Soil Biodiversity

NERC Thematic Programme

Photo: S Buckland

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SOIL BIODIVERSITY: The Second Phase

The Steering Committee met after the Warwick University discussions to define the second phase of the Programme. The main aim was to quantify functional groups of biota in C transfers in the soil, emphasising interactions, eg linkages between fungi and collembola or between bacteria, protozoa and worms. Studies should sit in an explicit modelling framework and provide output data to fit into mathematical models of segments of the food web.

The main themes:

- Quantification of C flows in the soil and the role of the diversity faunal groups. The use of C isotope signals from $^{13}CO_2$ labelled inputs was to be a key component of the experimental method. Bidders were told that $^{13}CO_2$ signals would be provided. A contract supervised by NERC would deliver the labelled CO_2 with the necessary flexibility to vary the dates over the remaining years. Proposals which focus on aspects of the N pathways would be considered, but the emphasis is on C, and the functional groups and processes controlling its fluxes.

- Development of model theory and an overarching conceptual model into which mathematical sub-models could be placed. Models linking C flows and the inter-relationships with functional diversity, possibly linking the size and activity of populations with soil architecture will require the development of new model theory and approaches. A key goal of the model development will be to reduce the number of parameters, while retaining a realistic representation of the critical processes and pathways.

- Resilience of key processes and the controlling organisms to stress/disturbance and the role of diversity in the relevant groups of biota in determining resilience. Opportunities exist for relaxing the existing treatments and for imposing new perturbations on the soil biota. Proposals in this area were asked to address functional and taxonomic aspects of biodiversity, either in the field or laboratory.

- Strategic studies related to the requirements of the user community, if possible largely funded by appropriate users. Projects to address questions of strategic importance, eg the influence of diversity of functional groups on rates of degradation of chemical compounds; the influence of stresses on the capacity of soils to degrade pollutants or contaminants; also the development of indicators of soil sustainability, sensitivity or resilience. Studies could be funded by relevant users. Areas of the Sourhope site could be used for additional treatments, for example specific contaminants.

- Studies filling gaps in understanding the functional diversity of specific groups of organisms in the Sourhope soil. In this context, a number of small Research Grants (up to £35,000), may be awarded. No further PhD studentships are envisaged.

Fruits of the Field

Basidiome diversity at Sourhope

Under a threatening September sky and with waterproofs at the ready, Janie Pryce Miller, Professor Roy Watling, Dr Mike Richardson and I entered the Sourhope field site. The reason we were there was to survey, collect and isolate the autumn-fruiting basidiomycete fungi. With Roy Watling and Mike Richardson as identification experts, we scanned each plot at the field site for any basidiomycete fruiting bodies (basidiomes). All basidiomycetes were identified *in situ,* except for difficult cases which were collected and given to Roy Watling for further study. A representative selection of species was taken for immediate isolation from spores in the laboratory at the Sourhope field station.

Compared with the species kindly collected in autumn 1999 by Dr Sarah Buckland, there were greater numbers of species and individuals recorded in 2000. There were also differences in the five most common species recorded between the two collections.

Basidiomes collected at the 2000 sampling showing the complete range of species morphology

In 1999 the five most common species collected were, in descending order: *Nolanea staurospora* (36 basidiomes), *Camarophyllus niveus* (11), *Psilocybe semilanceata* (11), *Clavulinopsis helvola* (10) and *Hygrocybe laetea* (7). By contrast, in 2000 the five most common species collected were: *Psilocybe semilanceata* (307), *Galerina clavata* (167), *Clavulinopsis fusiformis* (133), *Nolanea staurospora* (96) and *Mycena aetites* (60). All species that occurred in the top five of 1999 were also present in the 2000 samples. The species found in both years were typical of fungal assemblages in acidic grasslands. *Galerina clavata* is common in damp areas and was noted upon collection to be concentrated around the furrows of the site, where there is likely to be an increase in soil moisture. A further collection is planned in September 2001.

Lewis Deacon
King's College London
and CEH Merlewood

Vegetation changes in response to biocide effect on soil fauna

As part of our project "Biodiversity of root feeders and their impact on soil microbial communities" we are studying whether there are interactions between the large root-feeding insects (such as tipulids and chafer grubs) and arbuscular mycorrhizal (AM) fungi. One of our original hypotheses was that these insects consume large quantities of root and disturb the mycorrhizal mycelium through burrowing. Therefore their presence may serve to reduce fungal colonization. Reducing their numbers with an insecticide should therefore lead to an increased level of mycorrhizal colonization. We have recorded AM colonization levels in the control and biocide plots at Sourhope since June 1999. At the start of the experiment, there was no difference in colonization levels of *Agrostis capillaris* between treatments with the control plots having a level 1.33 times that of the biocide. However, by October 2000, this situation had changed and levels in the control plots were four times that of the biocide plots. Applying insecticide has not increased AM abundance and appears to have decreased it.

