On the diversity of Early Jurassic cartilaginous fishes across the Toarcian Oceanic Anoxic Event

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Elasmobranchii (i.e., sharks, skates, and rays) constitute a speciose group of chondrichthyan fishes, ranging back to the Permian. They form, together with extinct hybodontiform shark-like chondrichthyans, their supposed sister group ranging from the Devonian to the end of the Cretaceous, the most dominant chondrichthyan lineage during the Mesozoic.

The Early Jurassic marks a crucial time interval in the evolutionary history of elasmobranchs, because the Toarcian witnessed a first major diversification, probably accompanied by a subsequent diversity decline of hybodontiforms within marine environments. Potential factors underlying the Toarcian elasmobranch radiation event not only include evolutionary novelties in ecological adaptations of swimming, feeding, and reproduction, but also abiotic factors such as increasing seawater temperatures and variations in eustatic sea level associated with the Toarcian Oceanic Anoxic Event (T-OAE). These events might have played an important role in the Toarcian elasmobranch diversification event by regulating diversity patterns through the availability of higher speciation and dispersal rates.

In attempt to better understand macroevolutionary patterns and processes of Jurassic chondrichthyans, we analysed the generic diversity of Pliensbachian to Aalenian elasmobranchs and hybodontiforms and explored their response to the T-OAE. In doing so, we calculated the estimated mean standing diversities (EMSD) using 10 time bins of ~2 Ma duration and evaluated the relationships between EMSD and variations in seawater temperature and eustatic sea level to test whether these parameters affect the observed diversity patterns.

The EMSD is low in Pliensbachian to Aalenian hybodontiforms, indicating an evolutionary stasis. Conversely, a constant taxonomic increase in elasmobranchs is recorded. These divergent patterns might suggest that hybodontiforms were not competing with elasmobranchs, but more likely are the result of still existing taxonomic misconceptions of Jurassic hybodontiforms, mainly caused by morphological characters that are either ambiguous or broadly distributed among these anatomically rather conservative chondrichthyans. Notwithstanding this, our results indicate that variations in seawater temperature and eustatic sea level changes associated with the T-OAE were not the primary drivers underlying the observed elasmobranch diversity patterns. Therefore, it might be possible that the diversification of elasmobranchs was opportunistic, benefitting from the appearance of new food resources, probably in response of enhanced surface productivity during the T-OAE. This, however, needs to be tested, pending the inclusion of other time-equivalent marine vertebrate groups in future diversity analyses. Moreover, a detailed re-evaluation of Jurassic hybodontiforms will contribute to our understanding of chondrichthyan diversity dynamics across the T-OAE.