The tempo and drivers of body macroevolution in extant cephalopods

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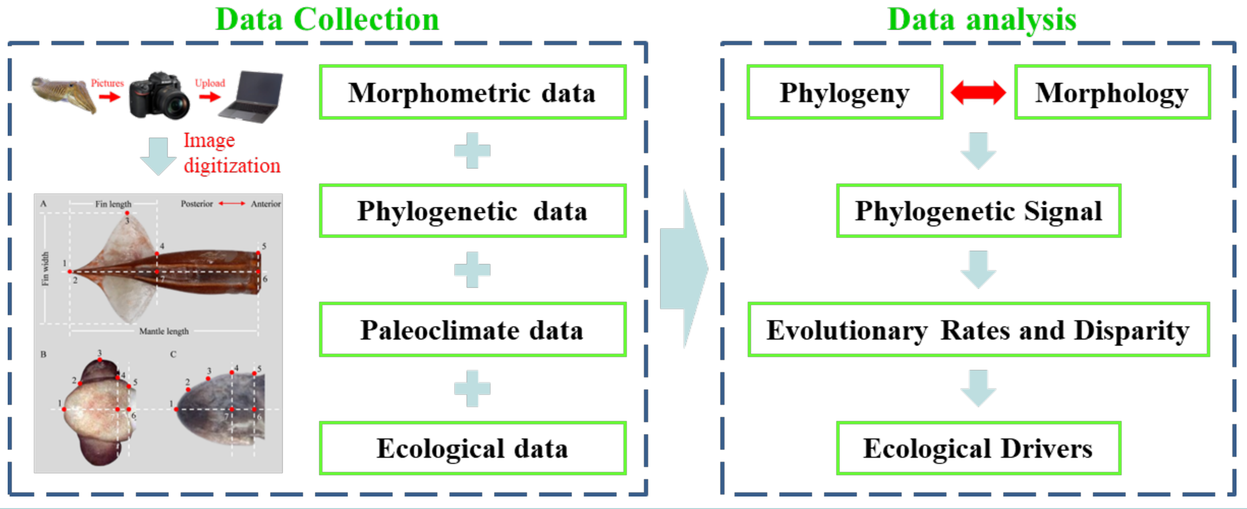
Background

- Cephalopods have evolved for ~500 Mya with dramatic body shape transformations.
- Despite their ecological and functional diversity, macroevolutionary patterns and drivers remain understudied.
- The goals of the study were (1) to reconstruct evolutionary tempo and disparity in body shape and size and (2) to Identify macroclimatic and ecological drivers of morphological change.

Methods

- **Sampling period**: 2021–2025
- **Study area**: Global oceans



Results

Result 1: Body morphology variation

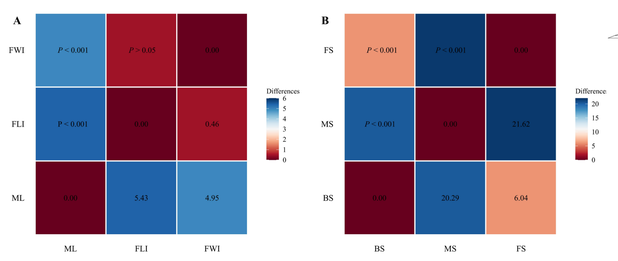


Fig. 1. Pairwise comparisons of phylogenetic signal effect sizes for cephalopod body size (A) and shape (B).

Table 1. Phylogenetic signal of morphological traits.

	N	lambda	*K*	*Z*	*P*	log-likelihood
Mantle length	161	0.784	0.360	9.903	0.001**	-207.245
Fin length index	82	0.639	0.628	4.505	0.001**	-24.623
Fin width index	82	0.684	0.649	4.923	0.001**	-33.894
Body shape	159	1.000	0.895	24.999	0.001**	611.493
Mantle shape	159	1.000	0.886	24.620	0.001**	382.360
Fin shape	159	1.000	0.843	23.632	0.001**	753.048

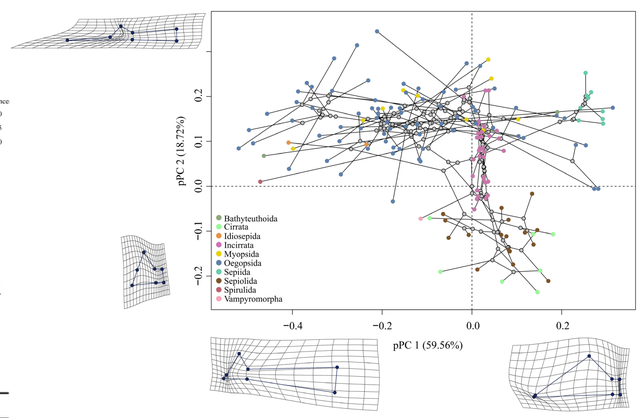


Fig. 2. PhyloPCA of mean genus body shapes using GLS-centering.