Our thoughts have therefore turned to other organisms present in the soil, which might be affected by the biocide, and which might affect AM fungi. The obvious candidate is the Collembola, as one of us (Gange 2000) thinks that these organisms can increase AM colonization, through their preferential feeding on non-mycorrhizal fungi in the rhizosphere, thus reducing fungal competition and allowing AM fungal growth. If this is so, then adding a biocide should reduce Collembola numbers and thereby decrease AM abundance. Collembola appear to be more evenly distributed over the site (relatively speaking!) than larger insects and are certainly more numerous. We are therefore now thinking that the most important subterranean herbivores are at the micro, rather than macro scale. When we get back on site, we will start testing this idea in Sourhope Collembolan communities ....

Gange, A.C. (2000) Arbuscular mycorrhizal fungi, collembola and plant growth. TREE 15, 369-72.

Amanda Currie, Alan Gange & Phil Murray

New Sourhope site manager

Graham Burt-Smith has been appointed to take over from Sarah Buckland this month. The two will work together during May on site maintenance and Sarah will remain in summer to carry on with her research under the Macaulay Institute award. Graham has been based in Sheffield carrying out environmental surveys, but has previous experience in banking, which may be useful in eking out the NERC grant money. His PhD was carried out on one of the LTER sites in the USA, so he has experience of long term sites.

It would be premature to say goodbye to Sarah Buckland at the moment, but as most of you will know by now she has retired as site manager. She has done a fantastic job of co-ordination and succeeded in keeping everyone happy. We wish her well for the future.

Richard Scott, Programme Manager

A microbial missing-link found at Sourhope

At CEH Windermere, in collaboration with the University of Glasgow (Prof. Keith Vickerman) and CEH Merlewood (Dr Helaina Black), we are studying protozoan diversity and its role in carbon and nitrogen turnover in Sourhope soils. Within the various research areas of this project, there is one devoted to the taxonomy of ciliated protozoa (CEH-Windermere). Ciliates are fascinating single-celled organisms characterised by having a real "mouth" which they use to ingest particles ranging in size from bacteria to other organisms as big as themselves. So far, we have found one hundred and four species of ciliates in re-hydrated soil samples from Sourhope. One of these species, Psilotricha acuminata, is particularly interesting.

Figure 1: The cilliated protozoon Psilotricha acuminata (approx. 70µm long). Arrows to some of the cirri.

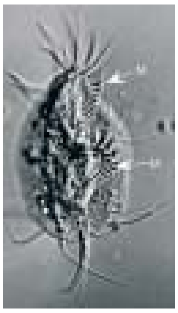


Figure 2: Specimen undergoing bipartition showing two mouths (M), one for each daughter cell.

It was first discovered in 1859 by a priest examining some rain-soaked manure on a farm in Germany, but it has never, until now, been described in detail. It belongs to a group known as hypotrichs, referring to the groups of cilia (the 'cirri', arrows to some of them in Figure 1) scattered across the ventral surface of the organism and used mainly for crawling on particles. The mouth is also on the ventral side (M on the dividing specimen of Figure 2).

As our investigations show, the ciliate is not just 'another hypotrich' (of which a few are described every year). Indeed, Psilotricha acuminata is probably the 'missing-link' between two large families of hypotrichs. The unknown identity of the common ancestor has been tormenting hypotrich taxonomists for some time. The features that give our species the status of missing link are the morphology of the ciliature (typical of the Euplotidae) and the morphogenesis during cell division (distinctive of the Oxytrichidae). In the past, several hypotheses have been offered for the identity of the common ancestor of both families, and in all cases the hypothetical ciliate would have had the features which we have now been able to demonstrate in Psilotricha acuminata. Further research into the natural history and cell division processes of this ciliate will help to illuminate the evolutionary history of the hypotrichs. The full re-description of Psilotricha acuminata is currently in press with the Journal of Eukaryotic Microbiology.

Genoveva F. Esteban, CEH-Windermere

Warwick University meeting of award holders November 2000

Braving the autumn monsoon season, most of the members of the Programme arrived to report research findings to date and to discuss the questions to be tackled in the second phase of research. The Programme manager emphasized in the buildup to the meeting the importance to NERC of the application of research to the user community. A panel of users was present and reflected to the meeting on the relevance of the Soil Biodiversity Programme to their needs. Prof John Lawton attended in his triple role as Programme author, PI and NERC Chief Executive. He gave a challenging summary of the meeting which generated a lively discussion.

