We propose using rarefaction to obtain sample-size standardized values of the Escoufier RV coefficient for comparisons across samples and to be used in downstream analyses

Extension 2

We suggested a nearest-neighbor procedure to study variation in modularity in geographic space (or other multidimensional spaces)

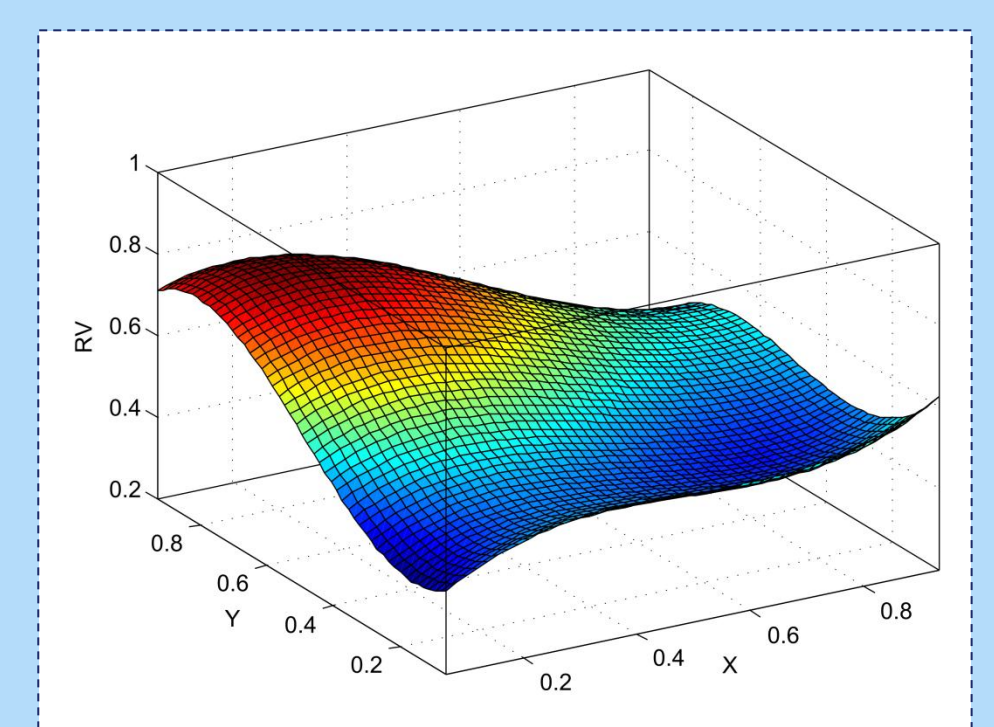
We developed a permutational procedure to test the null hypothesis of no difference in the RV coefficient between two *a priori* defined groups of observations. We also showed that such procedure has appropriate type I error rate.



Screenshot of the Java application that allows to perform the test. The application is freely available at the SB Morphometrics web page <http://life.bio.sunysb.edu/morph/>



Download the app!



Simulated variation of the RV coefficient in geographic space (X,Y are fictitious spatial coordinates).
Figure from Fruciano *et al.* (2013)

References

- Escoufier Y (1973) Le traitement des variables vectorielles. *Biometrics* 29: 751–760.
Fruciano C, Franchini P, Meyer A (2013) Resampling-based approaches to study variation in morphological modularity. *PLOS ONE* 8(7): e69376.
Klingenberg CP (2009) Morphometric integration and modularity in configurations of landmarks: tools for evaluating a priori hypotheses. *Evolution and Development* 11: 405–421.
Klingenberg CP (2011) MorphoJ: an integrated software package for geometric morphometrics. *Molecular Ecology Resources* 11: 353–357.
Torres Manzanera E (2013) xkcd: Plotting ggplot2 graphics in a XKCD style. R package version 0.0.1.