

## **SLOW DIRECTIONAL EVOLUTION, CRYPTIC SPECIATION, AND THE IMPACT OF ENVIRONMENTAL CHANGES ON ASSEMBLAGE COMPOSITION IN MIDDLE TO LATE MIOCENE MEDITERRANEAN AND PARATETHYAN PLANKTIC FORAMINIFERAL GENUS ORBULINA**

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The status of species belonging to the Middle Miocene to recent genus *Orbulina* can not be explained satisfactorily with existing taxonomic classification schemes. Genetically defined cryptic species as shown from modern Oceans can also be expected for the geological past. In order to combine ascertainable data from an early phase of the genus evolution to a coherent general view, we investigated Middle to Late Miocene *Orbulina* specimens on morphological and geochemical properties. This include biometric analyses (test size and thickness, pore sizes of adult and neanic stages, sizes of areal apertures) and stable isotope analyses ( $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) for successive time intervals from two different paleoceanographic settings. We found all combinations of neanic and adult structural properties (cancellate to non-cancellate) that made it impossible to identify separate species by different wall structures alone. The classification of planktic foraminifera on the base of wall structure is therefore not a useful taxonomic tool for the genus *Orbulina*. However, the combination of selected biometric and isotopic parameters allows the separation of distinct "populations". Mediterranean and Paratethyan *Orbulina* show distinct isotope signals, particular heavier  $\delta^{13}\text{C}$  values in the Paratethys. Among Mediterranean *Orbulina*, different habitats or vital effects are documented by distinct stable isotope compositions in *O. suturalis* and *O. universa*, especially in  $\delta^{13}\text{C}$  values. The observed temporal trends in neanic and adult shell structures towards smooth or non-cancellate surfaces point to an ongoing slow directional speciation in Mediterranean *Orbulina*. This trend is interrupted by recurrences of primary morphologies such as *O. suturalis* and cancellate wall structure during periods of environmental change. Based on the sole occurrence of *O. suturalis* in the Paratethys, the different combination of shell structures of adult and neanic stages compared with the Mediterranean samples, the larger apertures, and in combination with the particular isotopic shell composition (1‰  $\delta^{13}\text{C}$  specific offset), it is very likely that the Paratethyan *O. suturalis* represents a further cryptic species in the *Orbulina* plexus.