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Understanding morphometrics of cidaroid echinoid spines

The goal for this project was to take outlines of urchin spines, compare them, and then to properly plot these to help view trends among the spines. These outlines are 2D outlines in a coordinate system created through ImageJ on photographs of spines. These points cover homologous landmarks (4 landmarks) and then semilandmarks of non-homologous regions of the spines. The semilandmark data was then run through the package *Morpho*, to resample each outline to the same number of points, 250 semilandmarks for a total of 254 points). This is where the data was edited to not display my own data; the resampling was done incorrectly so that the personal research was not accessible for theft. This resampled data is what was uploaded to run through the tutorial. After loading in the data, the corrected data sets were put into an array. This array was then run through the package *geomorph* for analysis. After the Procrustes Analysis is run, to ensure all points are in the same orientation and to account for differences in size, the Principal Component Analysis (PCA) can then be run. The PCA is the analysis that compared the shapes and can be plotted to give a basic understanding of the area the spines plot. The PCA gives a percentage value on each axis to display how much variation can be captured by each axis. There can be quite a large range for this, the closer to 100% the two axes grasp, the more variance is captured by this plot. Low percents sometimes require addition axes beyond what is displayed must be plotted to show additional trends in data. The plotted points were extracted and merged with a data set that had details of the spines included, such as species and spine ornamentation type. This data was then plotted with *ggplot2*. Convex hulls were grabbed from the data based on details above and plotted in a scatter plot with convex hulls overlapping. Trends can be shown by what hulls, or certain details, overlap or do not overlap. Hulls covering a wide range of the scatterplot show that an individual genus has variety of spine shapes or in the instance of ornamentation, that certain ornaments can be found across many spine shapes. Hulls that overlap very little or are separate display that a genus has a unique shape in spines or that an ornamentation is characteristic to certain spine shapes. Since the beginning of this project, I have gone on to use this on a dataset with 147 specimens in which I have seen these trends and beyond.

References & Explanation:

Package *geomorph*:

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Code aid:

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General methods:

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Method aid:

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