Biogeographic patterns of belemnite body size responses to episodes of environmental crisis

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Body size changes have been investigated through episodes of environmental crisis among several groups of organisms but the relative contribution of within-lineage size changes, selective extinction and origination of taxa on these patterns is still being debated. Rapid warming, anoxia, and perturbations of the carbon cycle linked with volcanic activity, as well as their impact on marine diversity are well documented for the Pliensbachian-Toarcian (Pli-Toa) boundary and for the Toarcian Oceanic Anoxic Event (T-OAE).

Belemnites were a very abundant and successful cephalopod group in the Mesozoic oceans playing a paramount role in the oceanic trophic webs. Belemnites have mainly been studied from a geochemical perspective during this interval. Newly collected data from three northern and western Iberian sections (Peniche, Rodiles and Lastres) allowed an analysis of the belemnite body size dynamics across the Pli-Toa boundary and the T-OAE and a comparison with other European basins.

In Peniche (Lusitanian Basin, Portugal), a significant reduction in belemnite body size was recognized across the Pli-Toa boundary at the assemblage level (i.e. community scale of organization). From the analysis of the different taxa recorded, it seems that adult specimens of *Pseudohastites longiformis* are driving the body size pattern observed (13% rostrum size decrease). The uppermost Polymorphum-Levisoni zones interval is characterized by a dramatic decrease on both belemnite abundance and diversity. Only 4 specimens of the genus *Acrocoelites* were found, increasing the body size at the assemblage level.

In the Asturian Basin (N Spain), on the other hand, a body size increase at the assemblage level is recognized across the Pli-Toa boundary caused by a within-lineage effect mainly related to adult specimens of *Passaloteuthis* and *Pseudohastites* genera. During the onset of the T-OAE, belemnite body size increases due to the appearance of *Acrocoelites* genus.

To summarize, the increase in rostrum size at the assemblage level across the T-OAE is associated with the radiation of a large-sized taxon (*Acrocoelites* genus) and the extinction of various other species. On the other hand, across the Pli-Toa boundary, the

belemnite body size changes are dominated by within-lineage mechanisms. This suggests that species might have been able to cope within the early warming phase (Pli-Ta boundary), but were more affected by the subsequent warming and anoxia during the T-OAE. Our preliminary results indicate that this pattern might also be recognized in other western European sections, such as Cleveland Basin, western Paris Basin (Normandy) and Southern Germany sections. The biotic and abiotic drivers of belemnite body size changes still need to be comprehensively analyzed.

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