Comparative Morphological Variation and Evolutionary Trajectories in Asexual vs. Sexual Ostracodes: Insights from the Fossil Record

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Introduction

Asexual reproduction offers benefits such as higher efficiency and freedom from sexual selection, but it has limited ability to generate genetic diversity. Genetic recombination in sexually reproducing species breaks up the accumulation of deleterious mutations and can lead to faster adaptation (Griffiths & Butlin 1995). Testing the consequences of sex, especially in extinct species, is challenging because traits indicating reproductive mode rarely fossilize (Hunt et al. 2017).

One exception is the ostracode genus *Phacorhabdotus* from the Late Cretaceous of the U.S. Coastal Plain, which includes species with sexual, asexual, and mixed reproductive modes.

Our goal is to document the reproductive modes in the ostracode genus *Phacorhabdotus* and begin to assess the long-term evolutionary consequences of asexual reproduction.

Methods

Figure 1. Ostracodes on slide

1.Ostracode specimens were viewed and photographed in lateral view at the same magnification using extended depth of field microscopy

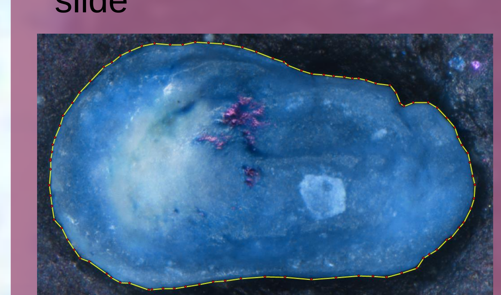


Figure 2. Ostracode being digitized in TPSDig

2. Outlines of all specimens were manually digitized using TPSDig. (Fig. 2)

3. Body size was measured as the area of the outline. Shape was measured as the length-to-height ratio, where length and height were taken as the major and minor axes of an ellipse fit to the outline.

4. Mixture models were fit to the log-transformed size and shape data using the R package *mclust*. Populations best fit by two sex clusters were characterized as sexual (Fig.3), whereas evidence for just one cluster was taken to indicate female-only (asexual) populations (Fig.4)

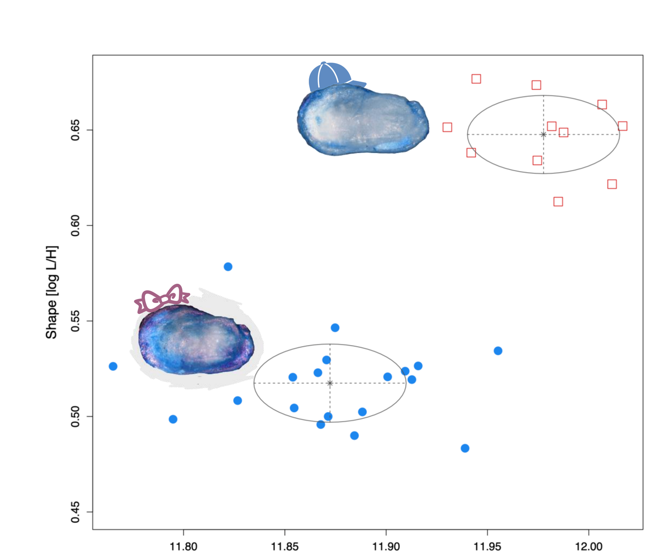


Figure 3. Two sex clusters with males (red squares) and females (blue circles).

