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Landscape and local influences on patterns of reptile occurrence in grazed temperate woodlands of southern Australia

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ABSTRACT

The woodlands of temperate south-eastern Australia are characterised by extensive historical clearing and ongoing modification of the understorey habitat through livestock grazing, fertilization and cropping. The reptile assemblage of these temperate woodlands, while relatively speciose, is believed to be in decline. We report on the abundance and diversity of terrestrial reptiles in native pastures in south-eastern Australia in relation to landscape and local factors; in particular, latitude and grazing management and tree retention. Reptiles were sampled on 24 paired farms spread widely over the south-western slopes of south-eastern Australia. Each pair comprised one farm under rotational grazing and a neighbouring farm with continuous grazing. Twenty-one species were detected, dominated numerically by several skinks and a pygopodid, with clear disparities in the biogeographic distribution of reptiles and also variation owing to survey technique, location, grazing regime, and the presence of trees. Multivariate models showed that the distribution of reptiles is influenced by factors operating at several levels and, to a lesser extent, by farm management. Reptile occurrence was regularly explained by correlations with site-level structural heterogeneity (e.g. native plant richness, number of large trees and log cover) as well as showing strong underlying latitudinal variation. The presence of woodland is critical to reptile occurrence in grazed (and fragmented) landscapes. If the reptile assemblage of this agroecosystem is to benefit from altered farm management, then different management and policy responses may be required, depending on the levels of habitat structural complexity and agricultural intensification that already exist.

1. Introduction

At the global scale, intensification of agricultural activity has had considerable deleterious effects on biodiversity; in particular, biodiversity in grasslands has been affected through changes to structure and vegetation patterns by intensification of livestock production and the increased use of organic and mineral fertilizers, as well as intense grazing pressure without fertilization (Benton, Vickery, & Wilson, 2003; Steinfeld et al., 2006). The woodlands of south-eastern Australia have not been immune from such impacts, commencing with the rapid spread of pastoralism in the mid-1800s and cereal cropping in the late 1800s (Wadham & Wood, 1939).

The issue is whether, after a protracted period of intensive agriculture, different farm management practices can mitigate the impacts on biodiversity; there is growing recognition that pastoral landscapes can be managed for both production and environmental benefits (e.g. Benton et al., 2003; Crosthwaite, Malcolm, Moll, & Dorrough, 2008; Dorrough, Moll, & Crosthwaite, 2007; Fischer, Lindenmayer, & Manning, 2006), although there may be trade-offs with productivity.

The occurrence of reptiles in temperate agricultural landscapes of southern Australia has received some attention in recent years (e.g. Brown, Bennett, & Potts, 2008; Driscoll, 2004; Fischer, Fazey, Briese, & Lindenmayer, 2005; Fischer, Lindenmayer, & Cowling, 2003; Michael, Lunt, & Robinson, 2004), not least because so little is known about the impacts of many agricultural practices on the distribution and abundance of this diverse animal group, and the prospects that altered management, such as extensification, hold for it. Broadly, reptiles in these agri-landscapes are thought to be in decline (Brown et al., 2008; Driscoll, 2004).

In these agricultural regions much of the relatively intact native vegetation persists as small lightly grazed remnants; there are few extensive tracts of woodlands in these 'fragmented' landscapes (sensu McIntyre & Hobbs, 1999). For reptiles in these landscapes, a greater proportion of remnant native vegetation in the landscape has usually been beneficial (Brown et al., 2008; Cunningham, Lindenmayer, Crane, Michael, & MacGregor, 2007; Dorrough, McIntyre, Stol, Brown, & Barrett, 2008; Fischer, Lindenmayer, Barry,

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& Flowers, 2005; Fischer, Lindenmayer, & Cowling, 2004). Native vegetation also persists within the production matrix, albeit in a modified form (McIntyre & Hobbs, 1999) and may contribute to the persistence of many plant and animal species. Scattered paddock trees are one of the most recognised forms of habitat that persist in these contexts (Bennett, Lumsden, & Nicholls, 1994; Gibbons et al., 2008; Manning, Fischer, & Lindenmayer, 2006), and when these are absent native plants may often comprise a large proportion of the ground-layer vegetation (i.e. native pastures). These vegetation elements are recognised as providing habitat for many species of native fauna (Fischer, Fazey, et al., 2005).

Agriculture has been implicated in the decline of reptile diversity and abundance throughout southern Australia (Brown et al., 2008). For many species the extent of suitable habitat has declined over large areas due to tree clearing and the replacement of native ground-layer vegetation with exotic annual-dominated pasture or perennial exotic sown pastures. Recent research has emphasised the loss of habitat complexity, especially in the ground-layers, owing to agricultural practices (Brown, 2001; Brown et al., 2008; Driscoll, 2004). However, little research has specifically considered those management practices that operate directly at the paddock scale, such as fertiliser application, grazing management (rotational vs continuous stocking), grazing pressure, and paddock tree retention (although see Dorrough & Ash, 1999, for inferences related to the occurrence of the striped legless lizard (Delma impar) in fertilised grasslands).