Result 2: Branch-specific rates of body morphology

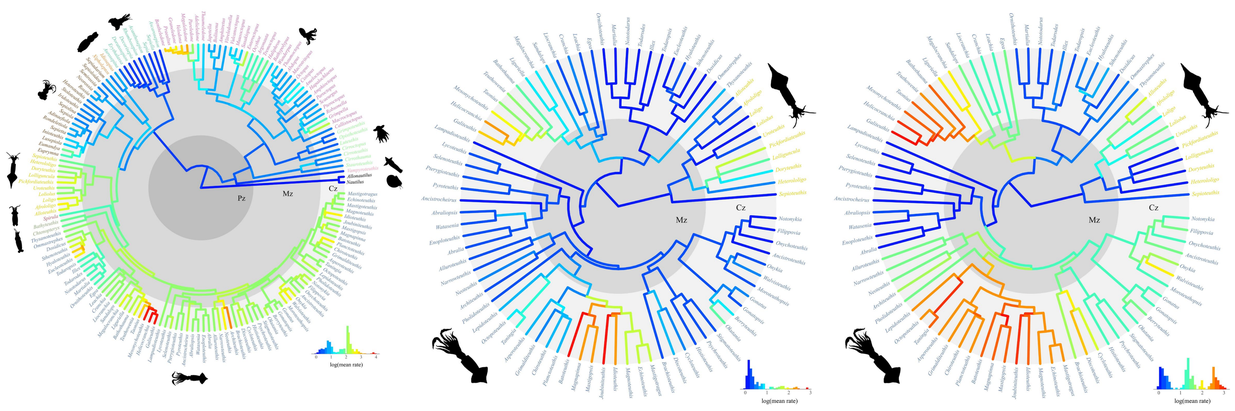


Fig. 3. Branch-specific evolution rates of (A) ML, (B) FLI, (C) FWI mapped on time-calibrated cephalopod phylogeny under best model.

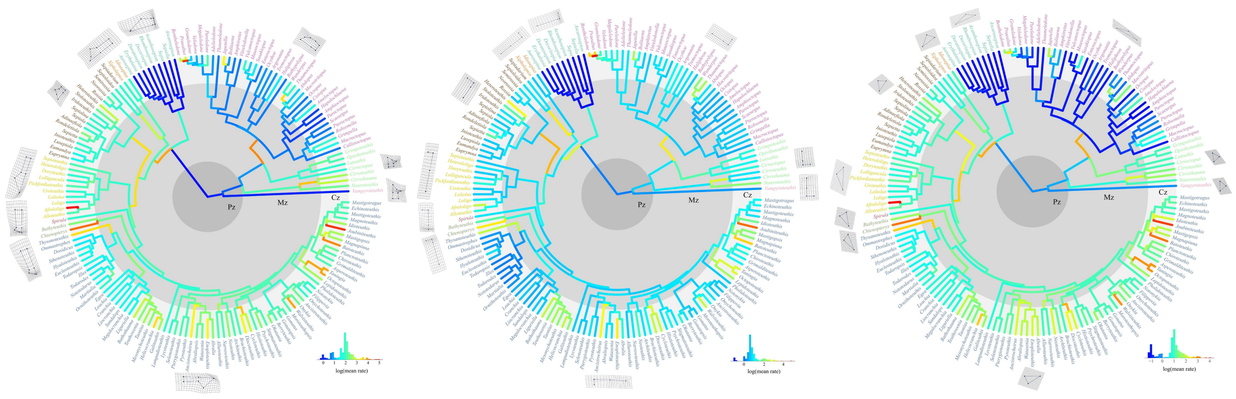


Fig. 4. Branch-specific evolution rates of (A) BS, (B) MS, and (C) FS mapped on time-calibrated cephalopod phylogeny under best model.

Result 3: Tempo and disparity of through time

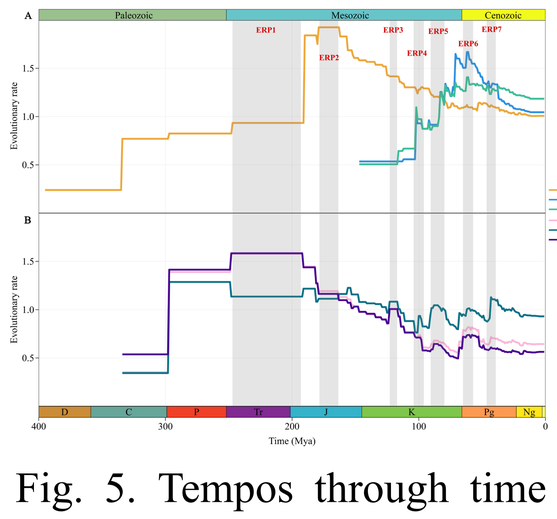


Fig. 5. Tempos through time of cephalopod body morphology.

