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GEIJERA PARVIFLORA LINDL. (RUTACEAE) FACILITATES UNDERSTOREY SPECIES IN SEMI–ARID AUSTRALIA: THE IMPORTANCE OF SHADE

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ABSTRACT

It is often found in harsh environments that trees can be beneficial to understorey species but little is known about this positive relationship. This study examined; whether zones of vegetation composition were associated with *Geijera parviflora*; and the importance of shading in facilitating understorey growth. Species abundance was measured under five randomly selected mature *G. parviflora* trees in south-western New South Wales, Australia. Artificial shade plots were constructed in a canopy free area to compliment the findings. The microhabitat created by the canopy of *G. parviflora* generates spatial heterogeneity over the broader plant community. It improves the establishment and survival of many understorey species and increases species diversity. Shading appears to be a key influence on the plant communities under the canopy. This emphasizes the importance of arid zone trees in conserving both over and understorey plant diversity.

INTRODUCTION

Plant community composition under tree canopies often differs to that of surrounding environments (Hastwell, 2001). While grass and herb biomass can be enhanced by the removal of trees in some areas through reduced competition, it is often found in harsh environments, such as arid environments that plant interactions can be positive (Hastwell, 2001).

Overstorey species can directly facilitate understorey species by releasing stimulatory allelochemicals, altering precipitation distribution under their canopy, soil bulk density, soil moisture, soil oxygen, soil and surface temperature, available light, and soil nutrients (Callaway, 1994). Indirect facilitation also plays a vital role through: protection from herbivores; increased microbial activity; creating heterogeneous seed banks; overstorey induced disturbance patterns; attracting pollinators or through interconnected webs of competitors (Anderson et al., 2001).

The plant species associated with *Geijera parviflora* Lindl. (Wilga) in south–western New South Wales Australia, were investigated to determine whether zones of vegetation composition occur around the tree. The effect of artificial shading on species in a canopy free area was also investigated to understand how shading influences plant growth in isolation from other factors.

METHODS

Spatial heterogeneity of plant communities

The study site was located within a 1 ha vertebrate herbivore exclosure plot on Tarawi Nature Reserve, south–western New South Wales, Australia (S33°25'21", E141°15'55"). This exclosure plot was located within *Casuarina pauper* (Belah) woodland with scattered *G. parviflora* growing to a maximum height of 5.00m and a maximum canopy radius of 4.10m.

Species abundance was measured under five randomly selected isolated *G. parviflora* trees from the following locations in the four cardinal directions: i) beside the tree bole, ii) mid–canopy and iii) 3m from the canopy edge. Sampling was conducted in autumn and spring.

Artificial shade
On the 1st February 2005, ten 90%, 50% and 0% light exclusion shade plots were constructed in a canopy free area of similar soil type on Nanya Research Station (S33°12'08", E141°17'04"), 20km north of the exclusion plot. Species density was recorded for all vascular plant species within a 1m^2 quadrat placed centrally in the exclosure plots after seven months of the shade construction.

Statistical analysis
Univariate data were analysed using a one–way ANOVA followed by Tukey's Pairwise comparison using Minitab 14.11. Multivariate data were analysed using canonical analysis of principal coordinates (CAP; Anderson and Willis, 2003) using the vegan package in the R statistics package (version 2.1.1). The Bonferroni (1936) adjustment was performed for multiple comparisons. Taxa significantly correlated with the model were identified by applying an envfit method from the vegan package to the abundance data.

RESULTS

Spatial heterogeneity of plant communities
Spatial heterogeneity of plant communities was more noticeable in spring, possibly a result of the preceding rainfall, having a significant effect on the abundance of 47% of species ($F=9.22$, $p<0.05$, $n=18$, Fig. 1). The CAP model suggested that two zones of vegetation exist in relationship to *G. parviflora*: i) a species rich community beneath the canopy and ii) a species poor community beyond the canopy dominated by *Dissocarpus paradoxus* (Cannonball) throughout the year with *Crassula colorata* (Dense Crassula) appearing after rainfall.

