Macroinvertebrate movements across a gravel-bed substrate: effects of local hydraulics and microtopography under increasing discharge

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Flow refugia provide a mechanism that can explain the persistence of macroinvertebrate communities in flood-prone, gravel-bed rivers. The movement behaviour of macroinvertebrates is a key element of the flow refugia hypothesis but surprisingly little is known about it. In particular, little is known about how local near-bed hydraulics and bed microtopography affect macroinvertebrate movements. We used a novel casting technique to reproduce a natural gravel-bed substrate in a large flume where we were able to observe the movement behaviour of the cased caddisfly Potamophylax latipennis at different discharges. The crawling paths and drift events of animals were analysed from video recordings and used to classify sites on the substrate according to the type of insect movement. We used Acoustic Doppler Velocimeter (ADV) measurements close to the boundary to characterise the hydraulic conditions at different sites and a detailed Digital Elevation Model (DEM) to characterise sites topographically. Animals made shorter more disjointed crawling journeys as discharge increased, although they tended to follow consistent paths across the substrate. As we hypothesised, crawling behaviour was locally associated with low elevations, low flow velocities and low turbulent kinetic energies, while sites that insects avoided were characterised by higher elevations, velocities and turbulence. Discrimination was greater at higher discharges. We suppose that these relations reflect the need of animals to reduce the risk of entrainment and minimise energy expenditure by avoiding areas of high fluid drag. As discharge increased there was a general upward shift in the frequency distributions of local velocities and turbulent kinetic energies. The animals responded to these shifts and it is clear that their different activities were not limited to fixed ranges of velocity and turbulence. We assume that the absolute hydraulic forces would become a limiting factor at some higher discharge. At the discharges examined here, which are below those required to generate framework particle entrainment, patterns of animal movement appear to be associated with the animals' experiences of relative velocities rather than absolute hydraulic forces.

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