Exploring Morphological Disparity in the Cassiduloida (Echinodermata, Echinoidea) Using Geometric Morphometrics

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Introduction

- Cassiduloida is a group of irregular echinoids with an expansive fossil record but with relatively few modern representatives.
- Cassiduloid diversity peaked in the Eocene and has been declining since [1]; however, the drivers of the plunge in diversity are not well understood.
- Modern and fossil cassiduloid disparity has never been assessed throughout geologic time.
- In this study, we quantify the morphological disparity in cassiduloids in order to test for changes in disparity over time and across subclades in this group.

Methods

1. Compile a large set of images of fossil and extant cassiduloids
2. Plot landmarks and semi-landmarks on test outline and petals using tpsDig
3. Perform statistic analyses in R to gauge overall disparity through time among 7 cassiduloid sub-clades

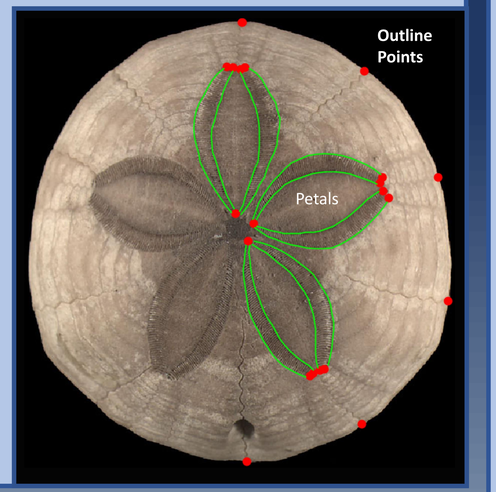
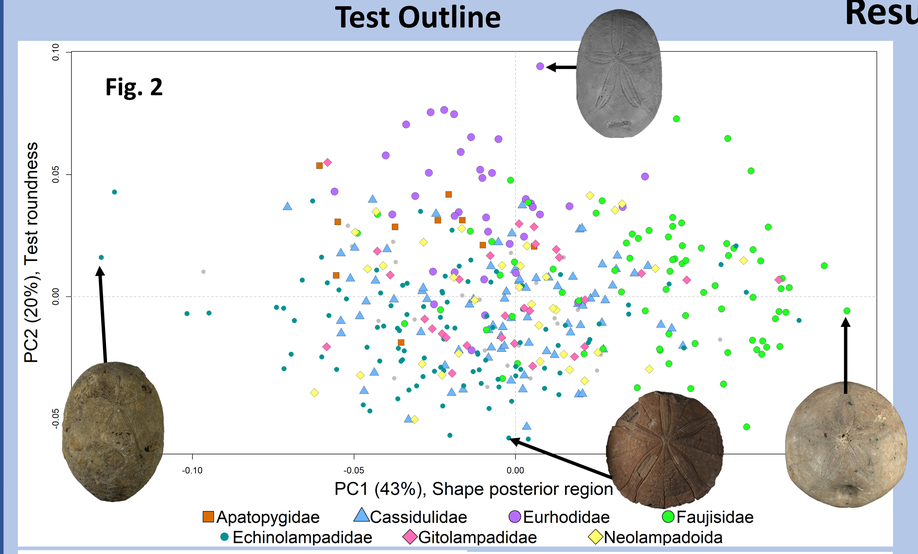


Figure 1: Aboral view of a cassiduloid with 6 landmarks on the test outline, and 15 landmarks and 12 curves on the petals. Photo credit: Echinoid Directory [2].

Results

Test Outline



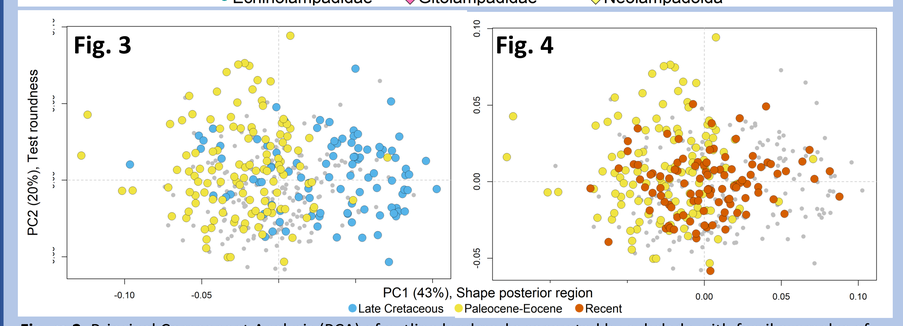


Figure 2. Principal Component Analysis (PCA) of outline landmarks separated by subclade with fossil examples of extreme morphologies. Photo credit: Echinologia [3], Echinoid Directory [2], MNHN [4], MNHN [4]. PCA of outline landmarks separated by time period: **Figure 3.** Late Cretaceous and Paleocene + Eocene, **Figure 4.** Paleocene + Eocene and modern. Gray data points are cassiduloids in other time bins.

