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# Morphological disparity of early ammonoids: A geometric morphometric approach to investigate conch geometry

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Fossils of Devonian ammonoids are abundant and well-preserved in the Anti-Atlas of Morocco; as such they provide an invaluable record of regional morphological disparity changes (diversity of shapes) that characterise the first steps of ammonoid evolution. However, they were rarely analysed quantitatively with respect to their morphological spectrum. Here, we investigated the morphological disparity of the Early–Middle Devonian ammonoids of the Moroccan Anti- Atlas by analysing the shape of their whorl profile. A geometric morphometric approach based on the acquisition of outline semilandmark coordinates was used to analyse the whorl profiles. For comparison, morphometric ratios based on classical conch measurements were also analysed to investigate the overall conch geometry. Several standard disparity estimators were computed to measure different aspects of morphological disparity fluctuations through time. It appears that a major increase in disparity occurred throughout the Early Devonian, followed by fluctuating disparity during the Middle Devonian constituting a general decreasing trend. Only the end-Eifelian Kačák Event shows a significant decrease in disparity. Thus, the ammonoids explored the range of possible shapes fairly quickly during their initial radiation; however, we found no evidence for an early burst of shape diversity (i.e., the rise does not exceed the expectations given diversity). Nevertheless, correlation tests between diversity and disparity time series support that they are partially decoupled. The highly resolved biozone record highlights that the increase in disparity began earlier than the increase in diversity that characterises the late Emsian.

**Key words:** Ammonoidea, conch geometry, geometric morphometrics, macroevolution, morphological disparity, Devonian.

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