The influence of fertiliser on the abundance and diversity of earthworms in pastures in Western Victoria

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Summary. The influence of increased fertiliser application and improved pasture production on the abundance and species diversity of carthwom communities was examined at five permanent pasture sites in western Victoria. The communities were dominated by the introduced species, *Aporrectodea trapezoides* and A. *caliginosa* (Lumbricidae), and the native species, *Heteroporodrilus* sp. and *Spenceriella* sp. (Megascolecidae). No treatment effects on abundance and a minor reduction in species diversity (at one site) were detected.

Introduction

Earthworms can significantly influence soil structure and fertility and increase plant production (10). Recently. much interest has been focussed on the role of earthworms in off-setting soil degradation and improving pasture and cereal production in south-eastern Australia (2,4). Surveys have determined the dominant earthworm species in agricultural soils, their life histories and population dynamics and the influences of several management practices (e.g. tillage, rotation, application of lime, drainage) on population numbers (2,3,4,6,11).

Sears and Evans (14) and Barley (5) showed that the addition of superphosphate fertiliser to pastures in South Australia and New Zealand increased earthworm populations, probably due to the resultant increase in plant production and hence available food as decomposing plant material. On the other hand, Lee (10) suggested that superphosphate can increase soil acidity and hence reduce earthworm numbers. This paper considers the influence of fertiliser application and improved pasture production on the abundance and species diversity of earthworm populations in permanent pastures in western Victoria.

Methods

Five pasture sites in western Victoria were sampled for earthworms in 1992. The first of these was a trial investigating the influence of superphosphate application (and stocking rate) on pasture and wool production whiich was set up at the Pastoral and Veterinary Institute, Hamilton, Victoria in 1979 (7,13). Superphosphate was applied to 18 pasture plots at 6 different rates (averages ranging from 1-32 kg P/ha/yr). Olsen P levels for the soils are shown in Fig. Ia. The 18 plots varied in size but were all large (e.g. 300 x30 m). They were arranged adjacent to each other with their longest sides running E-W and treatments were randomised. Merino ewes were grazed in the plots at three different rates for each P level. Stocking rates ranged overall from 5 to 23 ewes/ha, but varied between P levels (13). The soil within the site was a hard-setting clay loam with higher levels of gravel at the southern end. The pH(H20) of the soil was 5.6, with no significant difference between treatments. Pasture composition and production varied between plots. For example, onion grass (Romulea rosea) was most common in the low fertility plots (total annual pasture growth 5 t/ha) and perennial ryegrass (Lolium perenne) was most common in the high fertility plots (15 t/ha).

At each of four other sites in western Victoria (Ararat, Edenhope, Lismore and Vasey), two pastures, (Plots I & 3) were resown, by direct drilling to appropriate perennial grasses *(L. perenne* and *Phalaris aqualica)* and subterranean clover *(T. subterraneum)* in 1988-89 (Upgraded Pastures)(12). Two other pastures (Plots 2 & 4) were not resown (Typical Pastures). The Upgraded Pastures received higher applications of superphosphate than the Typical Pastures (15-25 kg P/ha/yr were applied to the Upgraded Pastures whilst Typical Pastures received approximately 4 kg P/ha/yr from 1988 to 1991 and no fertiliser in 1992). Olsen P levels for the soils are shown in Fig. lb. Soil types varied between sites: Ararat (relatively infertile, clay loam, hard setting in summer), Edenhope (sandy loam, generally well structured and friable, waterlogged in some years, moderate fertility), Lismore (basalt derived clay, waterlogged most winters, hard setting and cracked in summer) and Vasey (clay loam varying from gravelly rises to clay flats, hard setting and liable to dryland soil salinity). Soil pH for all sites was 5.3 to 5.6. The Upgraded Pastures had higher clover content, stocking rates and wool production than the Typical pastures (12).

In September 1992. ten soil samples (each 0.1 m^2 in area and 0.1 rn deep) were taken at 10 in intervals along a transect within each plot at Hamilton and hand-sorted for earthworms. In addition, 10 soil samples were taken in a similar way in each plot at Ararat. Edenhope, Lismore and Vasey in October 1992 and hand-sorted for earthworms.

