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ANTS AS INDICATORS OF THE IMPACT OF PERENNIAL SHRUB LOSS IN CHENOPOD SHRUBLANDS OF SEMI-ARID SOUTHERN AUSTRALIA

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ABSTRACT

The impact of perennial shrub loss on ant communities was investigated in semi-arid chenopod shrublands of the Flinders Ranges, South Australia, in the context of the potential use of ants as bioindicators in land management. Clear differences in ant species assemblage were noted between areas with and without shrubs, most notably in the abundance of a dominant species of *Iridomymrex*. Ant species richness was shown to be positively correlated with the richness of ground hunting spiders and wasps. Ants appear to be sensitive to ecological changes associated with perennial shrub loss, and their responses correlated with those of other arthropod taxa. Ants therefore show promise as indicators of ecological change within this semi-arid habitat.

INTRODUCTION

Overgrazing within the chenopod shrublands of semi-arid southern Australia has resulted in the loss of native perennial vegetation and its replacement by exotic weeds across vast areas. Such vegetation change is likely to have a major impact on biodiversity and ecosystem function. Prior to 1971, the bluebush (*Maireana* spp.) shrublands in the Flinders Ranges National Park of South Australia had been degraded and fragmented by decades of heavy grazing by sheep. It has since continued to suffer high grazing pressure from goats, rabbits and kangaroos. Within this open shrubland, only relatively small patches remain with perennial shrubs as the dominant overstorey, while Wards weed (*Carrichtera annua*), an exotic annual herb, dominates the residual area. Neighbouring sheep stations have retained large tracts of shrubland, and have reduced Wards weed invasion through more conservative stocking rates.

Within these chenopod shrublands, ants are one of the most abundant and species-rich arthropod groups (Clarke *et al.* 2003). Despite being touted as the quintessential indicator of ecological change (Majer 1983, Andersen 1990), the evidence for the use of ants as bioindicators in arid environments is still in debate (Hoffmann and Andersen 2003, Andersen *et al.* 2004). Previous work on the response of ants to disturbance in semi-arid environments has concentrated on the impacts of mining (Read 1996, Hoffmann *et al.* 2000), fire (Hoffmann 2003) and grazing (Landsberg *et al.* 1999, Hoffmann 2000, Read and Andersen 2000), or active regeneration of native vegetation during minesite rehabilitation (Andersen 1997, Majer and Nichols 1998). We are not aware of any previous studies examining ant responses to passive habitat recovery following long-term disturbance. The extent to which ant responses reflect those of other arthropod groups is also unknown in semi-arid environments (Andersen *et al.* 2004).

In this study, patterns of ant community structure in relation to the occurrence of shrubs are described within the bluebush shrubland, and ant species richness is correlated with the richness of two other arthropod groups, ground hunting spiders and wasps. The project aims to provide a greater understanding of the usefulness of ants as bioindicators in arid environments, as a potential tool for land managers to monitor habitat recovery.

METHODS

Study sites

The study took place in the Flinders Ranges National Park and on the neighbouring sheep property Wirrealpa Station, in the northern agricultural district of South Australia. All study sites are located in the plains areas of the Flinders Ranges, and receive an erratic annual rainfall of approximately 300 mm. The main shrub species on these plains are *Maireana astrotricha* (low bluebush), *M. pyramidata* (black bluebush), and *Nitraria billardierei* (nitre-bush). The exotic annual Wards weed (*Carrichtera annua*) is extremely prevalent, and dominates areas devoid of perennial shrubs.

A total of nine sites were surveyed, including three paired shrub/no-shrub sites within the National Park. Within each pair, one site was chosen inside a patch of shrubland (SHRUB), dominated by *N. billardierei* (Site 1), *M. pyramidata* (Site 2), or *M. astrotricha* (Site 3), with the other site of the pair at least 150 m from the outside edge of the patch in ephemeral herbland dominated by Wards weed (NO SHRUB). Three additional (SHRUB) sites were chosen on neighbouring Wirrealpa station. These were separated by at least 1 km, and were all dominated by *M. astrotricha*. Shrub cover (approx. 10%) was similar on all SHRUB sites, although Site 1 had larger, more widely spaced *N. billardierei* shrubs.

Sampling

Two lines of five pitfall traps (70 mm diameter) were established at each site, with traps spaced by 10 m and lines separated by 25 m. Traps were installed with lids four weeks prior to sampling to avoid digging in effects (Greenslade 1973). Immediately prior to sampling, the lids were removed and 50 mL of 50% ethylene glycol and a few drops of detergent were added to each trap. Traps were opened for five days in December 2002. Once collected, samples were transferred to 70% ethanol and all arthropods were sorted to order. Ants, wasps and spiders were identified to morphospecies. Voucher specimens are currently housed in the Insect Evolution and Ecology Laboratory, Darling Building, The University of Adelaide, and will be deposited in the South Australian Museum. To describe habitat structure, three 3 m transects, each separated by 1 m were surveyed at each pitfall trap. Every 5 cm along each transect, the type and height of the highest structure (bare ground, litter, or plant species) was recorded.

