Morphology-performance Mapping Determines Least Functional Resistance in Morphospace: A Case of Dual Locomotor Systems in Chinese Sturgeon

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April 05, 2024

Abstract

Morphology-performance (M-P) mapping seems to be predictive of how morphology may evolve along "functional lines of least resistance", regardless of genetic effect, but as yet it is not clear the strict (or mathematical) definition of the least functional resistance and how M-P mapping determines it. We recorded station-holding and swimming performance using a published critical swimming speed (Ucrit) test in Chinese sturgeon Acipenser sinensis, and used Ucrit as a proxy for fitness. We addressed a geometric morphometric framework to initiate Arnold's "morphology-performance-fitness" path model (Arnold, 1983), assessing and visualizing apparent and direct M-P mapping. We quantified them as that one unit of the most-performance-covaried shape vector generated fapparent and f units of standardized performance, respectively. We defined the least functional resistance as the theoretically minimum morphological variation on an arbitrary direction in morphospace required by one unit of standardized fitness, (|b-1|min), which was calculated as a multivariate function of direct M-P mapping (f), together with the angle between paired most-performance-covaried shape vectors in morphospace (ϑ) and direct performance effect on fitness (w), given dual performance systems. The simulated and empirical data suggested that |b-1|min was constrained by larger sum of absolute direct effects (|fhold| + |fswim|) and absolute functional interaction (|fhold fswim cos ϑ|), and its direction was biased by magnitude of direct M-P mapping.

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