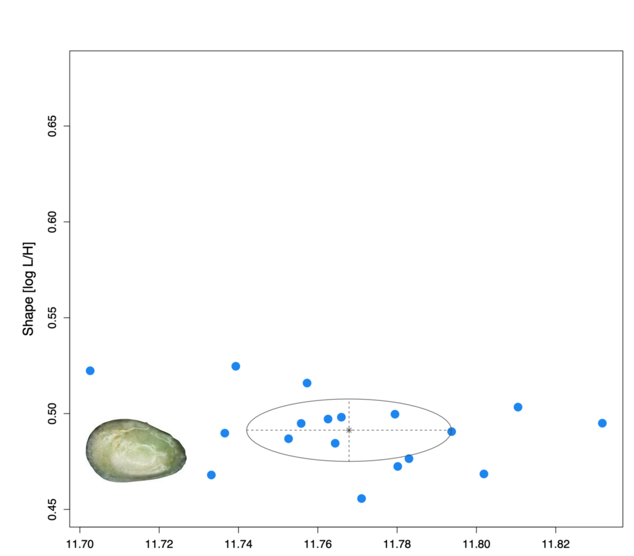
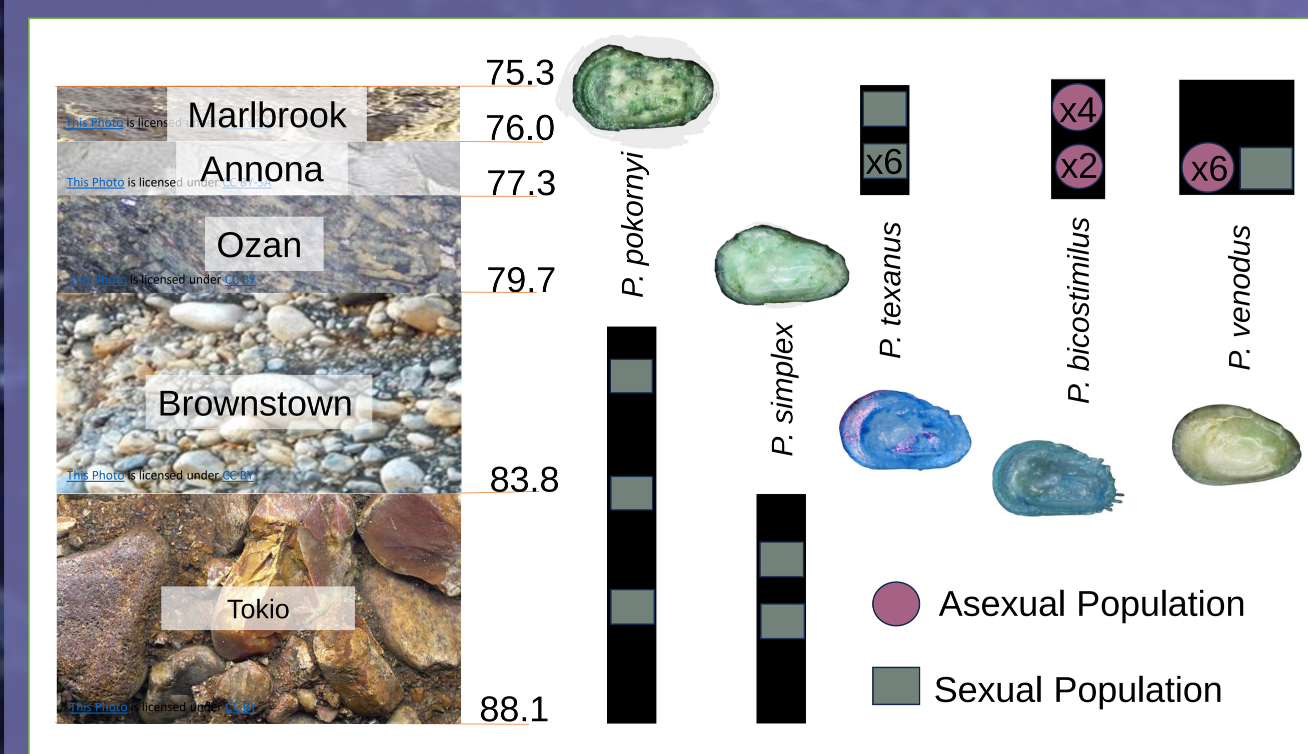


Figure 4. One sex cluster representing an all-female, asexual population

Results



- *Phacorhabdotus* species have sexual, asexual and mixed reproductive modes (Fig. 5).

Figure 5. Stratigraphic ranges of *Phacorhabdotus* species studied here. Sexual mode was determined for populations shown as colored shapes (red circles = asexual, green squares = sexual). The geological succession of formations is shown for the Arkansas area, with ages given in millions of years ago.

- In the Annona Chalk, abundance decreased from *P. texanus* (sexual) to *P. venodus* (mixed reproduction) to the strictly asexual *P. bicostimilus* (Fig. 6).

