BIODIVERSITY INDICATORS IN CONTRASTING VEGETATION TYPES: A CASE STUDY FROM WESTERN AUSTRALIA

Max Abensperg-Traun[1], Graham Arnold[1], Dion Steven[1], Graeme Smith[1], Lyn Atkins[1], Jan Viveen[2] and Mark Gutter[2]

[1]Division of Wildlife and Ecology, CSIRO, LMB No. 4, Midland, WA 6056, Australia
[2]Department of Nature Conservation, Agricultural University, Wageningen, The Netherlands

Abstract

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Vegetation structural diversity, species richness of plants, terrestrial arthropods and lizards, and the relative abundance of species within ant functional groups, were examined as indicators of faunal richness in gimlet (*Eucalyptus salubris*) woodlands (29 sites) and shrublands (27 sites) in semi-arid, agricultural Western Australia. Sites varied in grazing history (woodland) and in farming history (shrubland).

Total faunal richness was not effectively predicted by any indicator variable for either vegetation type. Vegetation structural diversity and richness of plants were effective indicators of the richness of some faunal groups in woodland but not in shrubland. Structural diversity explained 73% (+ve) of the pooled richness of scorpions + termites + lizards in woodland. In shrubland, no variable explained > 25% of the richness of any faunal group. Reasons for the differences in the predictive qualities of structural diversity and plant richness between the vegetation types are discussed.

Introduction

The loss of biodiversity (e.g., species richness) at all spatial scales must be of concern to all Australians. One of the issues that needs to be addressed by biologists is the identification of efficient indicators of biodiversity (Oliver and Beattie, 1993; Andersen, 1995; Majer and Beeston, 1996), such as vegetation structure or plant richness, because these are easy and hence cost-efficient to measure. With the exception of simple ecosystems, such as rehabilitated mine-sites (Majer, 1983), Australian studies give little hope for a quick solution to the search for effective biodiversity indicators (e.g., Yen, 1987; Oliver, 1993). The present study is a condensed version of a wider investigation into biodiversity indicators in native vegetation remnants in the Western Australian wheatbelt (Abensperg-Traun et al., 1996). It tests the qualities of four indicators of the species richness of terrestrial arthropods and lizards in two contrasting native vegetation types: 1, vegetation structural diversity; 2, species richness of native plants; 3, the richness of other faunal groups; and 4, the abundance of individual species within ant functional groups.

Methods

Study area and study sites

The study was carried out between 1991 and 1994, in a 1680 km area of the central wheatbelt of southwestern Western Australia (near 31°25′S, 117°26′E). Descriptions of the study area were given by Beard (1980), McArthur (1993) and Saunders et al. (1993). We selected eucalypt woodland (gimlet *Eucalyptus salubris*, 29 sites) and shrubland vegetation (27 sites) because these are major vegetation types in the study area and because they represent a range of disturbance histories. Most woodland sites have been grazed, and most shrubland sites have been farmed for varying periods and abandoned at least 20 years ago, and have regrown to varying degrees (Arnold and Weeldenburg, 1991). Sample areas were 0.25 ha for arthropods, 1 ha for lizards, and 400 m² for plants.

Data collection

Vegetation structural diversity was measured once (mid-winter) using subjective scores from 1 = low abundance of a structural component (< 10% cover), 2 = moderate abundance of a structural component (10–30% cover), 3 = high

abundance of a structural component (30-70% cover), 4 = very high abundance of a structural component (> 70% cover) for three components: living vegetation (native trees, shrubs, grasses); litter; standing and fallen dead wood. All scores were then summed to give an overall score of structural diversity for each site.

Plant species richness, measured once (spring), is the total number of native vascular plant species recorded within a 20 x 20 m site, located centrally within the fauna sampling area.

Differences between woodland and shrubland study sites in arthropod taxa selected for study are due to logistics, particularly the lizards, and to differences in the richness and abundance of the taxonomic groups. For woodlands, we studied scorpions, termites, beetles, ants and lizards; for shrublands, we studied termites, beetles, hemipterans (bugs, leafhoppers, cicadas), ants and butterflies. Sampling procedures followed standard techniques using pitfall traps (16 plastic cups per site, each 90 mm wide and 110 mm deep, opened for seven consecutive days) and hand collections (termites, butterflies, lizards). With the exception of woodland beetles which were sampled across four seasons, all other samples are from summer collections. For identification to species/morphotype level, specimens were matched with reference collections for the study area (scorpions, termites, ants), or using published keys (beetles, hemipterans, butterflies, lizards). Ant species were also placed into functional groups (Andersen 1990).

