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# **Response of soil invertebrates to pastoral management, and their links to soil services**

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## **Abstract**

Sustained pasture production requires soils which are fertile, porous, and can support invertebrate populations. Soil invertebrates influence soil processes, supporting soil services (e.g., nutrient and water supply) required in pastoral soils. The hypothesis, that invertebrates would show some consistent responses to pastoral management was tested and used in the development of a biological indicator. Specifically, this thesis explored the response of soil invertebrates (macrofauna, mesofauna and nematodes) to a diversity of pasture managements (livestock type, stocking rate, fertiliser application, irrigation), collecting soil samples from nine sheep grazed, 17 dairy grazed and 15 ungrazed long term research and commercial pastures. Focus was on the influence of management practices on soil physical condition and potential food resources for the soil food web.

Food resources influenced invertebrates, particularly in soils with lower stock live weight loading. Nematodes tended to respond positively to increased pasture production with increases in plant feeding nematodes. The physical disturbance associated with dairy cow treading was pronounced (compared with that of sheep treading) and this had consequences for the invertebrate community. Oribatida were low in abundance in dairy grazed pastures and slow to recover when treading pressures were removed. Some larger, predatory nematodes were sensitive to treading, but recovered when treading pressures were removed. Earthworms are capable of creating their own burrows and were more resistant to stock treading, especially anecic species. The calculated effect of earthworms on nitrogen mineralisation was greater under organic than conventional dairy pasture management. The importance of soil invertebrates in regulating nitrogen supply to plants in a compacted and high nitrogen fertility soil was demonstrated in a constructed mesocosm.

The influences of management on food resources and soil physical condition, and their relationships with invertebrates form critical components of a proposed invertebrate threshold indicator. Habitable pore space appeared to be a reliable indicator of invertebrate populations, as food may not always limit populations in pastures. The indicator, based on invertebrates (i.e., Nematode Channel Ratio, Plant Parasitic Index, abundances of earthworm functional groups, Oribatida, nematodes and herbivorous macrofauna) was linked to soil services by establishing thresholds at which soil services might be 'limited' or 'sustained'. Suggestions on how to manipulate invertebrate abundance are made. The proposed indicator may provide land managers with a tool linking invertebrates to soil services required for sustained pasture production.



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## **Preface**

Each chapter of this thesis has been written in the form of a standalone paper. As a result there is some repetition between the chapters. Some chapters have already been submitted for publication. I am the first author with the largest input into methodology, data collection, analysis and write up in all chapters. My supervisors made significant contributions to the thesis, and these are acknowledged below and in the authorship and acknowledgements of the published papers. Other contributions are shown in the acknowledgements.

### *Role of supervisors*

Chapters 1 to 7 explore the affect of different factors on soil fauna at various sites. Maria Minor, Alec Mackay and Gregor Yeates gave guidance on experimental design and methodology. Maria Minor gave input into the statistical analysis. Alec Mackay contributed valuable ideas to site selection and the manuscripts. Maria Minor and Gregor Yeates provided training in microarthropod and nematode identification, respectively, and improved the write up of the manuscripts. Mike Hedley provided valuable comments, particularly in relation to nutrient cycling.

Chapter 8 is a laboratory study examining the interaction between bulk density, nitrogen fertility and soil invertebrates on nitrogen cycling. All supervisors helped finalise the methodology and experimental design. Mike Hedley gave guidance throughout the mesocosm and helped to calculate the fate of  $^{15}\text{N}$  labelled litter. Maria Minor helped with the statistical analysis. All supervisors provided valuable comments on the manuscript.

Discussions with Alec Mackay and Gregor Yeates were valuable during the development of the indicator (Chapter 9 and 10). Comments from Maria Minor and Mike Hedley were also much appreciated.



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