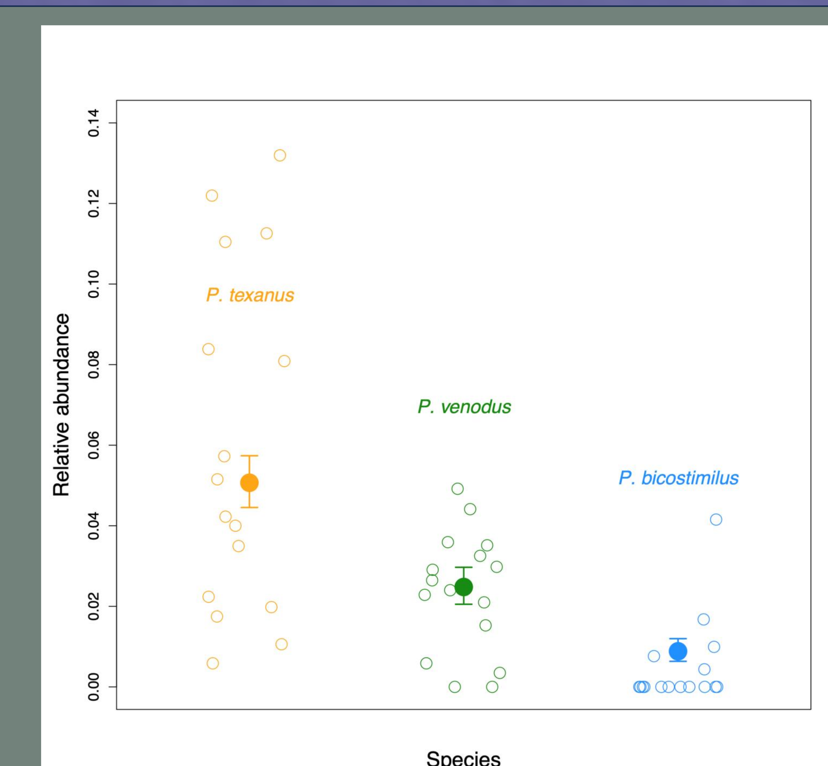


Figure 6. Abundance data for 16 samples from the Annona Chalk. Each open circle represents abundance in a sample; the filled circle gives the mean abundance with 95% confidence interval.

- Shape variation is lowest in the strictly asexual species, *P. bicostimilus*, but all confidence intervals overlap (Fig. 7, 8).

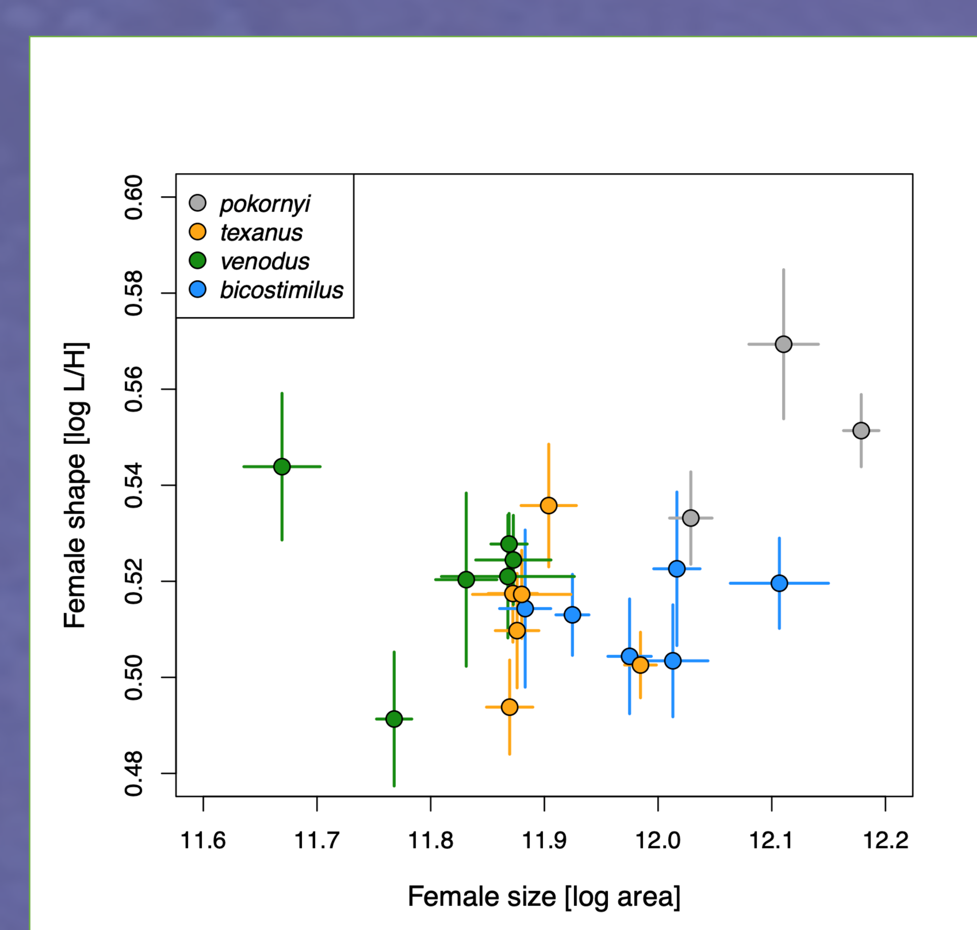


Figure 7. Shown are the mean size and shape of the female specimens of each population, with the horizontal and vertical lines indicating 95% confidence intervals.

