



Shrub–ephemeral plants interactions in semiarid north-central Chile: Is the nurse plant syndrome manifested at the community level?



Jaime Madrigal-González ^{a, b, *}, Douglas A. Kelt ^c, Peter L. Meserve ^d, Francisco A. Squeo ^{b, e}, Julio R. Gutiérrez ^{b, e}

^a Forest Ecology and Restoration Group, Department of Life Sciences, Science Building, University of Alcalá, ctra. A-2 km 33.6, 28805, Alcalá de Henares, Spain

^b Instituto de Ecología y Biodiversidad, Casilla 653, Santiago, Chile

^c Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, CA 95616, USA

^d Department of Biological Sciences, University of Idaho, Moscow, ID 83843, USA

^e Departamento de Biología and Centro de Estudios Avanzados en Zonas Áridas (CEAZA), Universidad de La Serena, Chile

ARTICLE INFO

Article history:

Received 29 September 2014

Received in revised form

28 July 2015

Accepted 3 August 2015

Available online 21 August 2015

Keywords:

Ephemeral plant communities

Facilitation

Nurse plant syndrome

Precipitation

Semiarid scrub

Biomass production

Diversity

ABSTRACT

Models of plant–plant interactions suggest that nurse plants are critical for the maintenance of biodiversity and ecosystem functions in arid and semiarid lands. At the community scale, however, empirical support of this idea is limited and context-dependent. Following on a preliminary work which suggested that a dominant shrub in north-central Chile (*Porlieria chilensis*) had nurse plant effects, we tested the effects of this and two other shrubs (*Adesmia bedwellii* and *Proustia cuneifolia*) on community biomass production, species density, and species composition of ephemeral plants in the semiarid scrub of the Bosque Fray Jorge National Park (Chile) over four consecutive years. We tested for main and interactive effects of shrubs and precipitation on total biomass production and species density of ephemeral plant communities using Generalized Linear Mixed Models (GLMM). To analyze the effects of shrubs and precipitation on species composition we used Canonical Correspondence Analysis (CCA) and t-value biplot analysis. Total biomass production increased significantly with precipitation and was consistently lower beneath shrub canopies, particularly under *A. bedwellii* and *P. chilensis*. Although ephemeral plant species density generally was higher in open areas, differences between open and shrub canopy samples diminished with increasing precipitation. Finally, despite significant differences in ephemeral plant species composition between open areas and shrub canopies, we found no evidence of shrub species-specific effects. In conclusion, our results do not support a classical nurse plant syndrome in the semiarid scrub of the Bosque Fray Jorge National Park although shrubs can increase local diversity by favoring some ephemeral plant species that are absent in open areas.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

In geographical areas where low rainfall and nutrient availability strongly limit plant survival and growth, woody species may facilitate herbaceous plants through amelioration of abiotic stresses via shading and redistribution of soil water and nutrients (Callaway, 2007). Study of plant–plant interactions strongly supports the nurse plant syndrome in semiarid lands worldwide (He et al., 2013)

and suggests that positive interactions could be critical mechanisms for the maintenance of ecosystem functions and biodiversity in severe environments (Flores and Jurado, 2003; Brooker et al., 2008). Three major hypotheses have been formulated to link mechanisms underlying the nurse plant syndrome with structure and functioning of beneficiary plant communities (see Filazzola and Lortie, 2014). First, nurse plants enhance fitness or productivity of beneficiary plants in their vicinity through direct and indirect mechanisms of interaction (Segoli et al., 2012). Among other benefits, increased water availability through hydraulic lift (Caldwell et al., 1998; Prieto et al., 2010), increased soil nutrient availability (Rodríguez-Echeverría and Pérez-Fernández, 2003; Pugnaire et al., 2004), reduced evapotranspiration and photoinhibition due to

* Corresponding author. Forest Ecology and Restoration Group, Department of Life Sciences, Science Building, University of Alcalá, ctra. A-2 km 33.6, 28805, Alcalá de Henares, Spain.

E-mail address: ecojpg@hotmail.com (J. Madrigal-González).

interception of direct solar radiation (Callaway and Pugnaire, 1999), and protection against herbivore pressure (Smit and Ruifrok, 2011) are the most conspicuous mechanisms in arid and semiarid environments. Second, it is commonly hypothesized that net positive interactions are more likely under severe conditions (Stress Gradient Hypothesis; Bertness and Callaway, 1994). Plant–plant interactions can shift from being net negative to net positive as resource availability declines along spatial gradients (Pugnaire and Luque, 2001; Pugnaire et al., 2004; Holzpfel et al., 2006; Armas et al., 2011). Although it is generally accepted that abiotic stress due to low resource availability promotes facilitative interactions, current theory suggests that positive interactions tend to collapse under extremely severe environments (Michalet et al., 2006) leading to a hump-backed relationship between facilitation and stress (Maestre et al., 2009). Third, and particularly under warmer and drier conditions, nurse plants increase local diversity of beneficiary plant communities by altering spatial dynamics of species with particular life strategies that are more likely to be facilitated (Davies et al., 2007; Soliveres et al., 2012).

