Impact of Root Herbivory on Grassland Community Structure: From Landscape to Microscale

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Introduction Root herbivores are an important functional group in grassland ecosystems. Whilst there is a plethora of information on their impact as pests in productive grassland, few studies of their impact on biodiversity in upland grassland have been made. Root herbivores act in a number of ways, they reduce host plant biomass, alter root architecture, change root exudation patterns and increase water stress in the plant. Root herbivores may change above ground plant diversity, both through direct removal of plant species and through reduction in competitive ability of some species, through their feeding. In addition, we postulate that root herbivores affect soil microbial communities through changes in root exudation.

Materials and methods *Field Study*. As part of the UK NERC 'Soil Biodiversity' thematic programme, a randomised block experiment was established on an upland grassland (NVC classification U4d), at Sourhope in the Scottish Borders, UK. The experimental area was fenced to prevent grazing and comprised five replicate blocks each with six 20 x 12 m plots, marked out in late 1998. Plots in each block were allocated to one of five experimental treatments: 1: control (C), untreated (two plots); 2: lime (L) applied at a rate of 1.2 kg/m^2; 3: nitrogen (N) applied at a rate of 12 g/m^2; 4: lime and nitrogen (N+L) applied as above; and 5: pesticide applied as chlorpyrifos (Dursban 4: Dow Agrosciences) at 1.5 kg active ingredient per ha. The N and the lime were applied once per year at the beginning of the season. The plots are cut every three weeks from May into September (5 times per year). The pesticide was applied after every cut. Root herbivore populations in three of the treatments (C, N+L and pesticide) were sampled at three monthly intervals from June 1999 to March 2001: at the end of the experimental programme a detailed botanical survey was undertaken.

Microcosm studies. In order to determine feeding effects at a smaller scale, a number of microcosm experiments were undertaken to investigate the impact of root feeding on soil microbial community structure. *Lolium perenne*, *Trifolium repens* and *Agrostis capillaris* were grown individually in soil microcosms with larvae of *Tipula palidosa* added to half of the units. Microbial community structure under the plants was determined by Community Level Physiological Profiles (CLPP)

Results and discussion In the field study, populations of *Tipula paludosa* initially reached *ca* 120/m^2, but reduced to zero in the second year in the C and NL plots. However, populations of *Agrotis* spp. (cutworms) increased in these treatments, thus maintaining root herbivory in the system. The pesticide addition removed all large insects within three months. In addition to the more obvious impact of root herbivory (i.e. removal of plant tissue) root feeding had a number of other more subtle effects, both on the plant and on the other members of the soil community. The detachment of large quantities of root material puts severe pressure on the plants and demands re-allocation of resources for root maintenance and replacement. This is important in determining the fitness of individual plants with implications for plant diversity. Plant species richness was greater in the pesticide plots than in the C plots and this may be a consequence of the removal of the root herbivores, particularly as the overall numbers of the major above ground herbivores (slugs) were not reduced by the pesticide. The removal of large amounts of plant tissue by root herbivores increases the inputs to the detrital pool in the soil and provides an energy source for the soil micro-organisms. The soil microbial community is also influenced by changes in root exudation patterns, mediated by root feeding. In the microcosm experiments the presence of the larvae led to a change in the CLPP of the soil microbial community which was mainly due to differences in sugars, carboxylic and amino acid usage, suggesting larval herbivory increases the release of these compounds, which then selects for microorganisms capable of utilising these substrates.

Conclusions A wide range of effects of root herbivory in grassland systems was demonstrated. It should be noted that the presence of root feeders is common in grassland and their impacts should not be dismissed lightly.

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