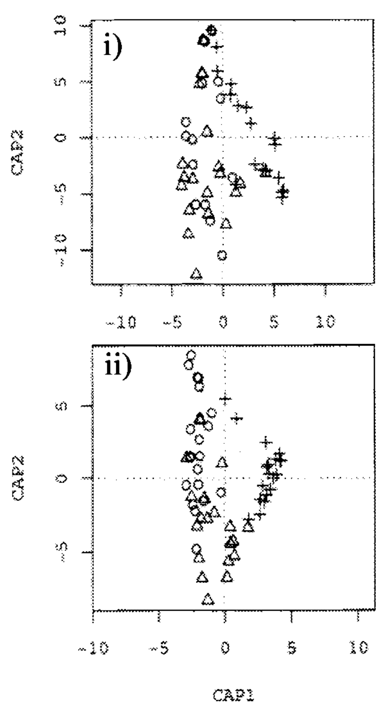

Figure 1: CAP plots of species abundance in i) autumn and ii) spring from the tree bole (○), mid–canopy (△) and 3m from the canopy edge (+)

Artificial shade
Shading significantly increasing species richness for both 50% ($p<0.05/3$) and 90% ($p<0.05/3$) shading treatments, however no significant difference ($p>0.05/3$) was found between the two treatments (Fig. 2).

The CAP model suggests that the abundance of the following species are increased by shade: *Brachyscome lineariloba* (Hard Head Daisy), *C. colorata*, *Calotis hispidula* (Bogan Flea), *Daucus glochidiatus* (Native Carrot), *Medicago minima* (Burr Medic) and *Scleranthus minusculus* (Cushion Knawel).

DISCUSION

Spatial heterogeneity of plant communities
The results support the hypothesis that *G. parviflora* creates spatial heterogeneity over the broader plant community. Two zones of vegetation existing in relation to the tree canopy. The first being under the canopy with high species diversity and the second being beyond the canopy dominated by *D. paradoxus* throughout the year with *C. colorata* appearing after

rainfall. This indicates that these species are either negatively effected by the overstorey or are displaced by more competitive species. The thick leaf litter under the canopy may also inhibit the germination of these species, exhausting the seed embryo reserves before the hypocotyl reaches light and reducing light required for germination of some species (Peterson and Facelli, 1992).

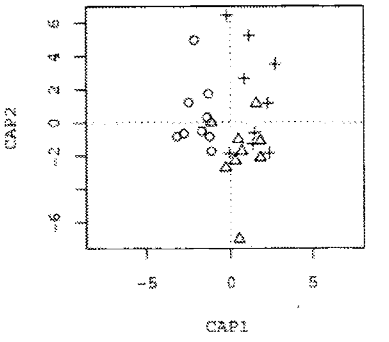

Figure 2: CAP plot of species abundance from 0 (○), 50 (△) and 90% (+) shade exclusion plots

Lower species richness may be found beyond tree canopies as this zone is low in soil nutrients and has high evaporation and evapotranspiration rates (Hastwell, 2001). Many species are unable to cope with these conditions, whereas some such as *C. pseudevax* and *D. paradoxus* have adapted to these harsh conditions. The reduced surface area of *C. pseudevax* and moisture storing leaves of *D. paradoxus* aid in the reduction of water loss (Pugnaire and Lázaro, 2000). Other more mesophytic plants such as *Parietaria cardiostegia* (Mallee Pellitory) are only found in the microclimate created by the tree, being less adapted to harsh environments.

Increased abundance of some species under the tree canopy may also be explained by an increased soil seed bank (Warnock, 2005), seed dispersing fauna often spending much of the day in the shade of trees or perched in the canopy (Shaukat and Siddiqui, 2004). Therefore, seeds are more likely to be dispersed in such areas, particularly species with fleshy fruits such as *E. tomentosa* var. *tomentosa*. Wind may also blow wind dispersed seeds such as *M. pentatropis* along the bare ground in canopy free areas eventually being caught in the litter underneath a tree canopy.

High rainfall was recorded preceding the spring sampling period when evapotranspiration is low compared to autumn where less rainfall was recorded and evaporation is typically higher (Anderson and Willis 2001; Warnock, 2005). These seasonal differences were correlated with the composition of the understorey plant community.

Artificial shade

The increased abundance of *B. leariloba*, *C. colorata*, *C. hispidula*, *D. glochidiatus*, *M. minima* and *S. minusculus* under the 90% shading treatment supports the concept that shading is an important factor in the growth and survival of understorey species. The shade allows more mesophytic species to colonise, increasing species richness and abundance under tree canopies. It is not known however how long species will survive in the microclimate created by shade and they may die off in drier months. This seasonal variability was also found under the tree canopies where in earlier drier months few species were present despite the effect of shading.

CONCLUSIONS

The microhabitat created by the canopy of *G. parviflora* generates spatial heterogeneity over the broader plant community. Species with a poor drought tolerance are able to establish under the tree canopy after a precipitation event which retains soil moisture, shades and increases leaf litter cover thus reducing evaporation and evapotranspiration (Hastwell, 2001). This emphasizes the importance of arid zone trees in conserving both over and understorey plant diversity.

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