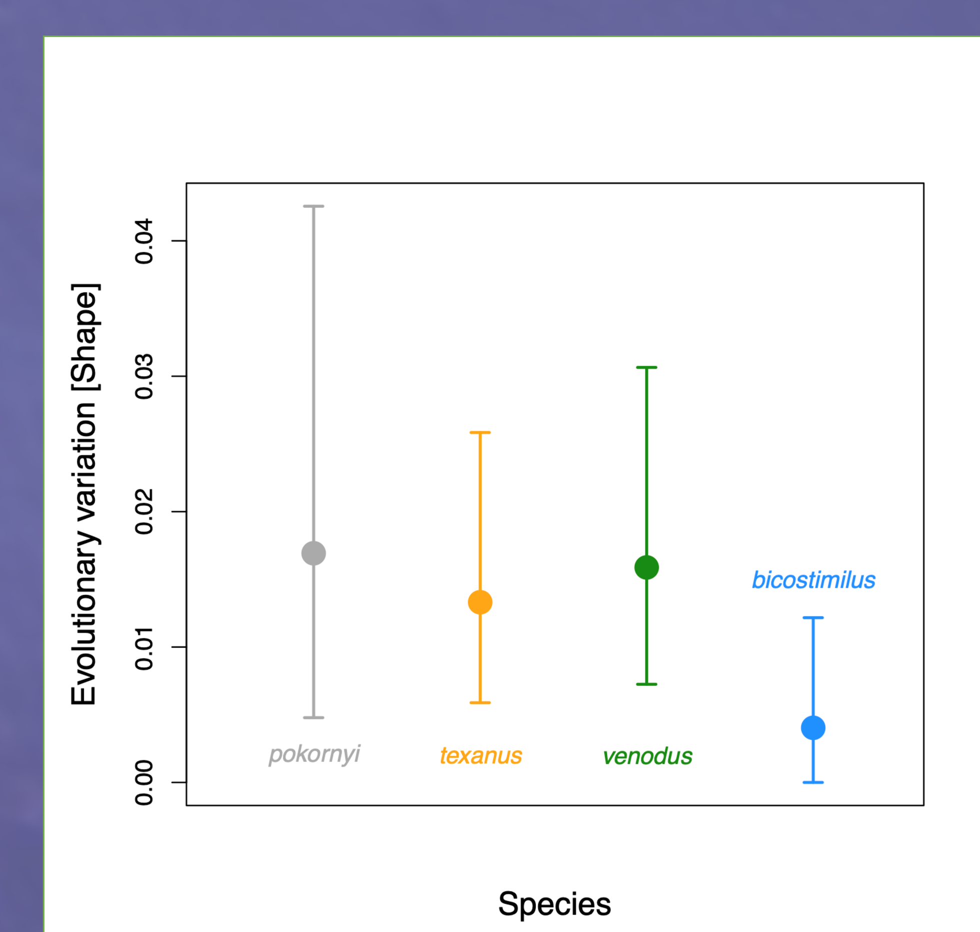


Figure 8. Evolutionary variation in shape for each species, computed from the among-population component of variance from a random-effects linear model.

Conclusions

- Sexual reproduction was correlated with abundance in *Phacorhabdotus*, suggesting that its adaptive benefits may overcome asexuality's greater efficiency.
- We cannot demonstrate faster rates of trait evolution in sexual species, although the only strictly asexual species, *P. bicostimilus*, shows the smallest amount of evolutionary variation.
- Sexual reproduction, despite its costs, may offer significant advantages in genetic diversity and adaptability, leading to greater long-term success.

Future Work

- We will continue to broaden our sampling of *Phacorhabdotus* and other taxa, to more fully understand the macroevolutionary consequences of asexual reproduction.
- This greater sampling will allow us to test if asexuality leads to higher extinction rates.

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