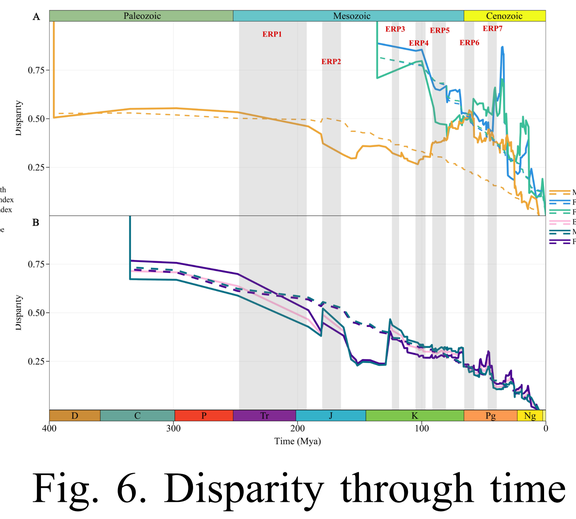


Fig. 6. Disparity through time of cephalopod body morphology.

Result 4: Paleoclimate as a driver of body evolution

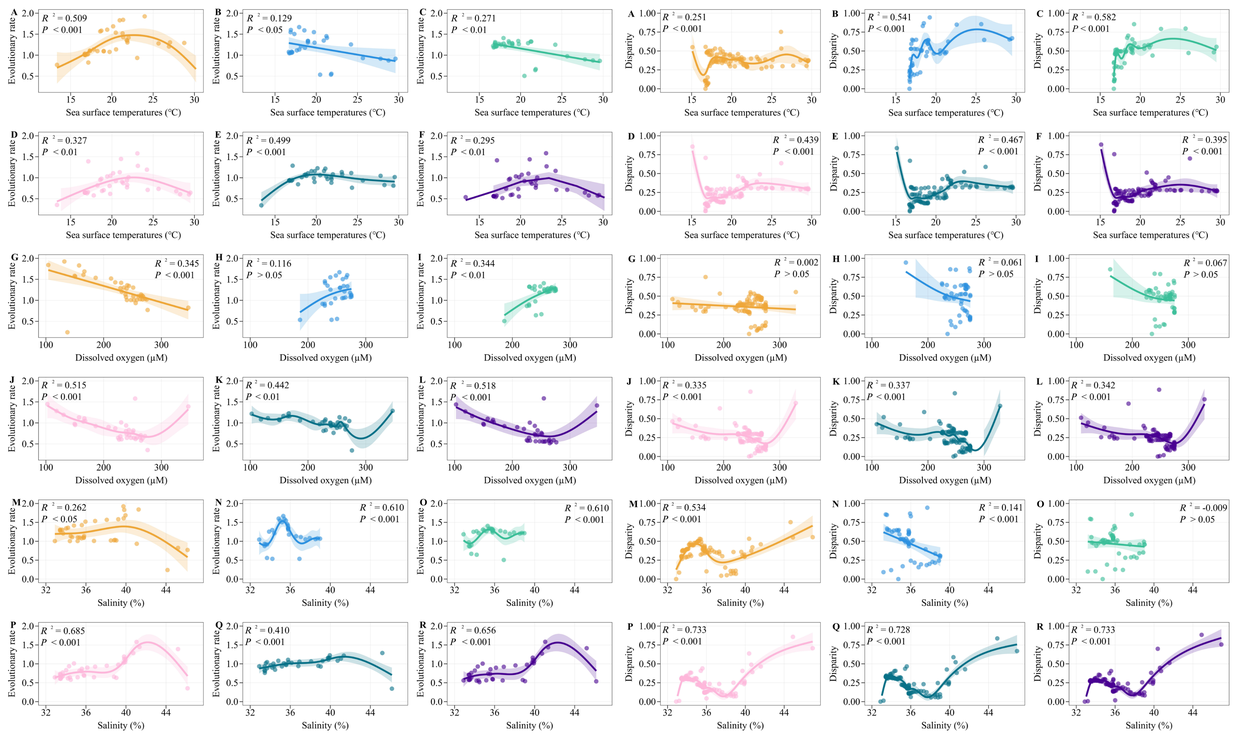


Fig. 7. Macroevolutionary dynamics of body morphological for cephalopods in response to 400 million years of climate change. Points show data; lines and band s show GAM fit ±95% CI.

Fig. 8. Macro disparity dynamics of body morphological for cephalopods in response to 400 million years of climate change. Points show data; lines and bands show GAM fit ±95% CI.

Conclusion

- Cephalopod body morphology evolution shows moderate phylogenetic signal and distinct adaptive radiations.
- Evolutionary tempo and disparity were strongly influenced by SST, DO, and salinity, with nonlinear, threshold-dependent effects.

Acknowledgments

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