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GRADUATE SCHOOL POSTER COMPETITION

Ecology of a Chalk Aquifer: Composition of Benthic, Hyporheic, and Phreatic Invertebrate Communities in Relation to Changing Environmental Conditions

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Introduction

Groundwater is recognised as an important resource for drinking water, agriculture, and industry, but it also plays an essential role in supporting the functioning of freshwater ecosystems and providing habitat for a number of rare species. However, despite its importance, groundwater ecology often receives little attention in environmental legislation or research. This study aims to improve our understanding of the organisms living in groundwater-dependent habitats and the influence of environmental conditions on their distribution.

The Study

Biological, chemical, and physical surveys were undertaken at thirteen sites across the Catchment of the River Stour, a lowland chalk environment located in Southern England (**Figure 1**).

Three different groundwater-dependent habitats were surveyed to assess community composition in relation to environmental conditions. Paired samples were collected at five sites on the Little Stour and Dour Rivers from the first two habitats, the riverbed (benthic habitat) and below the riverbed (hyporheic habitat), while individual samples were collected from eight sites across the wider aquifer (phreatic habitat) using boreholes and wells (**Figure 2**). Each of these three habitats reflects differing levels of groundwater influence. While the benthic habitat reflects surface water conditions and the phreatic habitat reflects groundwater conditions, the hyporheic habitat is a unique environment where the active mixing of downwelling surface water and upwelling groundwater occurs.

Samples were collected bimonthly over a period of four years using nets, pumps, and liquid nitrogen freeze coring (**Figure 3**).

Results and Discussion

More than one hundred invertebrate species, including some new to the British Isles, were identified using morphological and molecular techniques. During normal conditions, distinctive invertebrate communities were recorded in each of the three habitats (**Figure 4**). The benthic habitats were found to support a diverse community of pollution-intolerant, surface-specialist organisms typical of small, lowland chalk rivers such as *Agapetus fuscipes* (caddisfly), *Seratella ignita* (mayfly), and *Gammarus pulex* (freshwater amphipod). The community recorded in the hyporheic habitat comprised a mixture of surface and groundwater-affiliated organisms. This community was dominated by taxa

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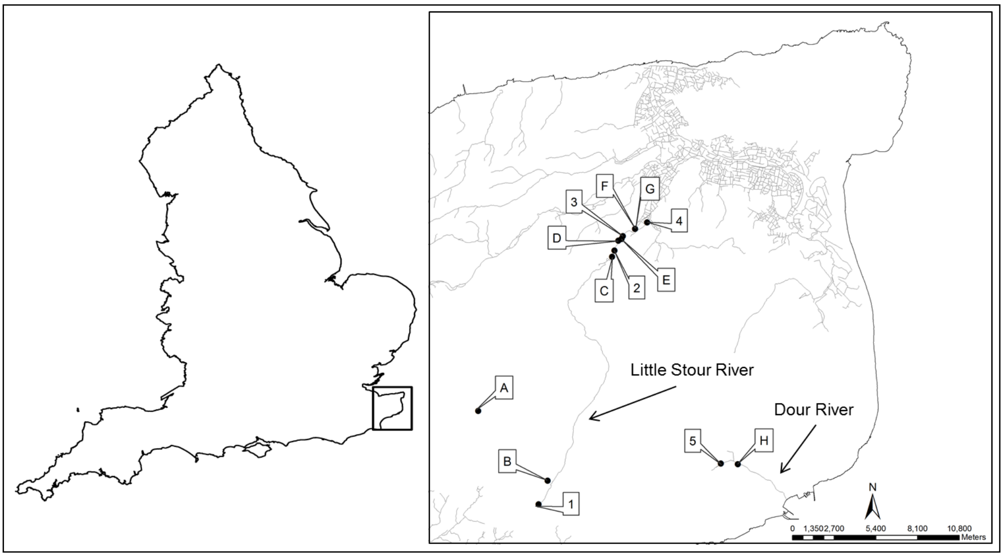

Figure 1: Maps of the study area in the south-east of England in which the riverine sampling sites (n=5) are represented by numbers and the phreatic sites (n=8) are represented by letters.

