Shrub-resident arthropods in an *Eremophila* and *Senna*–dominated shrubland

Kwok, A.B.C.[1] and Eldridge, D.J.[1, 2]

[1] Evolution and Ecology Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, NSW, 2052, Australia.

[2] Department of Environment, Climate Change and Water, C/- Evolution and Ecology Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, NSW, 2052, Australia.

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Abstract

Though shrub-encroached landscapes are viewed by some as 'ecological deserts', we know little of the biodiversity that they support. We investigated the shrub-resident arthropods in a turpentine (*Eremophila sturtii*)-silver cassia (*Senna artemisioides*) shrubland in eastern Australia, and how fine-scale shrub density affects these communities. We found that turpentine supported six times more arthropods than silver cassia (Hemiptera, Psocoptera and Collembola), as well as a distinct species assemblage of Hemipterans. Fine-scale shrub density also affects the Hemipteran community, particularly on silver cassia. We have shown that shrub-encroached landscapes support healthy arthropod communities, which are structured by shrub species and fine-scale patterns of shrub density.

Introduction

Though shrub-encroached landscapes are viewed by some as 'ecological deserts', we know little of the biodiversity that they support. In one of the few comprehensive surveys of the effects of shrub encroachment on biodiversity in Australia, Ayers *et al.* (2001) concluded that the effects of shrub encroachment are taxon-dependent. Responses to increased woody shrub cover range from preference to avoidance, and included neutral responses.

In this study we investigate the arboreal arthropod community on two widespread species of woody shrub, turpentine (*Eremophila sturtii)* and silver cassia (*Senna artemisioides*) in a mixed-shrubland of eastern Australia. We also investigate if fine-scale shrub density (*sensu* resource concentration) structures arthropod communities by sampling arthropods on shrubs growing in high and low density.

Methods

The study was conducted in May 2009 within Scotia Sanctuary, in south-western NSW, Australia. We sampled the arthropod fauna at ten sites by fogging shrubs with Pyrethrum-based insecticide. In this paper we focus on Psocoptera, Collembola and Hemiptera. Only Hemiptera were identified to species-level. At each site we sampled eight shrubs, four turpentine and four cassia. Half of each species were growing at 'low density' (i.e. fewer than two conspecific shrubs within a 5m radius, i.e. 80m^2), and the other half at 'high density' (10-20 conspecific shrubs within 80m^2).

We used a balanced Analysis of Variance (ANOVA) to test for differences among shrub species, shrub density, and the interaction of these two factors in the number of individuals (total arthropods, Hemiptera, Hem: Psyllidae, Collembola, Psocoptera), and for Hemiptera the number of species and effective number of species (*sensu* species diversity). Data were transformed where necessary and we ensured data met the assumptions of ANOVA. We used three-way permutational analysis of variance (Anderson and Gorley 2008) to test for differences between site, shrub species, and shrub density in the composition of Hemipteran species. All multivariate analyses were conducted within the PRIMER (Version 6) (Clarke and Gorley 2006; Anderson and Gorley 2008), and were based on log-transformed data and a zero-adjusted Bray-Curtis resemblance matrix (Clarke 1993).

Results

A total of 9,102 arthropods from eighty shrubs were collected in this study; 85% from turpentine and 15% from silver cassia. Fifty-one percent of individuals on turpentine were Psocoptera, 28% Hemiptera, 15% Psyllidae and 6% Collembola. The fauna on silver cassia was dominated by Psocoptera (69%) with smaller numbers of Hemiptera (22%), Collembola (8%) and Psyllidae (1%).

Shrub species effects on arthropod fauna

Every arthropod taxon was more abundant on turpentine than silver cassia (Table 1). Hemipteran abundance was significantly higher on turpentine (54.78 ± 8.38; mean ± SE) than silver cassia (7.3 ± 0.92), irrespective of shrub density (species x density interaction: P=0.29), however note shrub density effects described below.

