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External vortex pumping by oscillating plate arrays of mayfly nymphs ANDREW SENSENIG, Univ. of Akron, KEN KIGER, JEFFREY SHULTZ, Univ. of Maryland — Mayfly nymphs are aquatic insects, many of which can generate ventilation currents by beating two linear arrays of external plate-like gills. The oscillation Reynolds number associated with the gill motion changes with animal size, varying from $Re \sim 2$ to 50 depending on age and species. Thus mayflies provide a novel system model for studying ontogenetic changes in pumping mechanisms associated with transitions from a more viscous- to inertia-dominated flow. Observation of the 3-D kinematics of the gill motion of the species *C. triangulifer* reveal that the mayfly makes a transition in stroke motion when $Re > 5$, with a corresponding shift in mean flow from the ventral to the dorsal direction. Time-resolved PIV measurements within the inter-gill space reveal the basic elements of the flow consist of vortex rings generated by the strokes of the individual gills. For the larger Re case, the phasing of the plate motion generates a complex array of small vortices that interact to produce an intermittent dorsally directed jet. For $Re < 5$, distinct vortices are still observed, but increased diffusion creates vortices that simultaneously envelope several gills, forcing a new flow pattern to emerge and preventing the effective use of the high Re stroke kinematics. Thus we argue the transition in the kinematics is a reflection of a single mechanism adapted over the traversed Re range, rather than a shift to a completely new mechanism. This work is supported by the NSF under grant CBET-0730907.

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