Analysis

Multivariate analyses of ant species abundance data were performed using Non-metric Multidimensional Scaling (NMS) (Sorensen's Distance measure) in the PCOrd (Version 4.10) program. Multi-Response Permutation Procedures (MRPP), a non-parametric multivariate test for detecting significant differences between groups (McCune and Grace 2002) was used to test for the significance of the separation of the SHRUB and NO SHRUB sites. Regression analyses were performed on the average number of ant species and spider and wasp species for each site using the JMP (Version 4.0.3) statistical package.

RESULTS

Ant community

The ant species richness in the SHRUB sites was not consistently higher than in the NO SHRUB sites (Table 1). A degree of separation of the SHRUB and NO SHRUB sites can however be seen in the ordination of the ant assemblage (Figure 1). MRPP comparison of the ant assemblage data within the SHRUB and NO SHRUB sites revealed a significant difference (T = -31.26, A = 0.1489, $p < 0.001$) between the two groups. A small *Iridomyrmex* species (*Iridomyrmex* sp B. (*rufoniger* group)) explained a large amount of the variation along the axes. This species was collected in much higher numbers at two of the NO SHRUB sites, whereas it was either absent or collected in extremely low numbers at all other sites (Table 1). Only a few correlations of the ant community composition with the environmental variables were apparent ($r^2 \geq 0.2$) and these were: cover of bare ground, Wards weed and rock, and 0 cm structural category. No correlation with plant species or structural diversity was found.

Table 1. Ant species richness and abundance of *Iridomymrex* sp B (*rufoniger* group) at each site.

Site	Perennial shrubs	Ant species richness	*Iridomyrmex* sp B. abundance
National Park 1	SHRUBS	24	4
National Park 1	NO SHRUBS	18	3743
National Park 2	SHRUBS	16	0
National Park 2	NO SHRUBS	17	0
National Park 3	SHRUBS	17	1
National Park 3	NO SHRUBS	17	1542
Wirrealpa 1	SHRUBS	17	0
Wirrealpa 2	SHRUBS	21	0
Wirrealpa 3	SHRUBS	19	1

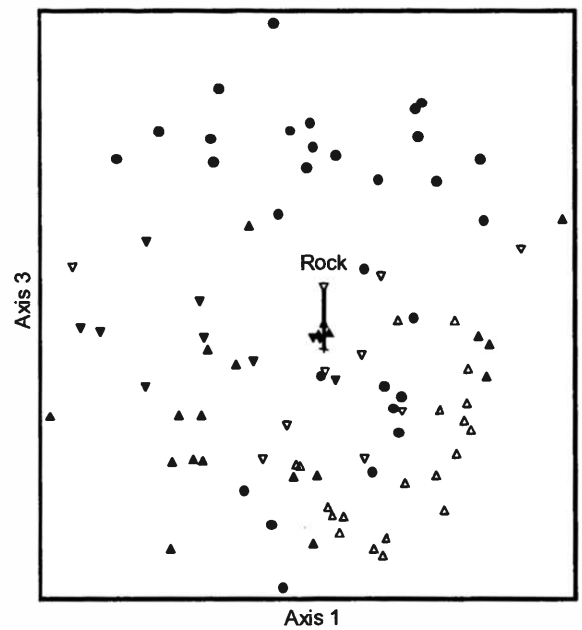

Figure 1. NMS Ordination of ant morphospecies assemblage (log χ +1). Open symbols are sites without perennial shrubs (NO SHRUB), triangles are sites within the National Park, and circles represent sites on Wirrealpa Station (SHRUB). (Stress 18.27, $R = 0.2$)

