Behavioural and community ecology:understanding mechanisms driving biodiversity in pasture-based systems.

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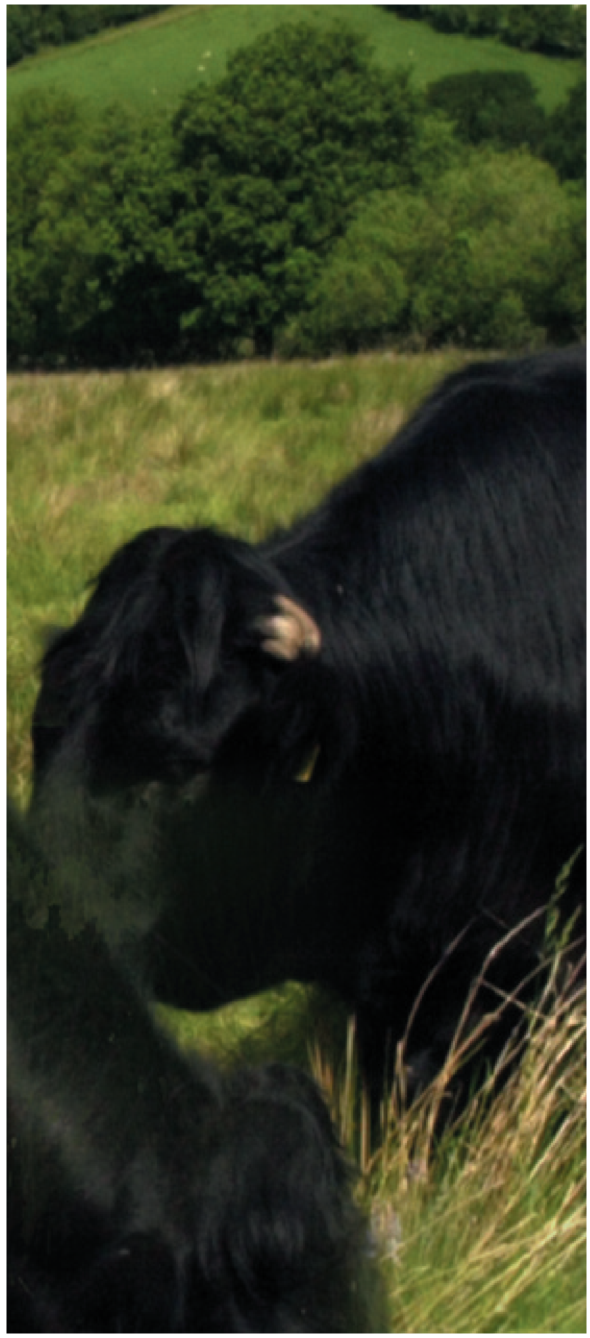

BEHAVIOURAL AND COMMUNITY ECOLOGY: UNDERSTANDING MECHANISMS DRIVING BIODIVERSITY IN PASTURE-BASED SYSTEMS

Andrew Rook, Jerry Tallowin, Mark Rutter, Robert Orr, Alan Hopkins, and Malcolm Gibb

Current agricultural policy emphasises the multi-functional role of the countryside and the necessity for land management systems that are both economically and environmentally sustainable. There has been a considerable body of work over recent years on methods to conserve and enhance biodiversity within farmed landscapes. However, interest is increasingly turning to the value of this diversity for the functioning of the ecosystem, either in terms of the resilience of the system to change or the delivery of goods and services required by man. Productivity by green plants within semi-natural and natural communities appears to be more resilient to abiotic and biotic stresses than is the case in the highly simplified communities commonly used for intensive agricultural production. However, there has been relatively little work to date on the mechanisms by which botanical diversity (including spatial and structural heterogeneity) influences functioning at other levels of the food chain and how these can be exploited to restore more complex ecosystems to agriculturally degraded landscapes. In this programme we are particularly interested in the management of semi-natural grazed grasslands, which are likely to increase in importance due to changes in subsidy regimes and environmental legislation. This complements other programmes at IGER that focus on options for more-intensively managed grasslands. We highlight below a number of key areas within the programme.