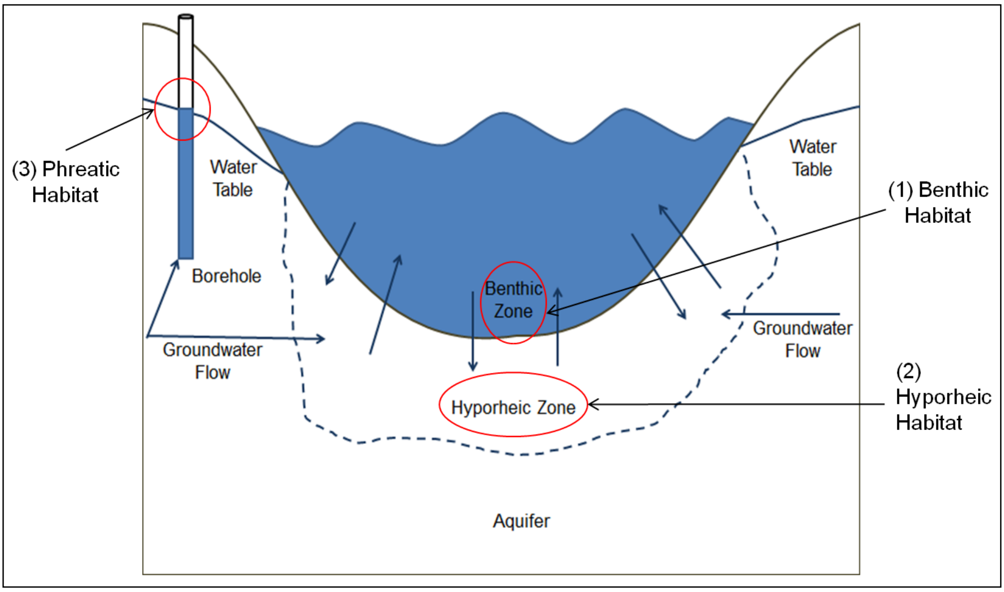

Figure 2: Diagram of the three groundwater-dependent habitats considered by this study, the: (1) benthic habitat (river bed); (2) hyporheic habitat (below the river bed); and (3) phreatic habitat (aquifer).

whose shape or size facilitated their exploitation of the hyporheic environment such as the vermiform Chironomidae (midge larvae) and comparatively small Hydrachnellae (water mites). Organisms affiliated with groundwater, such as *Niphargus aquilex* (freshwater amphipod), were also recorded. These organisms display morphological

Figure 3: Methods used to collect biological samples from groundwater-dependent habitats from left: suber net, phreatic net, Bou-Rouch pump, and liquid nitrogen freeze coring.

