Department of Sustainable Land Management, School of Agriculture, Policy and Development

University of Reading

Rapid changes in soil invertebrate and mycorrhizal activity after the conversion of forage pastures to diverse grasslands

S Shepperd | Z Barker | D Humphries | D Beaumont | T Misselbrook | H Jones | C Reynolds | M Tibbett | M Lukac

Introduction

Grasslands cover an estimated 7.2 million hectares in the UK, delivering animal-derived food stuffs and the guardianship of the countryside. Conventional ryegrass monocultures for livestock production require external inputs to maintain productivity, thus contributing to environmental degradation. Improving the environmental impact of food production systems to net zero targets have been set.

Little is known how cascade effects of above-ground diverse forage conversion impacts soil and its biota. Here we compare the effects of a conventional ryegrass monoculture and three differing diverse grasslands on earthworms, soil mesofauna and arbuscular mycorrhizal fungi (AMF) up to three years from sowing.

Methods

Forage Mixtures

- Single species perennial ryegrass (PRG; *Lolium perenne*) control receiving 250kg/ha N per year
- Three diverse forage mixtures of increasing species richness: Smart Grass (6), Biomix (12), and Herbal (17 species), receiving no fertiliser
- Sown September 2016 at two University of Reading farms:
  - Centre for Dairy Research Farm (CEDAR) – twenty 1ha paddocks
  - Crops Research Unit (CRU) – 4x4 Latin square at two sites which varied in soil type (Dry and well-watered (WW))

Sampling

Earthworms: Two 20cm^3 soil pits with chemical extraction per CEDAR paddock dug April 2019. All worms recorded, including half worms.

Meso fauna: 600g soil collected from each CEDAR soil pit. Tullgren funnels heated continuously for 16 days. Mesofauna identified down to phylum, class or order level depending on taxa.

AMF colonisation: March 2020 two ryegrass trap plants, grown in sterile controlled environment, per CRU plot were planted and extracted October 2020. Rinsed roots were stained with Ink/Vinegar solution. Percentage root AMF colonisation measured using the grid line intersect method.

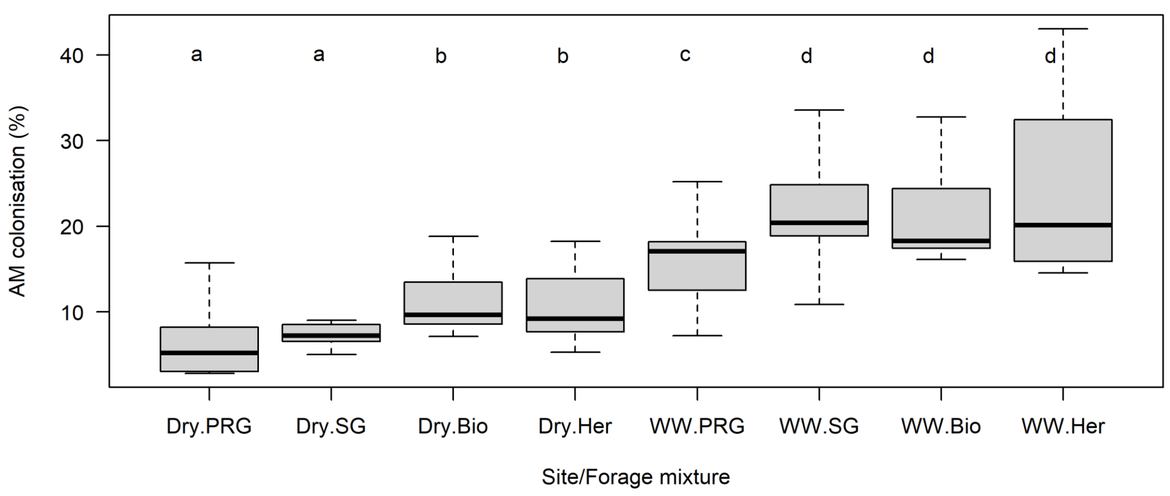

Fig. 1. AMF colonisation of ryegrass trap plant roots after 6 months field exposure at two differing sites at CRU and four plant forage mixtures. PRG – perennial ryegrass (1 forage species); SG – Smart Grass (6 species); Bio – Biomix (12 species); and Her – Herbal (17 species). Letters denote significance at $p<0.05$