While the distribution and type of habitats as well as variation in management are often important determinants of the distribution and abundance of reptiles in agricultural landscapes, underlying biogeographic patterns are also key (Brown et al., 2008; Fischer et al., 2004). Climatic determinants of reptile abundance, diversity and distribution are well recognised and as a result reptile distributions can vary at very broad scales with changes in latitude and broad topography, and within and among local landscapes due to variation in altitude and aspect (Fischer & Lindenmayer, 2005; Gaston, 2000).

In this paper we explore the abundance and diversity of terrestrial reptiles in native pastures of the inland slopes of the Great Dividing Range of south-eastern Australia and examine the roles played by broad climatic variables and variation in land management and habitat at local and landscape scales. We hypothesise that across our broad study region, and regardless of species-specific variation, reptile composition will vary with latitude and reptiles generally will be most abundant and diverse in those native pastures that still support woodland tree cover and are subject to the least intensive grazing regimes.

2. Methods

2.1. Study region

We confined our study to the grazing lands of the inland slopes of the Great Dividing Range of south-eastern Australia; that is, the south-western slopes of New South Wales and inland slopes and uplands of central and northern Victoria (Fig. 1). This large region roughly corresponds to the natural distribution of the southern temperate grassy woodlands, which accords with Hobbs and McIntyre's (2005) agro-climate category of 'temperate cool-season wet'.

This region was the focus of occupation during agricultural expansion by Europeans in the 19th century, and by 1860 supported a large proportion of the Australian livestock population (McIntyre, 2004; Wadham & Wood, 1939). By the mid-twentieth century, livestock numbers had risen dramatically, due primarily to the widespread application of phosphorus-based fertilisers, spreading of exotic annual legumes and sowing of exotic perennial pasture grasses (Vere & Muir, 1986). This also coincided with rapid and widespread clearing of the woodland overstorey associated with the introduction of livestock and cereal cropping, the result being that the south-western slopes is the most cleared bioregion in New South Wales, with typically less than 15% of the original tree cover remaining in many areas (Benson, 1999), although scattered paddock trees remain a major landscape feature. As recently as 1990, the rate of clearing in the biogeographic regions that cover our study area in NSW was 10 000–100 000 ha per annum (Commonwealth of Australia, 2000). Although broadscale clearing has now ceased, the decline of isolated paddock trees continues (Gibbons et al., 2008). In other cases recent changes in land management are leading to increased woody plant cover (Lunt, Winsemius, McDonald, Morgan, & Dehaan, 2010).

2.2. Site selection

The focus of this study was pastures that had not been sown to perennial legumes or grasses, nor cultivated or cropped in the last 30 years. In addition, half of the properties selected had to have practised rotational grazing for at least five years. We defined rotational grazing as a system of four or more paddocks on which alternating periods of grazing and rest were imposed; each paddock was grazed for relatively short durations (<56 days), followed by a rest of at least 21 days although, generally, the duration of rest periods exceeded the duration of grazing periods (Dorrough et al., 2008). For continuous stocking there was no regular pattern of grazing and rest—livestock were allowed unrestricted access to paddocks on a more extended basis. Grazing periods were typically greater than three months and rest periods usually less than three months.

Twelve pairs of farms were selected over a geographical range of approximately 450 km along the inland slopes of the Great Dividing Range; paired farms were replicated among localities to ensure latitudinal representation within the study region (Fig. 1). Each pair comprised a farm under rotational grazing and a neighbouring farm with a continuous grazing régime. Paired farms also provided a range of fertility levels, derived from the history of local fertilizer use. The mean duration of rotational grazing management for the twelve farms that had employed this approach was 7 ($\pm$1.6 SD) years.

To complete the fully factorial design, on each farm two 1 ha plots were identified that either retained some woodland tree cover ("tree") or had been completely cleared ("open"). Treed plots had a minimum of four mature trees with diameter at breast height >60 cm ha^{-1}; across all treed plots there was an average of 9.1 ($\pm$6.82 SD) large trees ha^{-1}. Plots were often within the same paddock but always separated by at least 200 m. Thus, we sampled a total of 48 $\times$ 1 ha plots (24 open, 24 treed) across 24 farms. Variations in habitat variables and stocking rate (means $\pm$ SE) across plots with and without trees in both continuous and rotational grazing plots are presented online as supplementary material.

2.3. Habitat measurement

Plant surveys were undertaken in late spring (November 2006). Ground layer native species richness was compiled from a close assessment of 30 m $\times$ 0.5 m quadrats and an additional 20 min search, undertaken across the entire plot by a single botanist. The percentage ground cover of native perennial plants was the mean visual estimate from the 30 m $\times$ 0.5 m quadrats. Quadrats were located in a grid pattern across each 1 ha plot, located systematically 1 m from the reptile sampling tiles (see below).

Detailed information on pasture structure was collected using a modified Ellinbank Rising Plate Meter (weight of 250 g) which