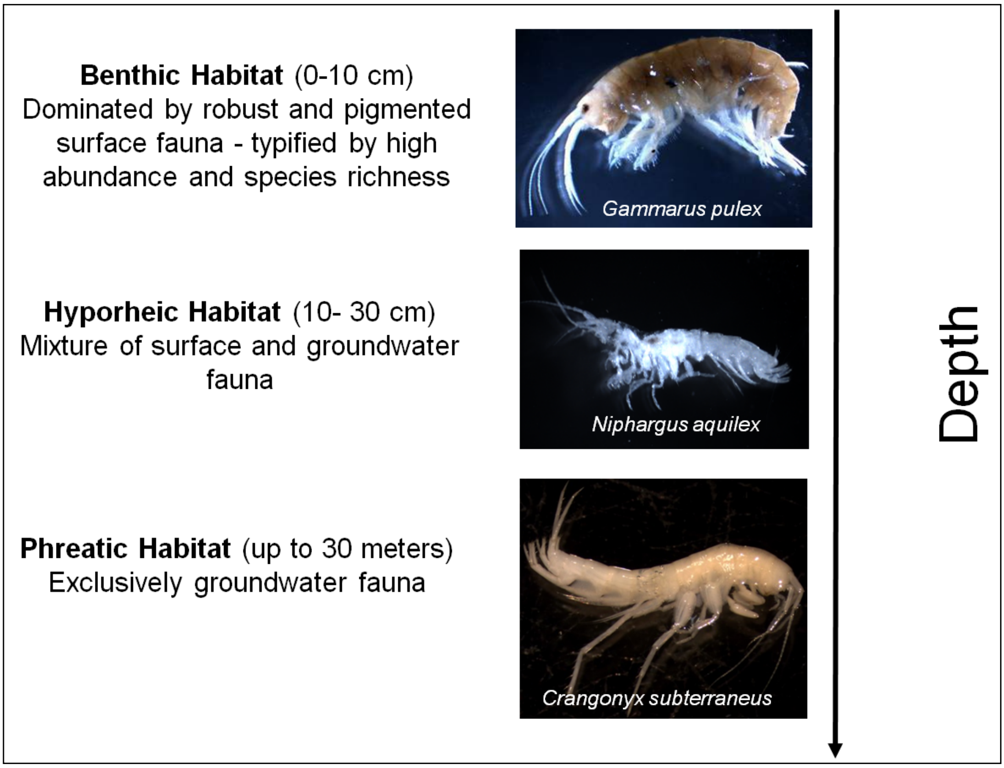

Figure 4: Illustration of invertebrate taxa, reflective of their wider communities, recorded within the three habitats considered by this study.

adaptations to the groundwater environment as they lack both eyes and pigmentation. The phreatic habitat exclusively supported these groundwater-specialist organisms including *Niphargus kochianus kochianus*, *Niphargus fontanus*, and *Crangonyx subterraneus* (all freshwater amphipods).

However, the composition of these communities was found to fluctuate during periods of environmental disturbance, particularly during the periods of high and low flows that occurred during the study (**Figure 5**).

The communities recorded in the benthic, hyporheic, and phreatic habitats were

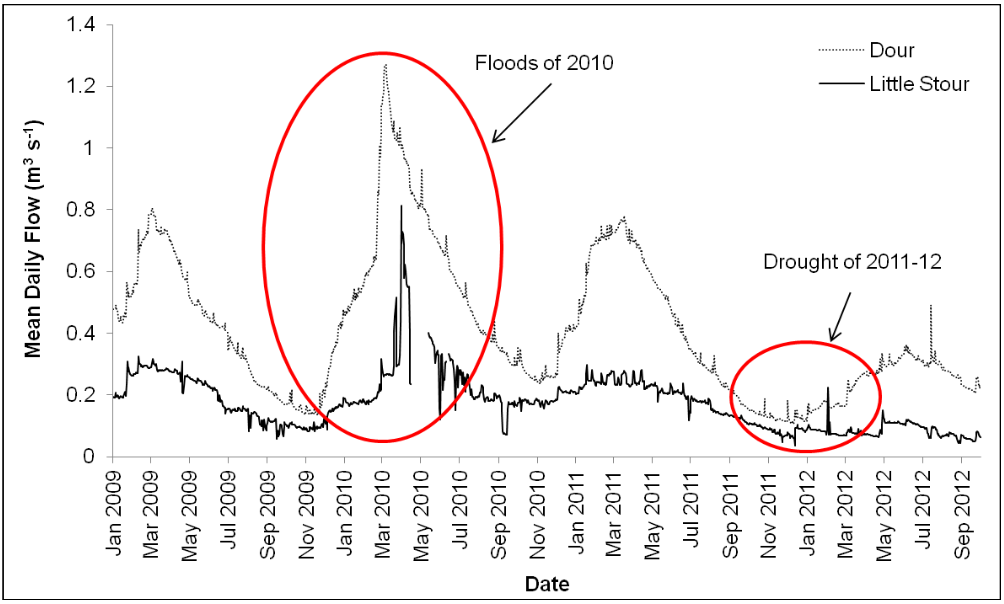

Figure 5: Hydrograph of mean daily flows recorded on the Little Stour (near site 2) and Dour (near site H) over the study period.

