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The significance of termites as decomposers in contrasting grassland communities of semi-arid eastern Australia

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ABSTRACT

Decomposition of various litter forms including dead tussocks of two native perennial grasses, woollybutt (*Eragrostis eriopoda*) and mulga mitchell (*Thyridolepis mitchelliana*), as well as roots of woollybutt, dung of sheep and kangaroo, and bleached toilet rolls, was studied in contrasting grazing exclosures, half of which had termites excluded by biocide (termiticide) treatment. Dead mulga mitchell tussocks decayed more rapidly than woollybutt tussocks during the first 17 months post mortem. Thereafter, rate of decay differed little between species. After 3 years, only small amounts of tussock residues of either species remained and only then did the impact of biocide treatment become significant.

Decomposition of kangaroo pellets was typically bimodal with significantly higher decomposition recorded in the controls (no biocide) up to 40 months after treatment, and many intact pellets remaining in the biocide-treated plots. While decomposition of sheep pellets showed similar bimodality, decomposition remained significantly lower in the biocide treatments for the entire duration of the experiment. Results suggest that abiotic processes, including those induced by UV radiation, may be dominant influences mediating decomposition of litter in these semi-arid ecosystems, especially following high-rainfall seasons when abundant grass biomass has been generated providing a surfeit of potential forage for harvester termites.

1. Introduction

Vegetation patterning in Australian semi-arid woodlands is widely recognised as a response to the redistribution of rainwater and topsoil containing organic material and plant nutrients (Ludwig et al., 1997). Soil biota play a critical role in maintaining soil-based processes in semi-arid landscapes although direct links between such diverse taxa and rates and efficiency of various landscape functions are much less clear (Giller et al., 1997; Jones et al., 1994; Whitford, 2002; Whitford et al., 1992). Even though preliminary studies have shown clear spatial patterning of surface soil features 'engineered' by vertebrates such as the burrowing bettong (*Bettongia lesueur*) (Noble et al., 2007) and invertebrates such as the harvester termite (*Drepanotermes perniger*) (Noble et al., 1989), little is known of the relationships between vegetation mosaics and ecosystem processes and their mediation by soil invertebrates in semi-arid ecosystems of Australia.

Perennial grasses, particularly C_3 species such as bandicoot grass (*Monachather paradoxa*) and mulga mitchell (*Thyridolepis mitchelliana*) commonly provide highly nutritious forage for livestock in rangelands dominated by mulga (*Acacia aneura*). Once senescent they become valuable forage for herbivorous invertebrates as well, in particular the ubiquitous *Drepanotermes perniger* (Watson and Perry, 1981). Watson et al. (1973) suggested that mound-building harvester termites alone in central Australia could consume around 100 kg ha^{-1} dry matter of herbage annually. Because they also claimed that the biomass of harvester termites was comparable to that of domestic livestock grazing in the same area, *viz.* 10–15 kg ha^{-1}, there has been an underlying assumption amongst some observers that harvester termites had the potential to become major competitors with domestic livestock once such forage, despite its relatively low nutritive value, was all that was available for livestock. However, given that harvester termites feed primarily on 'fungal gardens' growing on senescent plant material stored in subterranean galleries (Watson et al., 1973), they are more specifically detritivores than herbivores.

While there is no evidence of a significant decline in soil invertebrate abundance in Australia's semi-arid rangelands this may simply reflect a dearth of relevant information. Giller et al.

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(1997) distinguished three broad functional groups of invertebrates: 'ecosystem engineers', 'litter transformers' and 'micropredators'. Soil microarthropods, for example, are important 'litter transformers' in Australian rangelands. Their populations have been shown to vary considerably between different parts of these landscapes, the highest numbers of 'litter transformers' usually being found in grass-dominated patches (Noble et al., 1996).

According to Whitford (2000), there is now sufficient scientific evidence available to confirm that two groups of social insects, termites and ants, play critical roles as 'webmasters' in desert ecosystems by controlling their structural and functional properties. Termites are amongst the most abundant invertebrates found throughout the Australian arid zone (Noble and Tongway, 1986) and, as 'litter transformers', have a significant influence on particular ecosystem processes including nutrient cycling (Noble and Tongway, 1988; Whitford et al., 1992). In addition to having an influential role in the decomposition of both above- and belowground plant residues, they also produce macropores facilitating infiltration by rainwater (Eldridge, 1994; Elkins et al., 1986; Greene et al., 1990; Leonard and Rajot, 2001).

