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Abstracts

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Diversity dynamics in the global Permian–Triassic chondrichthyan fauna: taxonomic diversity, palaeoecology and distribution

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The Permian/Triassic boundary marks a time of major upheaval in the biosphere. The late Permian mass extinction, which occurred just before the boundary, is the most severe Phanerozoic crisis. Although preceded and followed by additional disturbances (e.g., end-Guadalupian and end-Smithian crises), this event has received most attention. Patterns and processes of extinction and recovery of marine vertebrates have been less well studied than those of marine invertebrates and terrestrial vertebrates. Here we present a novel analysis of Permian–Triassic Chondrichthyes. We show that chondrichthyan genus diversity declined throughout the Cisuralian and the rate of diversity decline increased from the mid-Guadalupian, following rising extinction rates while origination rates remained relatively constant. Both diversity decline and extinction rates intensified in tandem throughout the Lopingian, which supports a combined overall extinction as a result of the end-Guadalupian and late Permian events. This was followed by a Griesbachian peak in origination rates. As a consequence of the mass extinction event, Palaeozoic sharks were largely replaced by hybodonts and modern sharks (Neoselachii). The Cladodontomorphi and Petalodontiformes perished in the Lopingian, whereas the Eugeneodontiformes became extinct in the Early Triassic as a result of the end-Smithian crisis. The Holocephali and Xenacanthimorpha declined throughout the Permian, but both groups survived into the Triassic. Similarly, the Hybodontiformes and Neoselachii survived both the end-Guadalupian and late Permian events, but without being affected in terms of diversity. The late Permian extinction was (likely) not responsible for the appearance of modern chondrichthyans, but it appears to have influenced their evolutionary trajectory. A significant decrease in tooth size and body length is recorded across the Permian/Triassic boundary when data are pooled at epoch- and period-level, respectively, but the tooth size decrease is not significant for those genera that survive into the Triassic. This suggests a long-term selective loss of large-sized chondrichthyans as a result of the late Permian mass extinction rather than a temporary decrease in size as an adaptation for survival, unless this occurred on a much shorter time scale. Finally, there is evidence of a change in global chondrichthyan distribution as a result of the Permian extinctions and contemporary environmental changes. The Boreal Sea gained in diversity during the Wuchiapingian–Griesbachian, whereas tropical regions primarily experienced diversity loss. The largest extinction occurred amongst marine groups, with benthic and pelagic groups suffering most. However, no significant selectivity for these palaeoecological traits could be demonstrated, suggesting proportionate losses. In contrast to Chondrichthyes, osteichthyan marine diversity is considerably higher in the Triassic than in the Permian, highlighting the profound change in fish communities that took place at that time as chondrichthyan-dominated faunas transitioned into the typically Meso- and Cenozoic osteichthyan-dominated associations.

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