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The power of biology in rivers: The relative significance of invertebrates to fluvial geomorphology

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Organisms living in rivers have adapted to survive, utilise and modify fluvial environments. Despite a growing number of examples of animals altering river channels, fluvial biogeomorphology is not well integrated into geomorphological or biological systems.

Longitudinal energy dynamics along rivers is central to understanding geomorphological processes and energy transfers through trophic webs are fundamental to ecological study. These energy systems do not occur in isolation - there are exchanges between them of which biogeomorphic feedbacks are one example. For example, burrowing is an exchange in energy from the biological system to the physical system, expending trophic energy and, as a result, changing the physical energy required to subsequently mobilise sediment. Therefore, it is proposed that framing the interaction of organisms and the environment as energy transfers may be an informative way of integrating biogeomorphology into more established knowledge frameworks and assessing the relative significance of animals in comparison to physical processes.

Using a combination of modelling, mesocosms and existing knowledge, an example of an energy transfer was quantified and the results used to discuss the potential significance of animals to river processes. This was achieved by first modelling the stream power per unit width along three rivers using existing topographic, discharge and site survey data. In these rivers, there are also repeated species-level macroinvertebrate samples. Information on the calorific content of collected species was collated from the literature, which represents the theoretical maximal energy available. Only a proportion of this energy is available for day-to-day activity, of which a small proportion might be used in environmental modification.

As a proof-of-concept, the energy expenditure of the Signal Crayfish (Pacifastacus leniusculus), found in all three rivers, was quantified in mesocosms. Animals were placed for 2 hours on an experimental substrate consisting of uniform particles of the same shape, size and weight. During experiments, the dissolved oxygen level was continuously recorded and, from the oxygen consumption rate, it was possible to estimate the total energy expenditure of the animal. Because all grains were the same size and weight, the proportion of this expenditure associated with sediment modification could be derived by recording grain movements from repeat Structure from Motion and continuous videography.

The findings tentatively show that the total available biological energy from invertebrate animals dwarfs that of stream power for all studied rivers throughout the year. In addition, if the energy inputted into sediment modification by crayfish is extrapolated to the densities of crayfish found in the study reaches, crayfish alone would be the dominant control on sediment transport for all but the largest flows.

Extrapolating through population density and focusing on one species leads to large uncertainties in the results. However, the results do: 1) give an initial illustration of the potential relative significance of invertebrates to fluvial geomorphology; 2) raise important questions about the dominant controls on sediment transport in rivers, and; 3) provide a potential method for quantifying biogeomorphic activity and situate it in a wider academic context.