A Morphological and Mechanical Analysis of the Diving and Floating Methods in a Backswimmer

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As interest in marine resource development and naval capability grows, the need for efficient and maneuverable marine exploration technologies has become urgent. Current large-scale exploration equipment faces limitations, including high energy consumption and short operational durations, reducing efficiency in complex marine environments. Thus, the development of smaller, more efficient exploration devices is becoming increasingly important. This study explores the unique diving and buoyancy mechanisms of the backswimmer, a small aquatic insect, to develop biomimetic technologies for small marine exploration robots. The backswimmer regulates buoyancy by trapping and releasing air in its abdominal air sac using fine hairs, while powerful leg movements provide precise propulsion. Previous research has mostly focused on buoyancy control, with less attention to leg movement and the morphology of the abdominal air sacs. The study systematically analyzes the backswimmer's locomotion mechanisms. First, the structure of abdominal and leg hairs is examined morphologically, and the volume of trapped air is quantified. Next, the leg morphology contributing to propulsion is identified, and the area formed by the hairs is measured. A novel locomotion model integrating buoyancy, propulsion, drag, and gravity is then proposed and validated through experimental video analysis, comparing predicted and actual movement patterns. By improving understanding of the backswimmer's buoyancy and propulsion mechanisms, this research offers valuable insights for developing biomimetic marine exploration technologies that could improve energy efficiency, extend operational duration, and enhance maneuverability in complex underwater environments.

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