Impacts of livestock spatial behaviour on ecosystem processes

Livestock affect sward diversity by the patchiness they create. A key mechanism in creating this patchiness is the spatial distribution of excreta returns. Combining contemporary information on excretion and foraging patterns, obtained from a sub-metre global positioning system, with patterns of sward structure and botanical composition, allows us to identify functional relationships between animal behaviour and sward heterogeneity in both simple and complex swards at different spatial scales (Figure 9.1). For example, by measuring temporal and spatial synchrony of behaviour within groups we can assess the relative importance of social behaviour and food distribution in controlling the spatial distribution of excretion. This information will underpin practical recommendations for appropriate grazing management to achieve specific objectives in agri-environmental schemes, particularly those designed to meet Habitat Action Plan targets. We will also relate excreta distribution to sward state, as the impacts of nutrient inputs appear to depend on the type of sward patch on

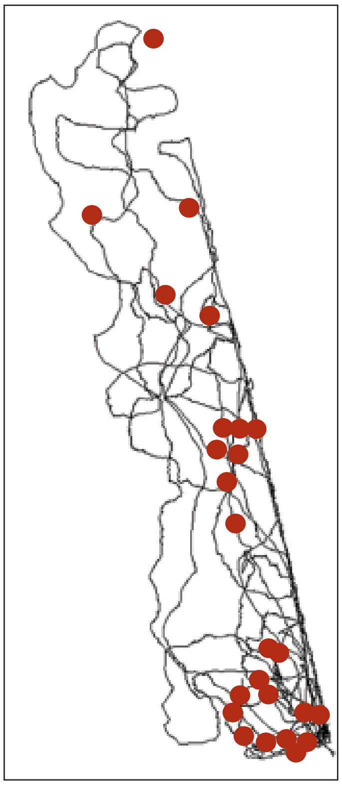

Fig 9.1. Plot of a heifer's movement (continuous line) and excretion events (red dots) over an 8 hour period.

Fig 9.2 Clover and grass sown in strips to test the scale at which animals can select different species

which they occur. This complements work in other programmes on soil and atmospheric processes which allows scaling up to catchment level and beyond.

Understanding dietary choices

Sward heterogeneity is also created by the dietary choices of grazing animals. Observations in semi-natural swards show that cattle return often to clover-rich areas, creating short clover-rich 'lawns'. This supports previous work showing a partial preference for clover by cattle offered a free choice between clover and grass. We have evidence from strip-sown systems (Figure 9.2) about the spatial scale at which cattle can make this selection. We have also examined motivation to eat clover and have shown that this declines as the distance animals need to walk to obtain clover increases.

We have developed short-term, small-scale, low-cost methods for evaluating intake characteristics of grazed perennial ryegrass varieties and demonstrated differences between varieties. We have also identified morphological characteristics (e.g., tiller density, leaf width) that appear to be driving these effects. We are now using these methods to explore the intake of a variety of grass species that are characteristic of semi-natural grazed grasslands and that differ in morphological or chemical defence strategies. Our present knowledge of the individual intake characteristics of most of these species is limited but it is needed in order to understand dietary choices between them. Our studies not only provide the basis for breeding more appropriate plants for sown multifunctional grasslands but also for understanding plant-herbivore interactions in complex semi-natural communities.

In recent years some nature conservationists have suggested that the use of traditional or indigenous livestock breeds may result in improved sward biodiversity due to differences in grazing behaviour and dietary choice. We are testing the relative importance of animal breed and stocking rate effects on sward structure and botanical and faunal diversity of grazed semi-natural pastures (Figure 9.3). We are also examining in detail the grazing behaviour of different breeds and the relative importance of breed or upbringing on animal behaviour and the resultant biodiversity outcomes. These results will inform the design of Environmental Stewardship schemes.

Fig 9.3 Do different cattle breeds have a different impact on semi-natural pastures?

Effect of sward biodiversity on product quality, secondary productivity and biological efficiency

In partnership with the Universities of Exeter and Bristol, we are investigating links between quality food production and biodiversity protection. This multi-disciplinary approach includes: (i) examining food products and production practices where biodiversity or local distinctiveness in forage resources is an important input in food production; (ii) providing biochemical data relating to final food products; and (iii) assessing perceptions of biodiversity-linked food quality and the role of these food products in rural development. Also, with Bristol University, we are looking in more detail at the composition and organoleptic (smell, taste, texture, etc.) properties of meat produced from both commercial and traditional breeds grazing either improved, species-poor pastures or more diverse semi-natural pastures. We aim to identify mechanisms by which quality benefits arise and to recommend management practices that will enhance these.