Data analysis

Correlation analysis was used to examine the relationships between faunal richness variables, and between faunal richness and vegetation structural diversity and plant richness. Relationships between the abundance of ant species within functional groups and the richness of other faunal groups were analysed in a principal components regression. Principal component scores of ant functional groups were used as new independent variables in the regression. A forward step-wise (linear) procedure was used where the model fits the constant and then adds the most significant indicator variables in a stepwise fashion. A backward procedure produced similar results.

Results

Vegetation structural diversity and plant species richness

Total faunal richness was poorly predicted by structure or plant richness in either vegetation type (Table 1). Structural diversity and species richness of plants were effective indicators of a subset of the fauna in gimlet woodlands, but explained low percentages of the variation in richness of shrubland faunal groups (Table 1). In woodland, the highest percentages explained were 55% for termites (structure, +ve), 52% for beetles (structure, -ve), 40% for scorpions (structure, +ve) and 56% for lizards (plant richness, +ve) (Table 1). Structural diversity explained 73% of the pooled richness of scorpions + termites + lizards (Figure 1).

Structural diversity was not significantly correlated with any shrubland arthropod richness variable. Plant richness was significantly correlated with beetle and butterfly richness but explained low percentages of the variation in richness (14% and 20%, respectively) (Table 1).

Table 1. Correlation coefficients (r) between the richness of faunal groups and vegetation structural diversity and native plant richness. * P < 0.05, *** P < 0.001; ns not statistically significant; — not sampled.

Taxa	Structural diversity		No. native plant species	
	Woodland	Shrubland	Woodland	Shrubland
Scorpions	+0.63***	—	+0.69***	—
Termites	+0.74***	ns	+0.59***	ns
Hemipterans	—	ns	—	ns
Beetles	−0.72***	ns	−0.45*	−0.37*
Butterflies	—	ns	—	+0.45*
Ants	ns	ns	+0.46*	ns
Lizards	+0.42*	—	+0.75***	—
All taxa	+0.38*	ns	+0.57***	ns

Discussion

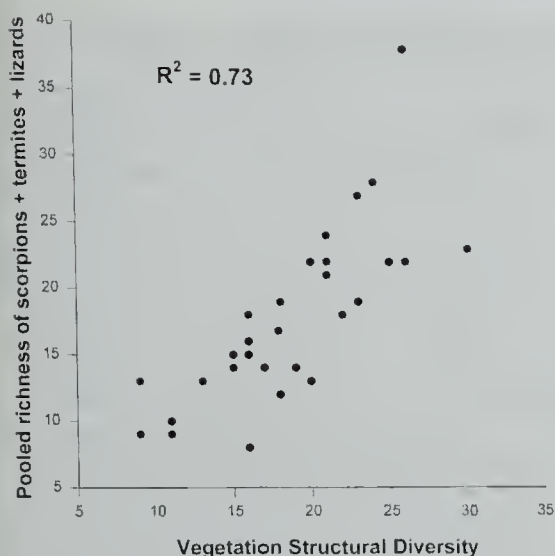Figure 1. Relationship between the pooled richness of scorpions + termites + lizards and the structural diversity of the vegetation.

Poor prediction of total faunal richness by any indicator variable follows a pattern found for studies in other Australian ecosystems (e.g., Yen, 1987; Oliver and Beattie, 1993). Observed differences between the vegetation types in the predictive qualities of vegetation structural diversity and plant richness may be due to differences in sampling regime, disturbance history, species composition of the fauna, biogeographic characteristics of study remnants, the way structure was measured, or simply because these are two very different systems and thus behave differently.

The woodland and shrubland data sets are comparable in numbers of study sites (29 sites as against 27 sites), trap size and density/m (identical), assessment of vegetation structural diversity (identical), and assessment of the richness of plants, termites and ants (identical). Beetles were sampled more intensively in woodland (4 seasons as against 1 season) and therefore provide no valid comparison across the two vegetation types.

Woodland remnants have a simple structure of the vegetation (and species-poor floristics), the major disturbance is livestock-grazing, and the remnants are small in area (mostly < 5 ha) and high in spatial isolation (Arnold and Weeldenburg, 1991). Shrublands, in contrast, are highly complex in structure (and floristics), they are largely ungrazed but some have been farmed for varying periods before abandonment (> 20 years ago), and they are larger in area (mostly > 20 ha) and lower in spatial isolation (Arnold and Weeldenburg, 1991). In addition to these different physical and biological characteristics of the vegetation types, the faunal groups differ in species composition and in their responses to disturbance (Lobry de Bruyn, 1993; Abensperg-Traun et al., 1996). Taken together, these differences may account for the discrepancy in the efficiency with which faunal richness was predicted in the two vegetation types.