Results and discussion

Twelve species of earthworm were found at Hamilton. with 5 to 8 species per plot (Fig. la). This site was exceptionally rich in species compared with an average of 1.9 species per site for a survey of approximately 400 pastures in S.A. and western Victoria (2). The most common species at Hamilton were the introduced *Aporrectodea caliginosa* and *A. trapezoides* (Lumbricidae) and the native *Spenceriella* sp. and *Heteroporodrilus* sp. (Megascolecidae). Because of the marked predominance of these four species, the species diversity (Shannon-Wiener Index) was low (0.87 to 1.52 for the 18 plots. mean = 1.20). Much higher species diversities have been recorded for earthworm communities in pastures in Europe (e.g. 1.87 to 2.79)(1). There was a weak, negative relationship between fertility status (Olsen P for the soils) and diversity (r_{18} = - 55, P < 0.05)

Species dominance and diversity varied between the other four sites (Fig. Ib). Native species (Spenceriella sp. and other unidentified Megascolecidae) predominated at Lismore, Ararat and Vasey, but the introduced *A. trapezoides* was most common at Edenhope. Diversity was greater at Lismore (6 species. mean Shannon-Wiener Index for the four plots = 1.35) compared with Edenhope (6 species, Index = 0.64). Ararat (4 species. Index = 1.11) and Vasey (5 species. Index = 0.51). There was no apparent relationship between earthworm diversity and pasture fertility at any of these four sites.

The sites reported here (with the exception of Edenhope) were unusual in their abundance of native species. Baker (2) reported that native species were usually rare in pastures in S.A. and western Victoria. However. Baker also reported a tendency for natives to be more common in western Victoria than in S.A. The reason for this trend is not yet understood.

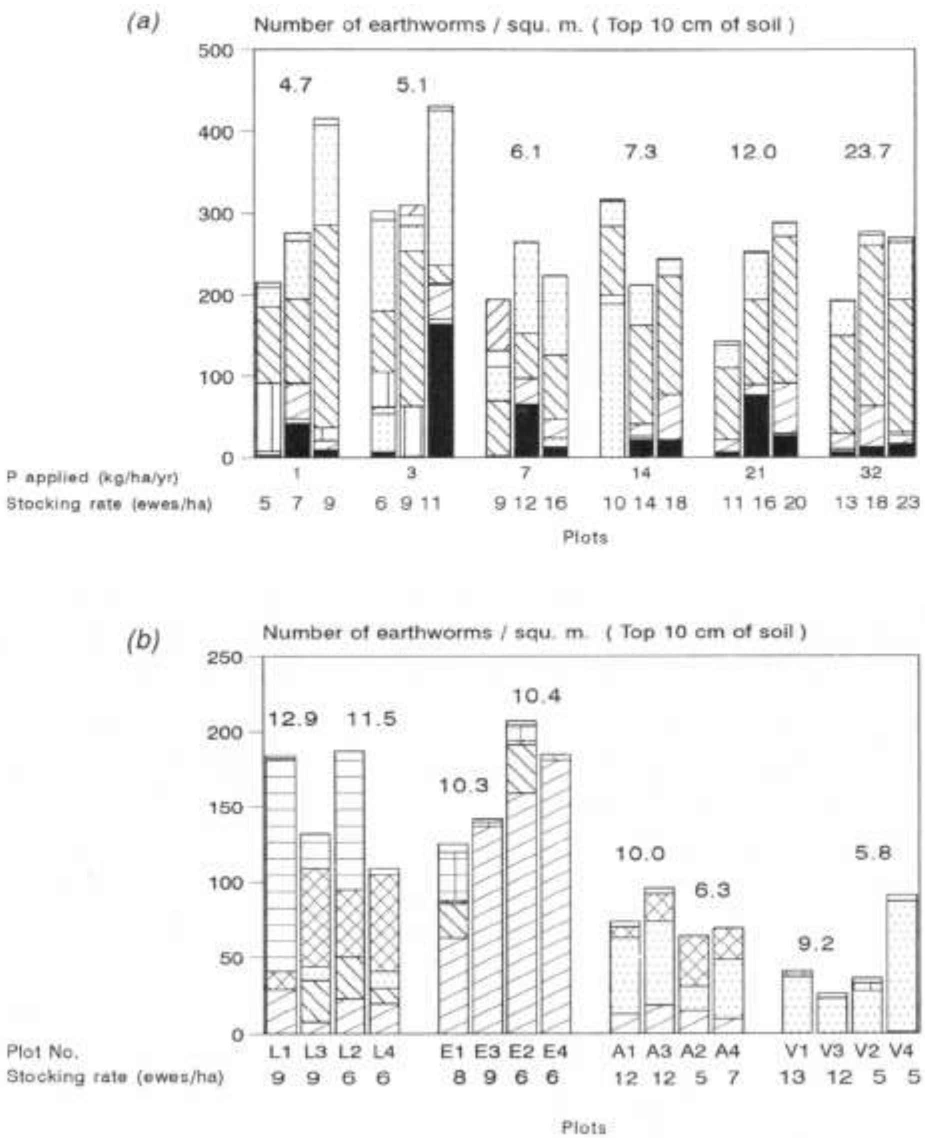
The total numbers of earthworms varied between plots at Hamilton (Kruskal-Wailis Statistic H = 38.87, P < 0.01), but not between plots at the other sites (H = 1.03 for Ararat, 11 = 6.23 for Edenhope, H = 6.55 for Lismore and H = 6.75 for Vasey, for all P > 0.05)(Fig. I). There was no significant relationship between total earthworm abundance and soil fertility at Hamilton (r_{18} = -0.16, P > 0.05).