Much of the evidence for their importance is based on overseas experience (e.g. Parker et al., 1982; Whitford et al., 1982) although subsequent research in Australia started to focus more on impacts by termites on soil ecology, particularly those relating to modification of soil (e.g. Lobry de Bruyn and Conacher, 1990). While mounds constructed by *Drepanotermes tamminensis* and *Amitermes obeuntis* and foraging galleries of *D. tamminensis* and *A. neogermanus* had significantly higher organic carbon contents with pH lower than the surface soil, such modified soil was regarded as essentially inaccessible for plant growth (Lobry de Bruyn and Conacher, 1995).

In semi-arid and arid regions, different termites may consume wood, herbaceous plants, and leaves of some shrubs and trees (Faragalla, 2002; Mando and Brussaard, 1999; Schuurman, 2005, 2006; Whitford, 1999; Zaady et al., 2003). In arid rangelands of the United States, subterranean termites were found to affect soil organic matter, water infiltration, soil nitrogen, plus the composition and productivity of the vegetation (Whitford, 2002). There the effects of termites on rangeland vegetation are the indirect result of their impacts as decomposers following their foraging activities. Because of the many effects of termites on arid ecosystems, they have also been referred to as 'keystone species' (Whitford, 1991).

In Australia, little is known about the role of termites in facilitating the decomposition of aerial litter represented by senescent grass tussocks, or indeed many other forms of organic detritus found throughout the semi-arid woodlands. While densities of dung pellets voided by different vertebrate herbivores have been used to estimate animal densities in semi-arid woodland landscapes (Landsberg and Stol, 1996; Landsberg et al., 1994), information detailing the comparative decomposition of such pellets is scant. This study examines the effects of termites by comparing decomposition of a variety of litter forms in the presence and absence of termites, as well as their influence on soil properties, in both runoff and runon zones located within a semi-arid mulga (*Acacia aneura*) woodland in northwestern New South Wales.

2. Methods and materials

Experimental sites were established on "Glenora" Station, *c.* 35 km north of Louth, New South Wales (30° 16′S, 144° 53′E) (Fig. 1) on two contrasting vegetation types representing the opposing extremes of a catenary sequence. One community, dominated by

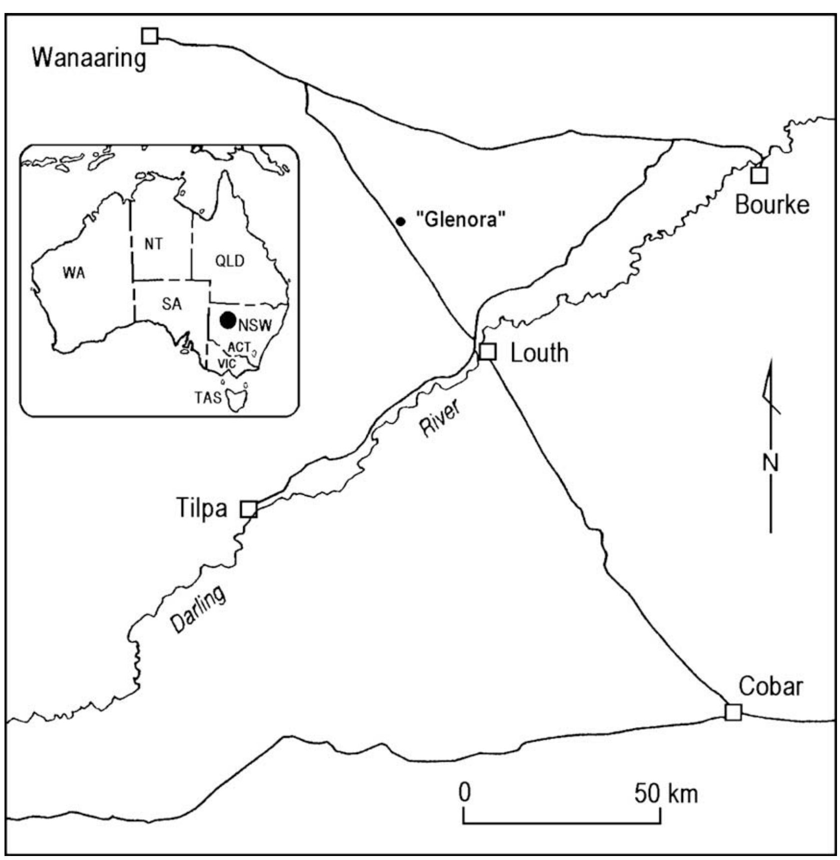

Fig. 1. Map showing the location of "Glenora" Station, west of Bourke, N.S.W., Australia (after Noble et al., 2007).