Across both shrub species, 25 Hemipteran species from the suborders Auchenorrhyncha and Heteroptera were recorded; 19 from turpentine*,* 17 from silver cassia and 11 common to both shrub species. Turpentine had a greater number of species (4.78 + 0.31 *c.f.* 2.38 + 0.31) and greater species diversity (2.96 + 0.19 *c.f.* 2.44 + 0.25) than silver cassia, though note the density interaction below (Figure 1b). When shrub density was pooled and the abundance of individuals standardized (rarefaction), Hemipteran species richness was higher on silver cassia (n = 17) than turpentine (n = ~10: 95% confidence interval = 7 – 13). The Hemipteran species assemblage differed markedly between shrub species (Pseudo $F_{1,9}$=81.18, P=0.01).

Table 1. Mean abundance (± S.E.M) of arthropods in relation to shrub species (E = *Eremophila sturtii*, turpentine; S = *Senna artemisioides*, silver cassia) and shrub density (L=low, H=high). All differences between Different letters within a row indicate a significant difference between means at P< 0.01.

Taxon	*Senna artemisioides*		*Eremophila sturtii*		Shrub	Shrub
	Low	High	Low	High	density	Species
All taxa	43.7 ± 7.2[a]	41.9 ± 5.8[a]	216.1 ± 40.9[b]	213.3 ± 30.1[b]	L = H	E > S
Psocoptera	21.9 ± 6.1[a]	24.0 ± 4.6[a]	88.6 ± 20.7[b]	111.0 ± 20.5[b]	L = H	E > S
Collembola	1.9 ± 0.6[a]	3.4 ± 0.8[a]	11.9 ± 3.5 [b]	10.8 ± 1.4[b]	L = H	E > S
Psyllidae	0.5 ± 0.3[a]	0.4 ± 0.1 [a]	32.8 ± 9.6 [b]	24.3 ± 7.2[b]	L = H	E > S
Hemiptera	9.1 ± 1.3[a]	5.5 ± 1.3 [b]	65.6 ± 15.2[c]	44.0 ± 6.8[d]	L > H	E > S

Shrub density effects on arthropod fauna

There was no effect (*P*>0.05) of shrub density on the abundance of the total arthropod community, nor Pscocoptera, Psyllidae or Collembola analysed individually, and this effect was consistent for both turpentine and silver cassia (Table 1).

In contrast, we recorded significantly more Hemipterans on shrubs growing at low density than high density ($F_{1,9}$=4.74, *P*=0.033), for both turpentine and silver cassia (shrub species x density interaction: *P*=0.29; Table 1). For silver cassia, shrubs growing at low density supported a greater number of species ($F_{1,9}$=38.47, *P*<0.001) and higher species diversity ($F_{1,9}$= 6.83, *P*<0.01) than shrubs growing at high density, while there were no effects of density on turpentine (density x shrub species interaction: species richness: $F_{1,9}$=6.20, *P*=0.015; diversity: $F_{1,9}$=8.02, *P*=0.006) (Figure 1).

The Hemipteran species assemblage also differed between high and low density shrubs (Pseudo $F_{1,9}$=2.45, *P*=0.02; shrub species x density interaction Pseudo $F_{1,9}$=3.01, *P*=0.006). This difference was much clearer for silver cassia (Pairwise *t*=1.79, *P*=0.02) than turpentine (Pairwise *t*=1.54, *P*=0.04).