Results

All diverse grassland mixtures had higher AMF colonisation rates of ryegrass trap plants compared to the monoculture (6 species: $z = 6.37 \pm 0.05$, $p<0.001$; 12 species: $z = 5.72 \pm 0.05$, $p<0.001$; 17 species: $z = 6.66 \pm 0.05$, $p<0.001$; Fig. 1), resulting from interspecific plant competition and infection potential.

Diverse grasslands and their soils contain a higher variety of root exudates compared to monoculture. This increases food resource availability for soil biota explaining why the 12 species diverse grassland had lower earthworm densities compared to PRG ($F_{1,37}=4.61$, $p<0.05$; Fig. 2). However, PRG harboured significantly higher abundances of collembola ($F_{1,37}=6.51$, $p=0.018$; Fig. 3), an unexpected result explained from greater root biomass in the PRG paddocks (data not shown) increasing food resource availability for collembola.

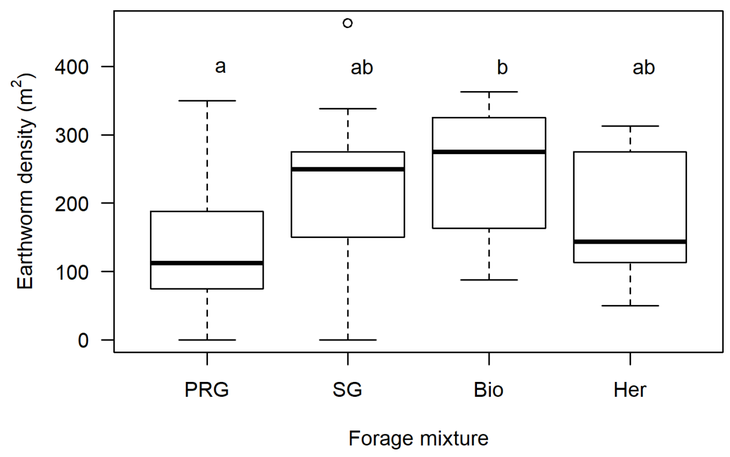

Fig. 2. Earthworm densities in four forage mixtures: PRG – perennial ryegrass (1 forage species); SG – Smart Grass (6 species); Bio – Biomix (12 species); and Her – Herbal (17 species). Letters denote significance at $p<0.05$