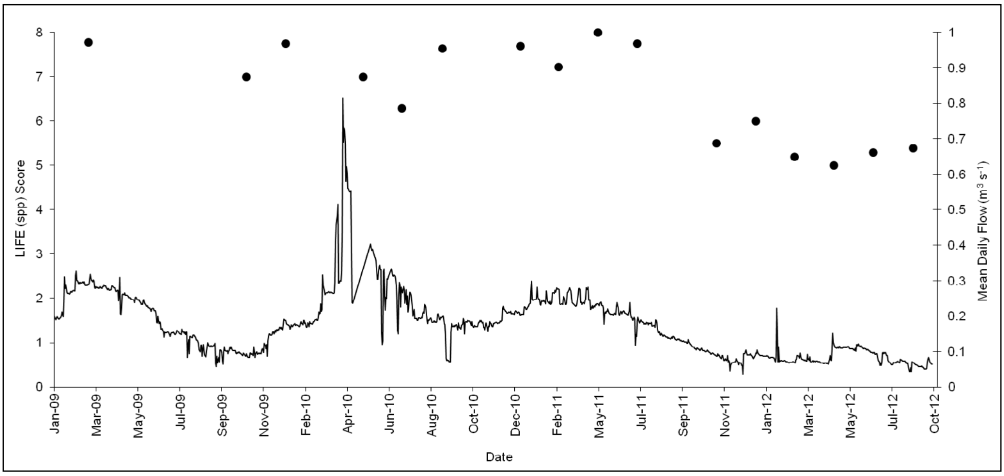

Figure 6: Assessment of changes in the number of flow-sensitive species (at Site 2) against mean daily flows (on the Little Stour) over the study period using the Lotic-invertebrate Index for Flow Evaluation (LIFE) scores (a community index in which higher values reflect greater sensitivity to low flows).

found to respond differently to these disturbances. In the benthic habitat, the number of flow-sensitive species declined markedly during the drought period, which is likely to be a direct result of low flows (**Figure 6**). Interestingly, there was also a slight reduction in flow-sensitive species immediately after the high flow event; however, this is likely to be an indirect result of a decline in water quality (owing to emergency discharges of sewage) over this period as many flow-sensitive species are also pollution intolerant.

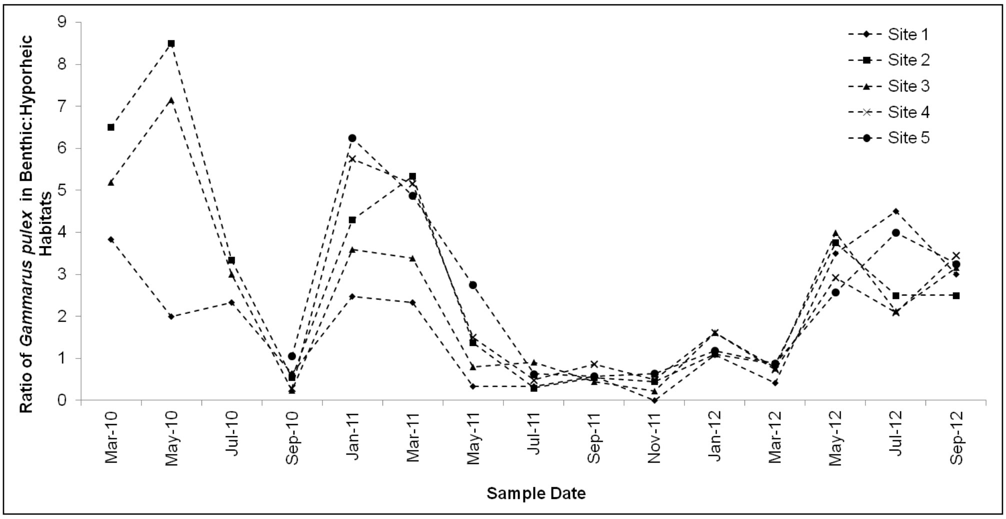

Figure 7: Ratio of *Gammarus pulex* in paired benthic and hyporheic samples depicting an increase of this normally surface-dwelling species into deeper habitats during periods of low flow.

