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石田螺與瘤蜷的生物流體力學分析與應用

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摘　　要　淡水螺是台灣水質的重要生物指標，同時也是螢火蟲的主要食物來源。對於水中生物而言，水流可以增加營養物質的傳輸與新陳代謝，但是同時也會施加應力在生物體上。本研究中將針對石田螺與瘤蜷的型態、阻力、升力、吸附力與衝落流速進行量測。根據所量測的結果，求得流體力學、形態與機械特性的關係。由本實驗的結果可以發現在高流速下流線型的螺殼將可以減少阻力與昇力，流線型的螺殼型態使得瘤蜷在減少水中應力上表現較石田螺佳。理論上，瘤蜷應較石田螺更能抵擋水流的沖落，但是衝落實驗的結果並非如此，瘤蜷反而較石田螺更容易衝落。經過衝落模式的分析可以將淡水螺的沖落機制分成兩個部分：衝落機制，包括阻力、升力與浮力；及抵抗衝落機制，包括吸附力與重力。總而言之，水流作用力主要是由螺殼的型態所決定，吸附力則可減緩水流直接的作用力，而衝落流速則是由水流作用力與生物力的交互作用下而決定。

關鍵詞：淡水螺、流體力學、型態、石田螺、瘤蜷。

The Analysis and Application of Biological Hydrodynamics on the Freshwater *Snails Sinotaia quadrata* and *Thiara granifera*

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ABSTRACT　Freshwater snails are important biological indicators of water quality and the primary source of sustenance for firefly larvae in Taiwan. Currents may promote the transport of nutrients and the metabolism of aquatic organisms. However, they may simultaneously exert stresses on organisms. In this study, the morphology, drag, lifts, adhesive forces and dislodgment velocities of *Sinotaia quadrata* and *Thiara granifera* were measured. The relationships among hydrodynamics, morphology and mechanical characteristics were derived from the results of the measurements. The results indicated that the streamline shell could reduce drag and lift under high current velocity. The morphology of *T. granifera* was superior to that of *S. quadrata* for resisting hydrodynamic stresses because it is streamlined. Theoretically, the *T. granifera* should be better able to resist dislodgment than *S. quadrata*; however, the results of the dislodgment experiment

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did not confirm this expectation but showed that *T. granifera* was more easily dislodged than *S. quadrata*. The analysis of the dislodgement model showed that the mechanism of dislodgment of freshwater snails consists of two parts - the actual dislodgment mechanism, involving drag, lift, and buoyancy, and the dislodgment-resistance mechanism, involving adhesive force and weight. In conclusion, the hydrodynamic forces were determined primarily by the morphology of the shell, and the adhesive forces served as a buffer of the direct effects of hydrodynamic forces. The dislodgment velocity was determined by the interaction between hydrodynamic and biological mechanisms.

Key Words: freshwater snail, hydrodynamics, morphology, *Sinotaia quadrata*, *Thiara granifera*