Title: Morphological Evolution of Diving Beetles (Dytiscidae) From a Fluid Dynamics Perspective
Name: Kai Miyajima
School: Sapporo Kaisei Secondary School
Place: Sapporo, Hokkaido, Japan

Diving beetles (Dytiscidae) are among the most well-adapted freshwater insects. A previous study on variations in the length between the point of maximum width of the elytra and the tip of the abdomen (DW) reported that DW is relatively shorter in species with larger body lengths. Variation in the Reynolds number (Re), which characterizes the flow state, presumably influences the DW of beetles as an adaptation to the surrounding fluid environment. This study performed a two-dimensional simulation of the flow field around a beetle and evaluated the effect of DW at various Re (Re = 100, 500, 900, and 1300). The velocity field, pressure field, and drag coefficient were calculated by solving the two-dimensional incompressible Navier–Stokes equations. During the initial flow development, the results indicated that a larger DW minimized the drag coefficient across all Re by suppressing boundary layer separation. Conversely, a smaller DW induced the early development of twin vortices, thereby increasing drag. However, a reversal of the drag advantage occurred over time: the larger DW eventually developed stronger separation and vortical structures, leading to higher drag. The reduced DW observed in larger species may represent an evolutionary adaptation to higher Re flow conditions following the transition. Because drag reduction associated with decreased DW is enhanced under high Reynolds number conditions, stronger selection pressure may act in high-Re environments. The structural modification of DW likely optimizes swimming efficiency in higher Re environments, providing a fluid-dynamic explanation for the morphological features of diving beetles.