For several species, there were marked differences in abundance between plots at Hamilton (Fig. la), but these differences could not be explained as due to treatment effects. When the data were arranged according to geographic position of the plots rather than treatment, it was clear that some species were most common at the extremities of the trial site (e.g. virtually all the A. *rosea* were found at the northern end of the trial and all the *Octolasion cyaneum at* the southern end). The patchiness in the distributions of these species might best be explained by (i) recent Introduction and lack of opportunity to colonise the site fully or (ii) local variation in the suitability of the site that is unrelated to the imposed treatments (eg, high gravel content at southern end). The abundances of some species also varied markedly between plots at the other sites (Fig. Ib), but again this variation was not clearly related to treatment.

Fager's recurrent grouping (9) demonstrates associations of species which occur together significantly often. At Hamilton. one recurrent group *(Spenceriella* sp., *Heteroporodrilus* sp. and A. *trapezoides)* was found, with highest affinity between the two native species (Fager's Index based on all 180 samples = 0.91. P < 0.05). This result could suggest there is strong similarity in the ecological requirements of the three species. particularly *Spenceriella* sp. and *Heteroporodrilus* sp. Recurrent groups were also demonstrated at Lismore (A. *trapezoides, Heteroporodrilus* sp. and *Megascolecid* sp. F), Edenhope (A.

trapezoides and Megascolecid sp. H) and Ararat (A. *(rape:aides* and *Spenceriella sp.).* Whether or not these associated species compete for resources is not known.

Variations in several soil properties can influence the abundance and species diversity of earthworms (10). Connell and Orias (8) suggested that greater production of organic matter (energy flow) in communities results in greater abundance of organisms and increased species diversity. However. there was no evidence in this study that greater fertiliser use and increased plant production altered earthworm abundance or increased species diversity.



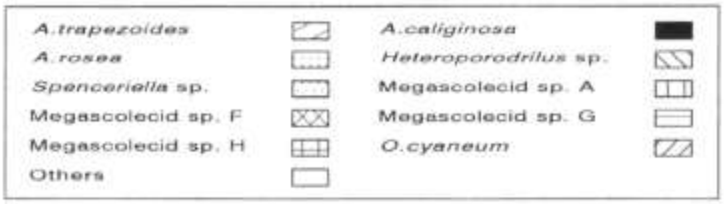


Figure 1. Numbers of earthworms collected in pasture plots at (a) Hamilton and (b) Lismore (L), Edenhope (E), Ararat (A) and Vasey (V) in September-October 1992. Average Olsen P levels (ppm) for the soils under different fertility treatments are given above each bar. For Lismore, Edenhope, Ararat and Vasey, plots 1 and 3 were Upgraded Pastures and plots 2 and 4 were Typical Pastures.

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References

1. Baker. G.H. 1983. Hol. Ecol. 6, 74-80.

2. Baker. G.H. 1992. Proc. 1992 Pasture Specialists Conf.. Hamilton. Vic. pp. 41-46.

3. Baker. G.H., Barrett. V.J.. Grey-Gardner. R. and Buckerfield. J.C. 1992. Aust. J. Ecol. 17. 177188.

4. Baker. G.H.. Williams. P.M.L.. Barrett. V.J. and Carter. P.J. 1993. Proc. 17th Intern. Grassi. Congr.. Palmerston North. N.Z. In Press.

5. Barley, K.P. 1959. Aust. J. Agr. Res. 10.171-178

6. Buckerfield. J.C. Proc. 17th Intern. Grassl. Congr.. Palmerston North. N.Z. In Press.

7. Cayley. J.W.D. 1991. Proc. 31st Ann. Conf. Grassl. Soc. Vic.. Melbourne. Vic. pp. 63- 69.

8. Connell. J.H. and Orias. E. 1964. Amer. Nat. 98. 399-414.

9. Fager, E.W. 1957. Ecology 38, 596-595.

10. Lee. K.E. 1985. Earthworms. Their ecology and relationships with soils and land use. (Academic Press: Sydney).

11. Rovira. A.D.. Smettem. K.R.J. and Lee. K.E. 1987. Aust. J. Agr. Res. 38. 829-834

12. Saul. G.R. 1992. Proc. 1992 Pasture Specialists Conf.. Hamilton, Vic. pp. 22-26.

13. Saul. G.R. and Cayley. J.W.D. 1992. Proc. Aust. Soc. Anim. Prod. 19, 235.

14. Sears, P.D. and Evans. L.T. 1953. N.Z. J. Sc. Tech. 35A, Suppl. 1. 42-52.