We are testing the hypothesis that allowing grazing animals to express their preference for a mixed diet results in optimisation of nutrient capture and thus reduced pollution per unit of production. Results elsewhere within IGER suggest that microbial protein synthesis in the rumen is maximised when a 30:70 grass:clover diet is fed. Our previous work has shown that animals select a similar mixture of their own accord when subject to minimal constraints. We will examine the importance of the pattern of selection over the day, which we have seen in previous work, by allowing the animal to manipulate nutrient uptake efficiency. We are also investigating whether different grass and legume species are exploited by the animal in this way, in order to provide a greater understanding of nutrient capture efficiency in semi-natural pastures. Our aim is to develop practical management systems that take account of these factors without imposing undue economic costs.

Effects of abiotic and biotic constraints on restoration and maintenance of grassland biodiversity

We are examining the timescale of the assembly of semi-natural grassland communities through natural colonisation at two agriculturally improved, species-poor sites, and associated changes in edaphic (soil-related) conditions. We are investigating whether species recruitment is limited by germination/establishment niche or by dispersal. In a separate project with the Centre for Ecology and Hydrology (CEH) and CABI Bioscience we have investigated manipulation of key mechanisms controlling the restoration of grassland biodiversity to species-poor former agricultural grassland. This has included overcoming high residual soil fertility and associated germination and establishment niche limitation, controlling dominance by competitive species through the use of hemi-parasitic plant species and controlling seedling herbivory by molluscs. Another, more applied, project with CEH and ADAS compared the effectiveness of different techniques for introducing appropriate wild flower and grass species into species-poor permanent grassland and arable-reversion land on commercial farms in Environmentally Sensitive Areas. The impact of these restoration measures on the agricultural value (grass production and quality) under hay cutting was examined.

In work with the British Trust for Ornithology (BTO) and CABI Bioscience, food resource accessibility in agricultural grasslands appeared to be a key factor limiting farmland bird abundance and diversity. Based on these findings, we are now, with Reading University and BTO, investigating mechanisms by which spatial and structural/architectural heterogeneity in grasslands influences faunal assemblages, the abundance of different invertebrate taxa and their likely availability as food resources for species higher in the food chain (Figure 9.4). This project will contribute to the achievement of Defra's Public Service Agreement target for farmland birds.

Fig 9.4 Creating structure and food resources for birds at the margins of intensively grazed fields

Effects of scale on ecosystem function

Our work has demonstrated the importance of scale. For example, we have shown that animal foraging movements in homogeneous swards are random at a 5 m scale but not at a 1 m scale. We have also demonstrated the effects of grazing pressure on stability of patch structure in swards at a field scale. In collaboration with Reading University we have demonstrated that distinct invertebrate assemblages are associated with particular patch types created by the grazing animal. This is likely to have important consequences for the restoration and maintenance of faunal diversity in grasslands, particularly under more extensive management systems.

Role of soil microorganisms in eco-system function

An important new area is improving our understanding of the role of soil micro-organisms in ecosystem function in grasslands (Figure 9.5). We will establish whether these organisms can be used to indicate suitability of grassland sites for biodiversity restoration and to identify management techniques required to promote soil fungal growth and thus potentially plant diversity. We are developing novel, inexpensive techniques to evaluate above- and below-ground processes and how they influence vegetation growth and development. In a parallel project we are identifying extensive management regimes that will result in significant increases in botanical diversity of grasslands through natural colonisation. This includes establishing whether soil nutrient status and/or microbial composition are useful indicators of plant diversity restoration potential and whether further species recruitment to extensification sites is limited by lack of availability of germination-establishment niches within plots or lack of dispersal of seed/propagules of new species to the sites.

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Fig 9.5 Mesocosms for studying effects of facilitator plant species on soil fungal-to-bacterial biomass ratios, and plant species diversity