Also, using the same scale of measurement of structure for two structurally very different vegetation types may not have been appropriate. In contrast to the woodlands, the shrublands of south-west Western Australia are renowned for their high alpha- and beta-diversity of plants (Lamont et al., 1984). Reasons given for this high spatial diversity are a complex underlying geology, small-scale changes in soil characteristics, and disturbance histories such as fire (Bell et al., 1984; Lamont et al., 1984). The qualities

Species richness of other fauna

Total faunal richness was poorly predicted by any faunal richness variable in either vegetation type (Table 2). More woodland faunal richness variables were significantly intercorrelated than in the shrubland fauna (Table 2). Highest correlations in woodlands were between termites and beetles (40% of variation explained), lizards and scorpions (31% explained) and scorpions and total species richness (30% explained) (Table 2). Scorpions were thus the best predictors of the richness of other fauna.

In shrubland, only richness of termites and hemipterans were significantly correlated with ants and total arthropod richness but explained low percentages of the variation (18% and 21%, respectively) (Table 2).

Abundance of ant functional groups

Total faunal richness, or the richness of any faunal group, was poorly predicted by the abundance of ant functional groups in either vegetation type. Highest percentages of total faunal richness explained by ants were 36% for woodlands (dominant dolichoderine ant spp.) and 27% for shrublands (opportunist ant spp.) (Table 3). Numbers of significant correlations, and percentages of the variation explained, were greater for woodland than for shrubland faunal groups (Table 3).

Table 2. Correlation coefficients (r) between the richness of individual faunal groups. *P <
0.05, **P < 0.01, ***P < 0.001; ns not statistically significant.

| | Eucalypt woodland | | | | |
	Scorpions	Termites	Beetles	Ants	Lizards
Scorpions	—				
Termites	+0.53**	—			
Beetles	−0.37*	−0.63***	—		
Ants	+0.50**	+0.41*	ns	—	
Lizards	+0.56**	+0.38*	ns	ns	—
All other taxa	+0.54**	ns	ns	ns	ns

| | Shrubland | | | | |
	Termites	Hemipterans	Beetles	Butterflies	Ants
Termites	—				
Hemipterans	ns	—			
Beetles	ns	ns	—		
Butterflies	ns	ns	ns	—	
Ants	−0.42*	ns	ns	ns	—
All other taxa	ns	+0.44*	ns	ns	ns

Table 3. Summary of step-wise regression (on principal component scores) using the abundance
of individual ant species within functional groups as indicators of faunal richness. Values are
percentage variation accounted for.

| Ant functional groups | Eucalypt woodland | | | | |
	Scorpions	Termites	Beetles	Lizards	Total species excl. ants
Dominant Dolichoderinae	18	ns	27	42	36
Sub-ordinate Camponotini	42	26	ns	ns	31
Hot-climate specialists	28	22	ns	ns	ns
Cryptic spp.	23	23	19	18	16
Opportunist spp.	25	ns	ns	ns	ns
Generalized myrmicine spp.	42	37	25	21	24

| | Shrubland | | | | |
	Termites	Hemiptera	Beetles	Butterflies	Total species excl. ants
Dominant Dolichoderinae	ns	22	ns	ns	26
Sub-ordinate Camponotini	ns	ns	ns	ns	ns
Hot-climate specialists	ns	27	ns	ns	25
Cryptic spp.	ns	ns	ns	ns	ns
Opportunist spp.	ns	ns	30	ns	27
Generalized myrminine spp.	16	ns	ns	ns	ns

Footnote. Dominant Dolichoderinae = *Iridomyrmex* spp.; Subordinate Camponotini = *Campon-
otus* spp., *Polyrhachis* spp.; Hot-climate specialists = *Melophorus* spp., *Meranoplus* spp.; Cryptic
spp. = *Tapinoma* sp., *Stigmacros* spp.; Opportunists = *Rhytidoponera* spp., *Tetramorium* spp.;
Generalized myrmicine spp. = *Pheidole* spp., *Monomorium* spp., *Crematogaster* spp.

of any one habitat component as a predictor of faunal richness is likely to decline with an increase in structural/floristic diversity of the vegetation (MacArthur, 1964).

Using vegetation structural diversity and plant richness as predictors of the richness of scorpions, termites and lizards in gimlet woodlands for comparable vegetation types elsewhere in Australia is limited, first, by geographic variations in their abundance and richness. Second, associated with such spatial variations are changes in the interactions between biotic groups, particularly the ants which are known to influence the abundance and richness of other arthropods. Third, disturbance type or intensity may influence the bioindicator quality of any one variable, yet disturbance effects on flora and fauna may vary with vegetation type, soil type, climate or life-history strategies of target biota (e.g., Grubb, 1977; Hobbs and Huenneke, 1992). The use of structural diversity or plant richness as faunal indicators for different vegetation types, or for vegetation types with different disturbance histories, or for different geographic or climatic regions, should not be adopted without verification of their validity.

Acknowledgements

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