Regression analyses

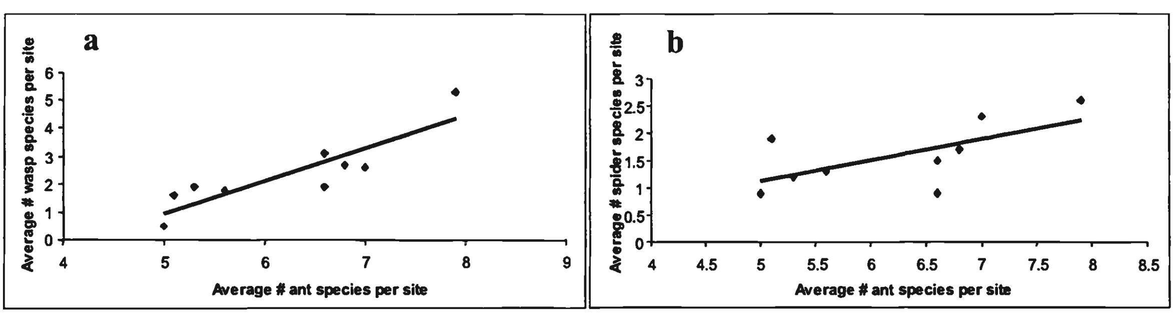

Figure 2. Regression analyses of number of ant species at each site (averaged over the 10 traps) against the average number of a) wasp species ($r^2 = 0.7657$, $p = 0.002$) and b) spider species ($r^2 = 0.4099$, $p = 0.0633$).

Results of regression analyses for average number of ant species against average wasp and spider species richness revealed positive relationships (Figure 2). Average number of spider species versus number of wasp species was also tested and revealed a positive but less significant relationship (r^2 = 0.5805, p=0.017).

DISCUSSION

Impact of perennial shrub loss on ant morphospecies assemblage

The loss of perennial shrubs has had no apparent effect on ant species richness, but appears to have altered species composition. This is a similar result to that found in the semi-arid tropics of northern Australia (Hoffmann 2000) and suggests that the removal of the perennial shrubland and its replacement with ephemeral herbland has affected the ant community.

The large numbers of *Iridomyrmex* sp. B collected at two of the NO SHRUB sites may be the result of the loss of shrub cover at these sites. This species appears to be numerically and behaviourally dominant where it occurs (*pers. obs.*) and is likely to affect the location of nests and foraging activities of many other ant species within its range. This could account for the changes in the ant assemblage noted between the SHRUB and NO SHRUB sites.

Several previous studies have found a correlation between plant species richness (e.g. Majer 1983) or structural diversity (e.g. Morris 2000) and arthropod diversity but this was not found in our study. This lack of correlation could be due to the low floristic and structural diversity in this environment when compared with habitats such as woodlands with understorey or grasslands. The *Iridomyrmrex* species present in the Flinders Ranges can also forage over large distances and have colonies of interconnecting nests (*pers. obs.*). The 3 m transects of the plant survey may therefore not have taken into account a large enough area for the important, widely foraging species, for which no relationships with the vegetation variables were revealed. However, the transects do appear to have been sufficient for most of the species with smaller home ranges for which some correlations were apparent.

The large numbers of *Iridomyrmex* sp. B at NO SHRUB Sites 1 and 3 was not recorded at Site 2 in the National Park. This site comprised a fairly small patch of ephemeral herbland near a large patch of shrubs, where the opposite was the case for sites 1 and 3. This provides more evidence, albeit circumstantial, that the plant characteristics of the wider area need to be taken into account when looking at ant assemblages in semi-arid environments, and may indicate a lower importance of small-scale structure and plant diversity for this species.

Correlations between ant, spider and wasp diversity

The positive correlation between the average species richness of ants and the average number of spider and wasp species is intriguing, however, an explanation for this effect is not obvious. The behaviourally dominant *Iridomyrmex* species and other carnivorous ant species may compete with ground hunting spiders sharing the same foraging space. Although a connection between ant and wasp assemblages is not so easily explained, most of the species collected were predators or parasitoids of ground dwelling invertebrates.

As a previous study (Majer 1983) found a similar phenomenon of ant species richness correlating positively with the diversity of other arthropod groups, this result deserves further consideration. The pitfall traps were not specifically designed to collect flying insects such as wasps, and these traps did not collect web-building spiders. Therefore other collecting techniques should be employed to investigate whether these correlations extend to wider samples of the wasp and spider assemblages.

Ants as bioindicators

Our results suggest that ants are responsive to the removal of perennial shrubs and their replacement with exotic ephemeral herbs within the Flinders Ranges. However, we could detect no simple relationship between ant species composition and plant species or structural diversity. In contrast, ant species diversity was closely correlated with the diversity of wasps and spiders.

This study highlights interesting possibilities for the use of ants as indicators of ecological change and arthropod diversity in chenopod shrublands. However, to be of practical use as a monitoring tool the results need to be easily measured, consistent, and repeatable. Ants are easily collected within this semi-arid environment using pitfall traps but the use of morphospecies for monitoring purposes is time consuming due to the taxonomic complexities of species level identifications. Ant species can, however, be placed into functional groups requiring identification only to genus. Indeed, an ordination of functional group data produced a better separation of SHRUB and NO SHRUB sites than that using species level data (Clarke *et al.* in prep). Therefore the use of functional groups should be considered for future monitoring work, despite their relative insensitivity to other land-use changes elsewhere in arid Australia (Hoffmann and Andersen 2003).

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