Some of the PDRAs and PhD students who attended felt that the format, with over 80 people in the meeting room, held in the luxury of the Scarman House conference centre, inhibited their full participation.

Generally, apart from the cost of attendance, the meeting was a success and set the scene well for Steering Committee to draft the objectives for the second phase of research.

The Committee decided to create a service contract for the provision of the $^{13}CO_2$ pulse and set five main categories under which awards would be invited (see front page article).

Richard Scott

Foot and Mouth

Restrictions affecting access to farmland have meant that researchers have not been able to access Sourhope since the Foot & Mouth outbreak began in February.
A case at Hownam near Jedburgh has brought Sourhope perilously close to the outbreak and into an area with tighter restrictions. For this reason special arrangements have been made for samples to be provided by MLURI site staff, under the direction of the PIs.

A detailed workplan has been produced by the Site manager showing the dates set aside for the samples for each project. (Link to 2001 F&M workplan is on the News page of the Soil Biodiversity web site *www.nmw.ac.uk/soilbio*).

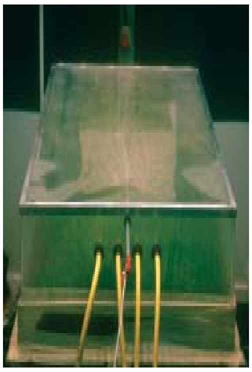
At the time of writing the disease appears to be declining and hopefully the access restrictions will be lifted later in the year.
Meantime teams must plan to work with the assistance of Sourhope staff who will strive to cope with the extra demands.

Richard Scott

Ecotron – the story continues...

Phase one of the Ecotron experiment investigated the effects of manipulated soil faunal diversity on ecosystem functioning. We reported the arduous task of setting up this experiment in issue 5 of this newsletter; here we provide an update on what has happened since. The first phase ran for nine months until early November 2000. This was followed by a busy interim period that, among other activities, included a ^{13}C pulse chase experiment. The Ecotron study tests the hypothesis that more diverse soil communities retain more carbon, as well as providing a mechanistic understanding of how they do it. Phase two of the experiment started after the model communities were N-perturbed in mid-December.

The initial nine months went to plan. The Ecotron Team and the 19 collaborators are currently analysing data amassed in phase one. We undertook a ^{14}C study to see if communities of different soil biota diversities metabolise C of different ages. This work was done with the NERC Radiocarbon Laboratory at East Kilbride. The ^{14}C samples are currently being analysed at the NSF Accelerator Mass Spectrometry (AMS) facility in Arizona, USA. Between the two experimental phases Nick Ostle and Phil Ineson brought SID to the Ecotron. The chambers were pulsed with $^{13}CO_2$ in early November; little did we realise what we had committed ourselves to. On top of massive amounts of ^{13}C sampling we frantically collected both final harvest data for Phase One as well as the baseline data for Phase Two. Even now we Ecotron scientists shudder as we think back to those long bleak days in November. The pulse-labelled samples are being analysed at Merlewood by the ^{15}N-SIF team as we write this report.



That team, the Ecotron team and associated collaborators will mass balance the work and determine trophic relationships. A modelling approach, in collaboration with Bill Hunt of the NREL, will aid interpretation of the data, as well as developing and testing specific hypotheses only feasible with a model.

Phase Two of the Ecotron experiment is a nine-month perturbation study. The resistance and resilience of our established communities comprising the three biota treatments (micro-fauna, micro- and meso-fauna, and micro-, meso- and macro-fauna) are being followed subsequent to N fertilisation. Just prior to fertilisation, each of the 15 Ecotron communities were divided into discrete halves with a stainless steel sheet.

NH_4NO_3 fertiliser was applied (quantity equivalent to 240 kg N ha^{-1}as at Sourhope) to one half of each community across two days. The unperturbed half functions as the control. The Ecotron Soil Biodiversity experiment is scheduled for final harvest at the start of August 2001.

That is when those 16 tonnes of soil we so laboriously transferred from Sourhope to Silwood will be thrown out of the window into an awaiting skip!

George Tordoff & Till Eggers
Imperial College, London

DATES FOR THE DIARY

Steering Committee meeting
26/27th June 2001 - York University

British Soil Science Society
3-5 September 2001 - Durham University
(meeting opportunity for PI's - old and new)

Programme Meeting
28-30 January 2002 - Stirling University

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