Functional Morphology and Biomechanics of Chonetidine (Brachiopoda) Spines

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Chonetidine brachiopods are a suborder within the Order Productida that originated in the Late Ordovician and went extinct in the Permian. Chonetidines are concavo-convex brachiopods that are distinguished by the presence of a row of spines along their hinge. As chonetidines lacked a functional pedicle as adults and lived unattached to the substrate, their spines may have provided the chonetidines with additional weight and surface cohesion to keep them in contact with the substrate. Therefore, it is plausible that spines may have permitted chonetidines to resist transport and to live in higher energy environments than did their spineless ancestors. Also, it has been hypothesized that chonetidines lived with their spines oriented upstream, but this hypothesis is untested. The intent of this study is (a) to determine whether chonetidine spine morphology enabled chonetidines to maintain position in higher flow velocities than non-spinose specimens, and (b) to determine their life orientations relative to flow direction. High-energy conditions were simulated within a recirculating hydrodynamic flume. Experiments were performed on chonetidine specimens with and without spines to compare velocity at entrainment and final orientation. The results are consistent with the hypothesis that the evolution of hinge-spines may have enabled chonetidines to live in higher-energy settings. Chonetidines without spines were entrained, turned over, or buried at significantly lesser velocities than were the spinose specimens, even in cases in which the non-spinose specimens were heavier (one-way T-test, $p \ll 0.01$). In addition, spinose individuals consistently reoriented with their spines downstream, 180º opposite the orientation predicted by previous hypotheses; non-spinose individuals did not display a consistent final orientation. Chonetidine spines may act as "flow-splitters," reducing the onset of turbulence in the downstream direction and, thereby, reducing destabilizing drag and scour. This study is the first to demonstrate biomechanically that chonetidines could have survived higher-energy paleoenvironments.