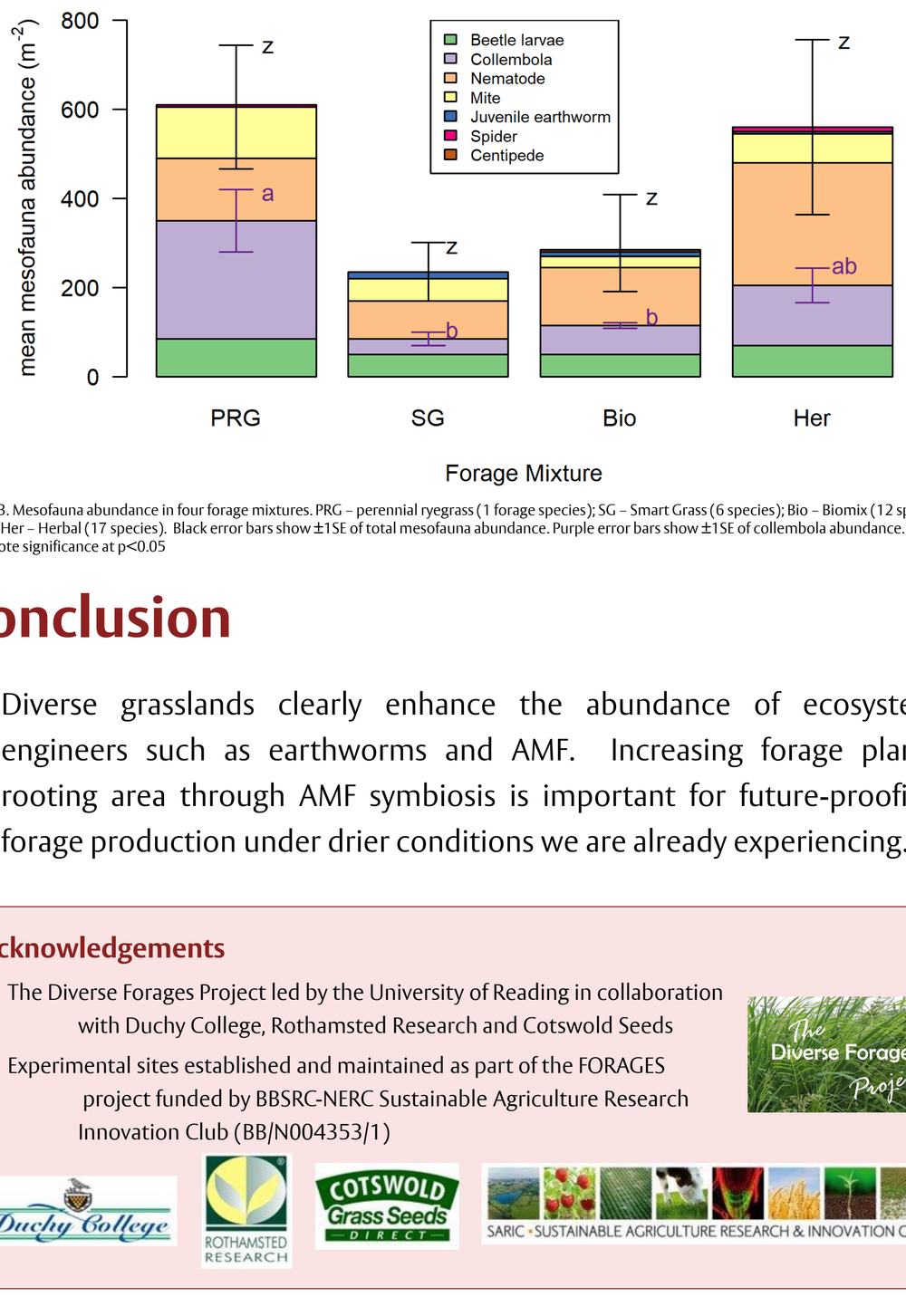

Fig. 3. Mesofauna abundance in four forage mixtures. PRG – perennial ryegrass (1 forage species); SG – Smart Grass (6 species); Bio – Biomix (12 species); and Her – Herbal (17 species). Black error bars show ±1SE of total mesofauna abundance. Purple error bars show ±1SE of collembola abundance. Letters denote significance at $p<0.05$

Conclusion

Diverse grasslands clearly enhance the abundance of ecosystem engineers such as earthworms and AMF. Increasing forage plants rooting area through AMF symbiosis is important for future-proofing forage production under drier conditions we are already experiencing.

Acknowledgements

- The Diverse Forages Project led by the University of Reading in collaboration with Duchy College, Rothamsted Research and Cotswold Seeds
- Experimental sites established and maintained as part of the FORAGES project funded by BBSRC-NERC Sustainable Agriculture Research Innovation Club (BB/N004353/1)

Contact information

- SAPD, University of Reading, Whiteknights, RG6 6EU
- s.e.shepperd@pgr.reading.ac.uk
- reading.ac.uk/apd/research/apd-resslm.aspx | reading.ac.uk/apd/research/apd-resfpqdfp.aspx