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Livestock grazing exclusion and microhabitat variation affect invertebrates and litter decomposition rates in woodland remnants

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ABSTRACT

Most of the remaining grassy woodland in south-eastern Australia exists as remnants on private land in agricultural landscapes. These have been subjected to various forms of disturbance including exotic plant invasion and livestock grazing. Little is known about the invertebrate communities in these remnants, which could contribute greatly to the diversity and function of these ecosystems. We need to know what invertebrates are present and how they respond to different types of land management, such as livestock grazing, in order to conserve them.

We aimed to determine firstly if the invertebrate community was more diverse and abundant and leaf litter decomposition rates faster in woodlands with livestock excluded. Secondly, we asked how important microhabitat variation is for the invertebrate community and decomposition rates, and finally if grazing exclusion influences these microhabitat variables and alters the vegetation condition. We addressed these aims through the use of leaf litter decomposition bags and pitfall trapping near three microhabitats: beside logs, under trees and in open habitat, considering woodland remnants still grazed by livestock and remnants where livestock grazing had been excluded. A vegetation condition assessment was also performed at each site. Grazed woodlands were subject to either a strategic or set stocked grazing.

Sites with grazing removed had a greater abundance of beetles and the Opportunist ant functional group, a faster rate of litter decomposition, greater native plant richness, greater length of logs and a better vegetation condition score. The Dominant Dolichoderinae ant functional group were the only insects trapped more frequently in currently grazed sites. Total invertebrate abundance, beetle abundance and richness, *Anonychomyrma* abundance and the quantity of leaf litter was greatest under trees. In comparison ants were in higher abundance and richness in the open areas. Leaf litter decomposition rates were fastest near logs. Beetles and Generalised Myrmicinae ants were more active near two of the microhabitats in rotationally grazed sites in comparison to the set stocked.

Excluding livestock from woodlands has benefits for components of the invertebrate community, vegetation condition and the important process of litter decomposition. Strategic grazing which includes substantial periods of rest could play a role in balancing the production and conservation needs of privately owned woodlands. Woodland remnants have a range of invertebrates that are dependent on mature trees or logs, such that a variety of microhabitats needs to be retained within remnant native vegetation in agricultural landscapes to maintain a diverse and abundant invertebrate community.

1. Introduction

Woodlands in many parts of the world have been subjected to clearing, fragmentation and various disturbances (e.g. Villard et al., 1999; Farrell et al., 2000; Yates and Hobbs, 2000; Hewinson et al., 2001). This is often driven by the demand for land for primary production. Grassy eucalypt woodlands were once common in south-eastern Australia, however most now exist as small isolated patches on private property in a matrix of modified agricultural land (Prober and Thiele, 2005). The woodlands were cleared to promote grass for livestock or to grow crops, with the remaining remnants often subjected to livestock grazing, nutrient enrichment, weed invasion and edge effects (Lindenmayer et al., 2005).

Livestock grazing has occurred in most grassy woodlands some time in the past 200 years, with many regularly grazed. Livestock grazing has been linked to many environmental problems including soil degradation and compaction (Greenwood and McKenzie, 2004), a decline in native plant species diversity (Prober and Thiele, 1995; Abbensperg-Traun et al., 2000), changes in bird assemblages (Martin and McIntyre, 2007), and declines in

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reptile populations (Brown, 2001), large web-building spiders (Horváth et al., 2009) and gastropods (Boschi and Baur, 2007).

Over the past 10–15 years excluding livestock has become a common management tool for conservation and restoration of remnant native vegetation (Spooner et al., 2002).

Sites where livestock have been recently excluded have been found to have higher native plant species richness and cover than those with moderate to heavy grazing pressure (Spooner et al., 2002; Briggs et al., 2008). Others, however, have found that light levels of grazing are required to maintain plant richness (Tremont and McIntyre, 1994; Tallowin et al., 2005). This grazing might be achieved by native and feral herbivores, or might require managed livestock.

The removal of livestock from native vegetation does not always create the desired conservation outcome. After prolonged disturbance the vegetation community can transition into another undesirable but stable state (Spooner and Allcock, 2006; McIntyre and Lavorel, 2007). It has been proposed that there are certain barriers that have to be overcome in order to shift the plant community back to the desired state (Prober et al., 2002). While there is some understanding of how woodland vegetation responds to changes in management and the removal of grazing, there is little information on how other aspects of the ecosystem respond, such as soil processes and insect communities.

Grassy woodlands have open canopies, and logs (coarse woody debris) as a part of the ground layer, contributing to structural heterogeneity. Logs are, however, often removed in agricultural areas for firewood, as part of 'tidying' up the site, or because they are thought to harbour pest animals. Several studies have shown that logs play a vital role in forested ecosystems as food and habitat for invertebrates (Grove, 2002; Evans et al., 2003) and reptiles (Fisher et al., 2004), and act as a slow steady source of soil organic matter (Wu et al., 2005).

