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SUPPLEMENTARY INFORMATION

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Morphospace expansion paces taxonomic diversification after end Cretaceous mass extinction

Christopher M. Lowery[1]* and Andrew J. Fraass[2,3]

[1]University of Texas Institute for Geophysics, Austin, TX, USA. [2]Sam Houston State University, Huntsville, TX, USA. [3]Present address: School of Earth Sciences, University of Bristol, Bristol, UK. *e-mail: cmlowery@utexas.edu

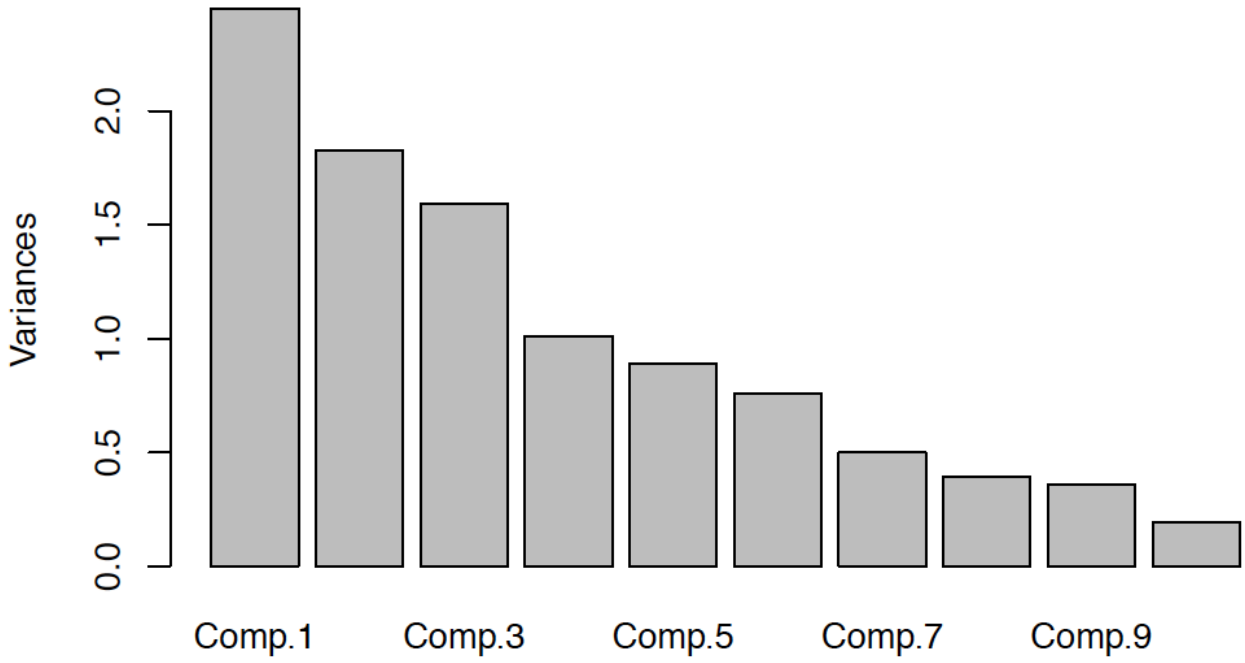
Supplemental Information

Alternative Statistical Analysis - PCA

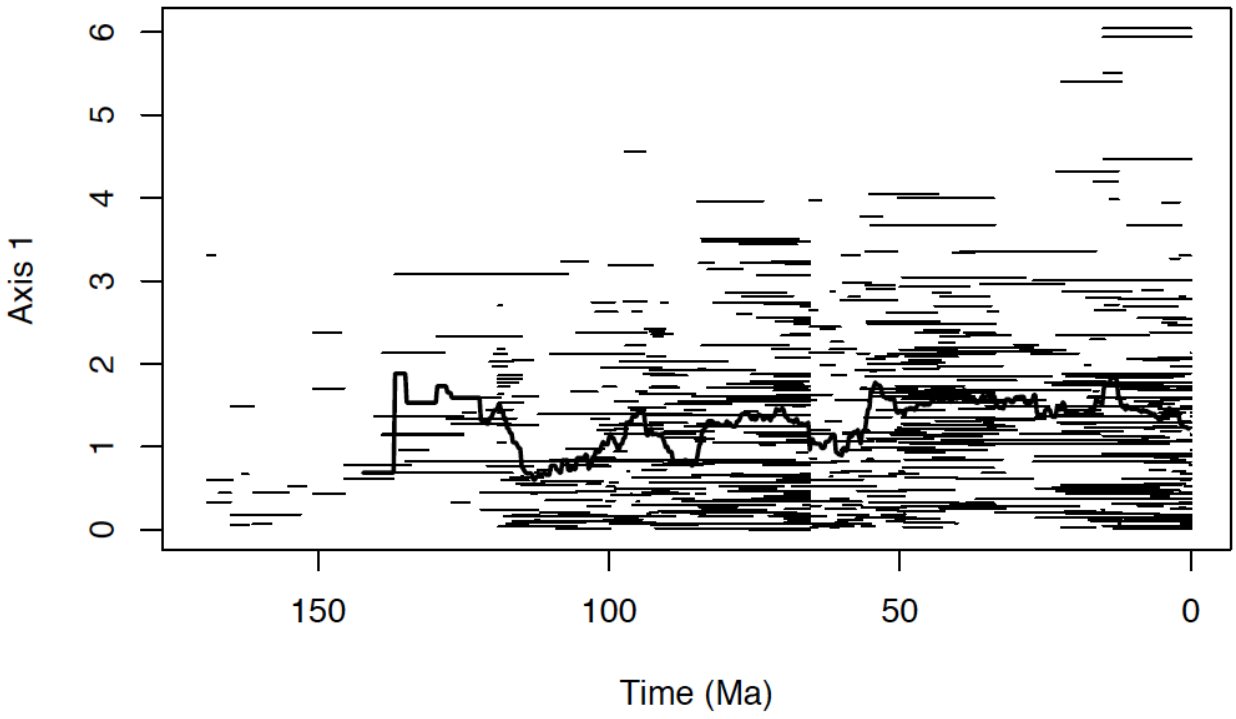
Simply taking the absolute value of our morphological complexity measurements and plotting the mean through time is not the only way to quantify changes in morphological complexity across the K-Pg mass extinction and the Paleocene recovery. To test our results, we also ran a principal components analysis (PCA) on our dataset. Eigen values are presented in Supplementary Figure 1. Axis one indicates that area and number of chambers and keeledness explain the most variance. Axes 1-3 explain 58.8% of the variance. The lack of differentiation within the first three axes is concerning, though this is an artifact of which morphometric parameters we selected. All the measurements were chosen specifically to discriminate between the major groups, and to be highly varying. That is likely the reason that variance is spread more evenly throughout the axes.

When we plot the first PCA axis against time (Supplementary Figure 2), a grossly similar trend can be observed between this and the mean of the absolute value of complexity (Fig. 1B). A significant drop is evident at the K-Pg boundary, with a slow recovery throughout the Paleocene and, here, a major increase at the end of the Paleocene. This axis primarily corresponds to test size and many species, although they became more complex in other ways, stayed relatively small throughout the Paleocene. Later increases in PCA Axis 1 correspond to radiations of photosymbiont-bearing planktics and the associated increase in diversity, and Axis 1 very nicely shows the radiation of larger, symbiont-bearing forms at the end of the Paleocene. Thus, PCA produces similar results, though