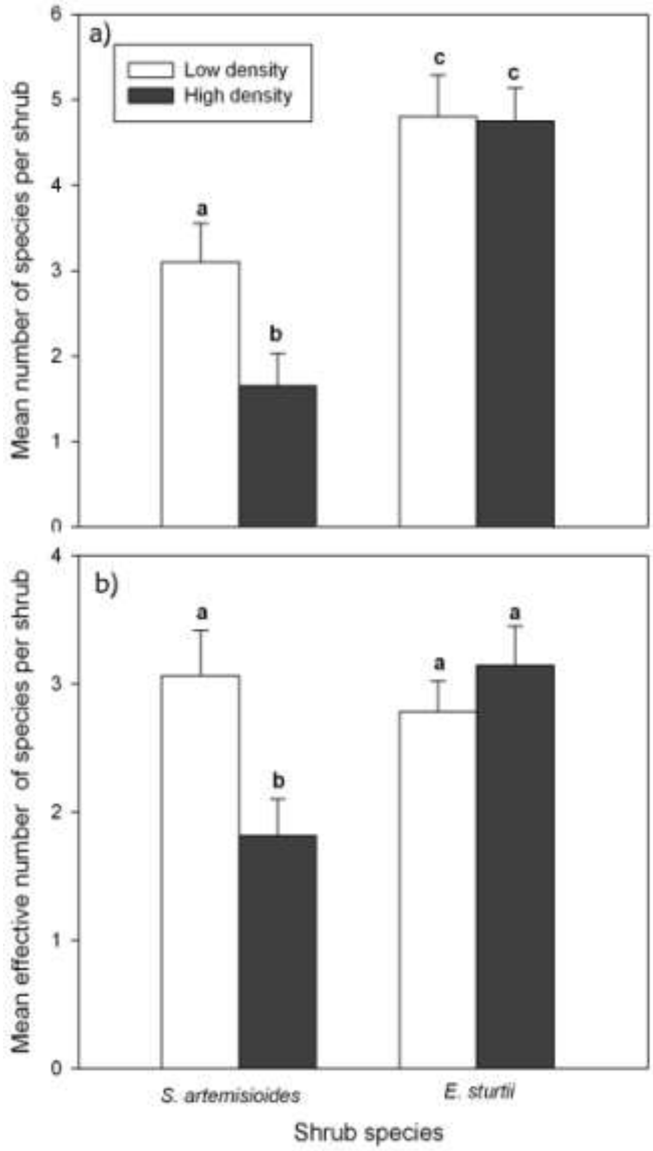

Fig. 1: Mean ± SE a) number of Hemiptera species and b) effective number of Hemiptera species per sample for Senna and Eremophila across two densities (low and high). Different letters indicate a significant difference in Hemiptera (log x +1) at P<0.05 using Tukey's LSD. SE = standard error of the mean.

Discussion

This study revealed that arboreal arthropods are numerous and diverse in shrub-encroached landscapes. We also found that fine-scale shrub density affects the diversity and species assemblage of Hemiptera, while shrub species affects the entire composition of the arthropod community.

Fine-scale resource concentration has variable effects on arthropod communities

Two of the major arthropod groups (Psocoptera and Collembola) were not affected by the fine-scale density of shrubs (high or low density). Hemiptera, however, were more abundant on shrubs growing in low density. Furthermore, low density silver cassia supported a richer, more diverse and compositionally different community compared to high density silver cassia. This indicates that differences in resource concentration over the scale of tens of metres can affect arthropods in dramatic ways, though the effect is taxon-dependent, at both the species- and family-level.

Different shrubs – different bugs

We found two distinct Hemipteran communities in *Senna-Eremophila* shrublands, with arthropods far more abundant on turpentine. Furthermore, most Hemipteran species were found exclusively or dominantly on only one shrub species. This suggests that multiple shrub species can increase local arthropod biodiversity. This also suggests that there are minimal associational effects on the Hemipteran community due to the coexistence of two shrub species (e.g. increased herbivores on species *A* as a result of proximity to species *B*; Agrawal *et al.* 2006).

Herbivorous arthropods are the forgotten 'winners' of shrub-encroachment. Shrub-encroached landscapes in eastern Australia vary tremendously in shrub-species composition and density (Ayers *et al.* 2001). Proliferation of shrubs provides a substantially greater supply of resources for arthropods, allowing population increases and perhaps changes to the distribution of many species (including rare taxa). Additionally, encroachment may alter the abundance of preferred and potential hosts species, resulting in diet-switching by predominantly monophagous herbivore species (e.g. Agrawal *et al.* 2006). Diet-switching can have clear effects arthropod fitness (Mody *et al.* 2007), and broader consequences of this at a community or ecosystem-level are unpredictable. There is an incredibly wide scope for future research investigating not only the arthropod community of shrublands, but also how encroachment alters these communities and their dynamics through plant-arthropod interactions and arthropod-arthropod interactions.

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