The understorey component of woodlands often has greater functional diversity and species richness than the shrub and tree layers (Prober and Thiele, 2005). The ground-dwelling invertebrates and invertebrates that interact with the ground layer vegetation could be just as important for the functioning of these ecosystems and contribute a greater proportion to the biodiversity of these communities than the vegetation. The invertebrate communities in grassy woodlands of south-eastern Australia are, however, little studied.

There have been three other studies of ground-dwelling invertebrates in different types of woodland communities in other parts of Australia, all addressing livestock grazing impacts. The study of Bromham et al. (1999) investigated litter invertebrates in riparian areas of Victoria, and found a much greater difference in the invertebrate community between pasture and woodland than between woodlands with different grazing treatments. They found a greater ordinal diversity in sites without livestock, but several insect orders were in greater abundance in grazed woodland or pasture. In contrast, a *Eucalyptus salubris* woodland study in Western Australia found a lower abundance and diversity of scorpions and termites in grazed woodlands than ungrazed, with other target taxa not impacted or higher in grazed sites (Abbensperg-Traun et al., 1996). In a *Eucalyptus capillosa* woodland study little difference was found between the litter arthropod community in grazed and ungrazed sites (Abbensperg-Traun et al., 2000).

We need to know what invertebrates are present in remnant grassy woodlands and how they respond to different types of land management in order to conserve them. We investigated, using pitfall traps, how the ground dwelling invertebrates responded to the removal of livestock grazing, in terms of their abundance and richness, through the comparison of sites still grazed by livestock and those with livestock excluded for many years. Our first aim was to determine if the invertebrate community was more diverse and abundant following the exclusion of livestock.

As well as invertebrates potentially making a large contribution to the biodiversity of an ecosystem, they are also involved in key ecosystem services and processes such as litter decomposition, pollination, water cycling, pest control and maintaining soil structure and health (Lavelle et al., 2006). Leaf litter decomposition is performed by invertebrates, microbes and fungi. Invertebrates fragment organic debris and introduce microorganisms to fresh organic matter and assist in converting organic matter to inorganic elements. This process is vital to the recycling of nutrients and soil formation. Our second aim was to determine if leaf litter decomposition rates was faster in woodlands with livestock excluded.

Our third aim was to determine how important microhabitat variation is for the woodland invertebrate community and litter decomposition rates. We investigated this by comparing samples adjacent to trees, logs and in open spaces, hypothesising the litter substrates would decay faster near logs and trees than in open areas. Our fourth aim was to determine how grazing exclusion influenced these microhabitat variables and altered vegetation condition.

2. Methods

2.1. Field site selection and description

We selected 20 remnant temperate grassy woodland and dry sclerophyll forest field sites in agricultural landscapes of the south-west slopes and southern tablelands of New South Wales, Australia. The sites were spread over an approximate north-west gradient stretching 190 km from 149.6038°E, 35.5643°S near Braidwood though to 34.1860°S, 148.5202°E near Young.

Two to four edges of each woodland site were bordered by paddocks. The paddocks were predominately pasture; either a mixture of native and exotic grasses, or improved pasture (deliberately sown with palatable grass species). No site had been burnt in the past 15 years and most had not been burnt in over 25 years. All sites were privately owned and managed as a hobby farms or commercial agricultural enterprises.

All sites had an over-storey dominated by one to four species of *Eucalyptus*, with a similar canopy cover of 19 ± 7% (1 S.D.). The most common eucalypt species were, in descending order: *Eucalyptus melliodora*, *E. blakelyi*, *E. goniocalyx*, *E. nortonii*, *E. pauciflora*, *E. albens* and *E. cinerea*. The understorey was dominated by grasses, with shrubs uncommon and native forbs more common in the ungrazed sites. All sites contained old eucalypt trees and were not dominated by juveniles.

The woodland remnants were 0.5–33 ha in area, with an average of 5.6 ha, with some as narrow as 50 m. We established a 50 m × 50 m plot in each site, situated so that at least two sides of the plot were on the pasture-woodland edges, and all measurements were conducted inside this plot.

2.1.1. Grazing treatments

All sites had a long history of cattle and sheep grazing (>150 years). Ten of the sites were still grazed by cattle and/or sheep (grazed treatment), with no fence separating the remnant from adjacent pasture. The other 10 sites shad livestock grazing excluded for 6–25 years. None of the sites were or had been nocturnal livestock camps.

The sites grazed by livestock fell into two broad regimes; set stocked (continuous grazing, $n = 3$) or rotational (strategic grazing, $n = 7$). Set stocked grazing means that livestock had access to the woodland for most of the year. The amount of livestock in the paddock was sometimes adjusted by the farmer to the amount of