Are There Trends in Bivalve Ornamentation Throughout the Cretaceous?

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Research Questions

(1) Do bivalves exhibit increased ornamentation throughout the Cretaceous, suggesting a possible morphological response to the diversification of predators?

(2) Do ornamentation trends in Cretaceous bivalves differ based on epifaunal or infaunal life habit?

(3) Are more ornamented bivalves less likely to go extinct than smooth ones, suggesting that increased ornamentation may be advantageous against predation for Cretaceous bivalves?

What did we do?

Using taxonomic data on Cretaceous bivalves from the Paleobiology Database as a guide, we searched for examples of Cretaceous bivalves in the primary literature. We assigned ornamentation scores for six different types of ornamentation: ribbing, folding, spines, tubercles, smoothness and auricles. For ribbing, folding and spines, ornamentation scores were determined by the degree of ornamentation (major, minor, absent); for tubercles, smoothness and auricles, the presence or absence of such ornamentation was scored. The overall ornamentation value per species is the sum of all scores.

	Score		
	1	**0.5**	**0**
Ribbing	Major	Minor	Absent
Folding	Major	Minor	Absent
Spines	Major	Minor	Absent
Tubercles	Present		Absent
Smoothness	Present		Absent
Auricles	Present		Absent

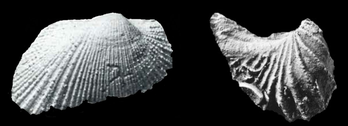
Ribbing

Acila allisoni
Major Ribbing, Score: 1

Glycimeris pacificus
Minor Ribbing, Score: 0.5

Rhynchostreon suborbiculatum
Ribbing Absent, Score: 0

Tubercles



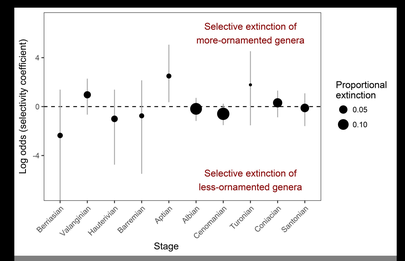
Bethyarca perla
Tubercles Present, Score: 1

Arca tashiroi
Tubercles Absent, Score: 0

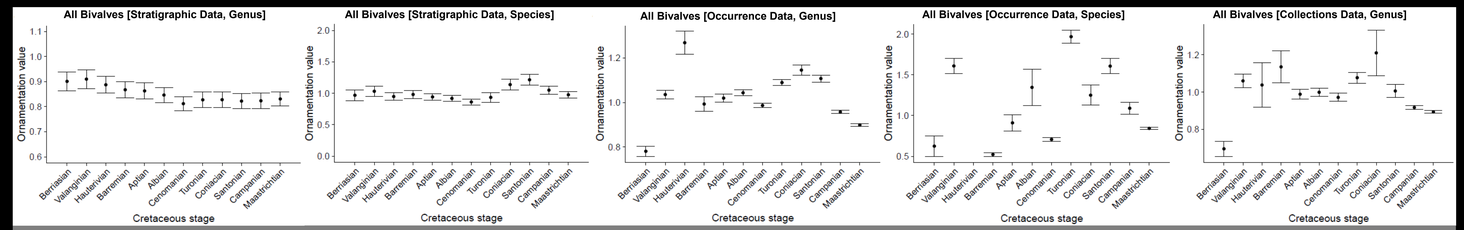
Images from: Squires & Sauls (2006); Squires (2010); Dhondt (1984); Heinberg (1979); Komatsu & Maeda (2005)