with different magnitudes to our total complexity data presented in the main text (Fig. 1B), indicating that our results are robust across different analytical methods. However, as discussed above, each axis only accounts for part of the dataset, and therefore does not provide a complete picture of morphological variability throughout the study interval. For

instance, PCA Axis 1 does not capture the rapid increase in complexity (Fig. 1B) in the earliest Paleocene as it is driven by different variables. Therefore, although a PCA provides a bit more statistical rigor, it does not capture the full range of complexity and thus masks the overall trends in the data in the Paleocene.



Supplementary Figure 1. Scree plot of variance explained by each axis of principal component analysis. Axes (or components, "Comp.") 1-3 explain 58.8% of the variance.



Supplementary Figure 2. PCA Axis 1 plotted as a timeseries ranging from the Jurassic to the Recent. Note the similarity of the trends plotted here with those in Figure 1, especially the major fall at the K-Pg Boundary and the major increase at the Paleocene-Eocene Boundary. Note that Axis 1 is most strongly related to test size and not total complexity, and so this plot primarily shows the recovery of test size throughout the Paleocene, as well as the expansion to previously unrecorded sizes in the Eocene (an example of expansion to previously unoccupied morphospace by the end of the recovery).

Supplementary Table 1. Correlations between different morphometric parameters. Ch. = chamber.

	Final Ch. circularity	Apical Angle	Number of Ch.s	Expansion Rate	Test Area	Final Ch. Area/Test Area	Clavateness	Keel	Biconvexity
Final Ch. circularity									
Apical Angle	-0.19****								
Number of ch.s	-0.09*	0.43****							
Expansion Rate	-0.04	0.12**	-0.32****						
Test Area	-0.16****	0.08*	0.23****	-0.11**					
Final Ch. Area/Test Area	0.07	0.08*	-0.47****	**0.74******	-0.12**				
Clavateness	-0.16****	-0.07	-0.07	0.13***	-0.05	0.05			
Keel	-0.30****	0.36****	0.41****	-0.11**	0.38****	-0.14***	-0.01		
Biconvexity	-0.02	0.12**	0.09*	-0.08*	0.15****	-0.07	-0.06	0.22****	
Lobateness	0.44****	0.03	0.04	-0.06	0.10*	0.13**	-0.49****	-0.09*	0.01

$p < .0001$ '****'; $p < .001$ '***', $p < .01$ '**', $p < .05$ '*'