These results suggest that community composition in the benthic habitat responds quickly to changes in flow and water quality.

In the hyporheic habitat, community composition also changed during periods of low flows, as the proportion of some taxa associated with benthic habitats, such as *Gammarus pulex*, increased, suggesting that some benthic species may use the hyporheic habitat as a refuge during adverse conditions (**Figure 7**). This migration is most marked during a short period of low flow in September 2010 in which some of the riverine sites dried completely.

Unlike the communities recorded in the benthic and hyporheic habitats, the composition of the phreatic community did not alter in relation to disturbance, recording little change in abundance or diversity over this same period (**Figure 8**). This consistency in results may be attributed to the comparative resilience of the phreatic environment to short-term perturbations.

Conclusions

This study surveyed three different groundwater-dependent habitats to better understand the organisms they support and the way in which these communities may be influenced by changing environmental conditions. The results indicate that each of these habitats supports a distinctive invertebrate community during normal conditions, the composition of which reflects its surrounding environment; however, these communities were found to fluctuate during periods of disturbance. The recovery of these communities following a disturbance event is likely to depend on the frequency, duration, and intensity of the perturbation and requires further investigation.

These conclusions suggest that the invertebrate communities occupying benthic, hyporheic, and phreatic habitats each respond differently to changes in the environment and that the assessment of a single community, as is the current practice with most statutory freshwater monitoring programmes, under-records the presence and the movement of a number of sensitive species, particularly during disturbance events. A greater understanding of the distribution and the requirements of communities occupying groundwater-dependent habitats, and the impacts of environmental change on these communities, is essential for the

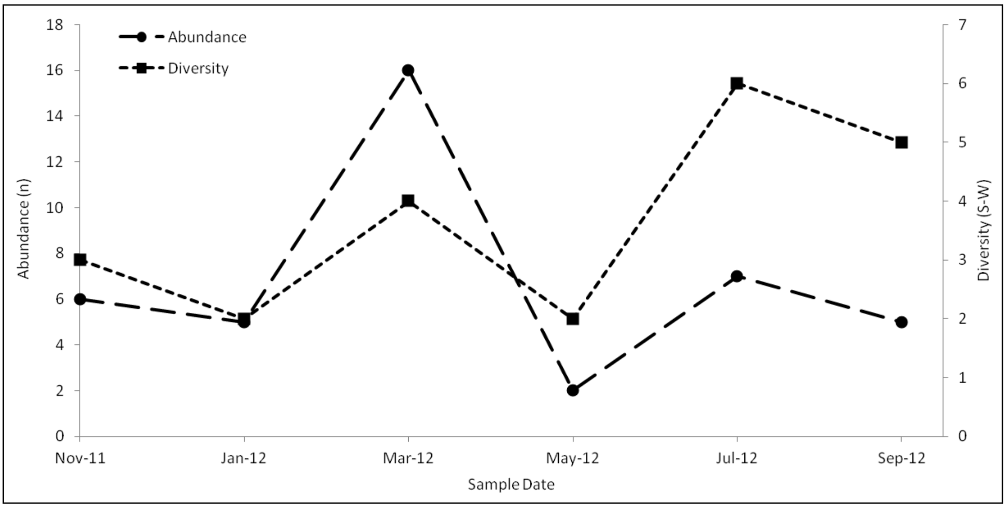

Figure 8: Aggregate abundance and diversity (Shannon-Wiener) for all phreatic sites (n=8) from November 2011 until September 2012 showing little change in either the number of individuals or the diversity of the communities recorded at these sites over this period.

management and conservation of freshwater ecosystems.

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Notes

This manuscript reflects the content of a winning poster (by the same name) presented at the UCL Graduate School 2014 Poster Competition.

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