Abstract

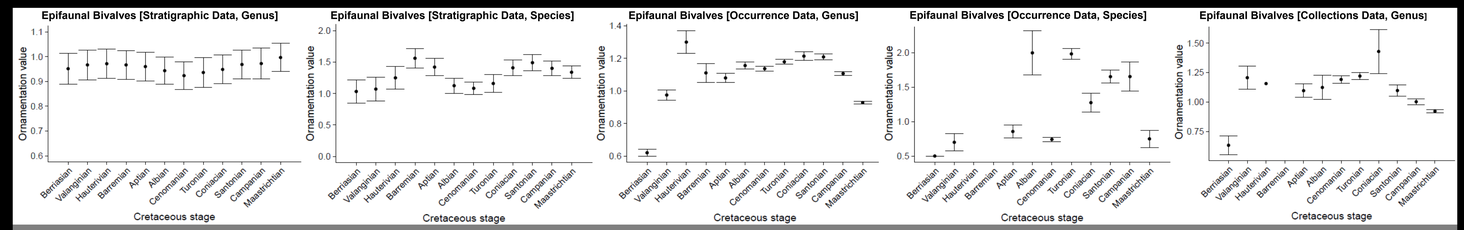
Evolutionary trends in morphology may serve as indicators of interactions between predators and their prey. During the Mesozoic Marine Revolution, bivalves are thought to have faced increased predation from shell-crushing crustaceans, drilling gastropods and teleost fishes, particularly near the end of the Mesozoic (Vermeij, 1977). Experiments have shown that ornamentation features on bivalves, such as ribbing, folds and spines, can be effective against predation. To test the hypothesis that bivalve ornamentation increased throughout the Cretaceous in response to diversification of predators, we assembled a database scoring the ornamentation (presence and strength of ribs, folds, spines, tubercles, smoothness and auricles) of ~500 Cretaceous bivalve species. Epifaunal bivalves show no evidence of increasing ornamentation throughout the Cretaceous, while ornamentation of infaunal bivalves may decrease slightly, perhaps indicating increased infaunalization. During most Cretaceous stages, there is little difference in the degree of ornamentation between extant and newly originating genera, and the degree of ornamentation rarely has a significant influence on extinction risk. Combined with other analyses of Jurassic mollusks, our results suggest that any morphological responses to predator diversification among bivalves were idiosyncratic and lineage-specific or delayed until the Cenozoic.



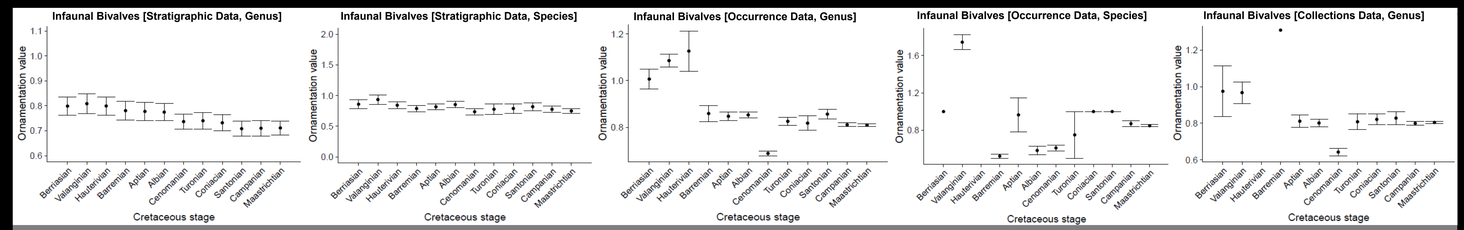
Degree of ornamentation has no discernible effect on extinction risk. Log odds values with standard error bars are shown. The proportion of taxa that went extinct during each Cretaceous stage is also shown.



As a class, bivalves show no strong trends in ornamentation across the Cretaceous. Mean values with standard error bars are shown.



Epifaunal bivalves show no strong trends in ornamentation across the Cretaceous. Mean values with standard error bars are shown.



Infaunal bivalves may show a slight decrease in ornamentation across the Cretaceous. Mean values with standard error bars are shown.

What did we do? (continued)

For both species and genera, mean ornamentation scores for each Cretaceous stage were calculated using their stratigraphic ranges, occurrence data, and for collections with at least five occurrences. Similar analyses were conducted for epifaunal or infaunal bivalves separately to determine how ornamentation trends across the Cretaceous differ based on life habit. We conducted logistic regression analyses to determine whether degree of ornamentation was an important predictor of extinction risk during each stage. All analyses were performed in R.

What did we learn so far?

The slight decrease in infaunal bivalve ornamentation value across the Cretaceous may indicate increased infaunalization. Infaunality has been suggested as an evolutionary response to predation pressure (Vermeij, 1977; Aberhan, 1994; Aberhan et al., 2006). Infaunal organisms, by the nature of their life habit, are out of the reach of many surface-dwelling predators. An increase in infaunalization has also been documented in bivalves towards the end of the Jurassic (Aberhan, 1994; Aberhan et al., 2006).

The lack of strong trends in all bivalves and epifaunal bivalves combined with our findings that degree of ornamentation is not an important factor in determining extinction selectivity suggest that any morphological responses to diversification of predators during the Cretaceous were either lineage-specific or delayed until the Cenozoic.

Where do we go from here?

Using similar methods, we would like to investigate how different types of bivalve ornamentation change throughout the Cretaceous. Although the data originates mostly from Europe and North America, uncovering potential latitudinal trends may be another research avenue (see Vörös, 2014, for Jurassic brachiopods).

References

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