Petals

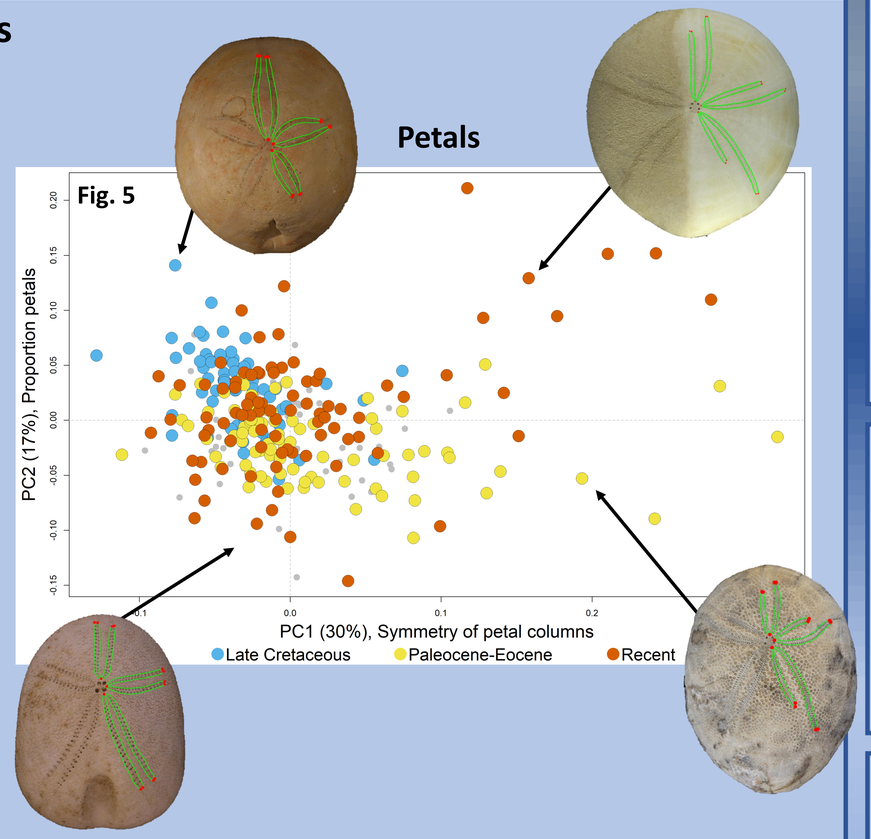


Figure 5. Principal Component Analysis (PCA) of petal landmarks through geologic time, Late Cretaceous, Paleocene + Eocene, and modern. Gray data points are cassiduloids in other time bins. Clockwise from top: Faujasiidae, Echinolampadidae, Echinolampadidae, Apatopygidae. Photo credit: Echinologia [3], Camilla Souto, Echinologia [3], Camilla Souto.

Discussion and Conclusions

- Outline morphospace is driven by the shape of the posterior region of the test (axis 1, Figs. 2-4) and the roundness of the test (axis 2, Figs. 2-4), which varies by sub-clade.
- Rounded cassiduloids, associated with an epifaunal niche, went extinct at the K-Pg boundary and did not experiment with this morphology again until the Neogene.
- While petal size, shape, and symmetry are more complex than test outlines, the symmetry of the petals (axis 1, Fig. 5) and the ratio of petal sizes (axis 2, Fig. 5) are important distinguishing features across lineages.
- Petal morphospace continually expands from the Cretaceous to the modern, however, which lineages innovated into new areas of morphospace differed over time.
- Modern cassiduloid disparity is dominated by the Echinolampadidae in the Indo-Pacific in both outline and test disparity.
- Next, we plan to gauge overall petal area as a proxy for respiratory surface area, plot landmarks on the oral images to link morphology to feeding biology, use these data to fit models of trait evolution in cassiduloids, and compare disparity through time with more successful echinoid lineages [5].

References

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