Empirical support for these hypotheses at the community or ecosystem levels is limited, however, and at times contradictory (Cavieres and Badano, 2009; Soliveres and Maestre, 2014; Michalet et al., 2015). At the community level, indirect interactions along with nurse species-specific effects (Blank and Carmel, 2012) and/or disparate functional strategies of beneficiary plants could result in idiosyncratic plant responses to open and shrub conditions leading to complex scenarios of interactions (Schöb et al., 2013; Michalet et al., 2015). For example, many plant species in arid and semiarid environments have evolved tolerance mechanisms such as increased root–shoot ratios, or shortened vegetative–reproductive periods to restrict resource use to episodic favorable periods (Noy-Meir, 1973). Such life strategies are frequently incompatible with survival under shading conditions as suggested by the existence of functional trade-offs between tolerance to drought and shading in drylands (Smith and Huston, 1989; Holmgren et al., 1997). Accordingly, differences in species composition between open areas and under the canopy of shrubs in some semiarid ecosystems have been previously observed (López-Pintor et al., 2006). These findings at the community level question whether the outcome of net plant–plant interactions would scale up to multispecies interactions following the stress gradient hypothesis. Data obtained during a one-year study focusing on the nurse plant *Porlieria chilensis* in north-central Chile suggested species-specific responses of ephemeral plants and neutral interactions at the community level (Gutiérrez et al., 1997). However, it is still poorly known whether interannual variability of precipitation or different shrub species can shift the shrub–ephemeral interaction outcomes at the community level (Tielbörger and Kadmon, 2000, but see Pugnaire et al., 2004).

These uncertainties led us to pursue a field study to test the three hypotheses outlined above in the semiarid scrub of north-central Chile, and to expand this to consider the three most abundant shrubs in this system throughout four consecutive years. First, we hypothesized that these three shrub species would enhance annual plant community productivity, as observed in other semiarid habitats. Second, we predicted that the intensity and direction of shrub–ephemeral interactions would shift across a temporal (multi-year) precipitation gradient (i.e., lower precipitation should lead to higher facilitation but this benefit should be diffused when rainfall is sufficiently high that no microhabitat is water-stressed; Tielbörger and Kadmon, 2000). Most experimental and observational approaches to plant responses across stress gradients in arid and semiarid lands have considered spatial gradients of water availability, but our long-term study provides us with an unusual opportunity to complement these studies with an

approach emphasizing temporal variation in stress associated with variation in rainfall. Third, we hypothesized that patterns of species density and composition would differ between open areas and shrubs, and microhabitats beneath shrub canopies, leading to qualitatively distinct annual plant community structure (i.e. species composition and density).

2. Materials and methods

2.1. Study area

Our study area is near the coast of north-central Chile, in Bosque Fray Jorge National Park (71°40'W, 30°38'S) 100 km S La Serena and 350 km N Santiago. This 10 000 ha park contains semiarid thorn scrub vegetation and remnant fog forest, all of which has been protected from livestock grazing and disturbance since 1941. The flora of the lower elevated scrub zone includes spiny drought-deciduous shrubs and understory herbs on a primarily sandy substrate (Gutiérrez et al., 1993). Total cover of shrubs is ca 55%, dominated by *P. chilensis* L. M. Johnst. (Zygophyllaceae, 30% cover), *Adesmia bedwellii* Skottsb. (Fabaceae, 5% cover), and *Proustia cuneifolia* D. Don (Asteraceae, 6% cover). The climate is semiarid Mediterranean with 90% of the mean annual 122.6 mm (± 91.8 mm; data from 1989 to 2014, both years included) precipitation falling in winter (May–September) and precipitation from May to July is critical for seed germination and growth; summer months are warm and dry and during this period no ephemeral communities are present/growing. After a rainy 2002 (282.6 mm May–July rainfall) associated with an El Niño event, 2003 and 2005 were relatively dry (77.2 and 42.8 mm, May–July rainfall respectively), whereas 2004 and 2006 were relatively wet years (98.8 mm and 127.4 mm, May–July rainfall respectively).

2.2. Interacting species

Ephemeral plant communities in semiarid Chile are comprised of plants growing in a few weeks after the end of discrete water pulses, mostly in the winter season (Vidiella and Armesto, 1989). As water becomes limiting, these plants die, leaving a seed bank for the next favorable period. This strategy makes such species “stress-avoiders” with respect to summer drought in the broad sense (Slatyer, 1967) although variability of functional strategies is particularly high in this biogeographical area (Armesto et al., 1993).

Dominant shrub species in semiarid Chile are evergreen (i.e. *P. chilensis*) or drought-deciduous (e.g., *A. bedwellii* and *P. cuneifolia*) and have dimorphic root systems that passively mobilize water from shallow horizons during winter (Muñoz et al., 2008). Less is known about whether specific morphological-functional features of shrubs are related to shifts in the balance of their interactions with annuals. Perhaps most notably, the three shrub species selected provide very different levels of shading. According to the foliage density and Plant Area Index (PAI) the three shrub species can be arranged as follow from highest to lowest PAI: *P. chilensis*, *A. bedwellii* and finally *P. cuneifolia* (Tracol et al., 2011). Additionally, *A. bedwellii* is a N-fixer which could contribute to soil nutrients and enhance the performance of herbaceous plants (Aguilera et al., 1999).

2.3. Sampling design

We selected 3 individuals of each shrub species (*A. bedwellii*, *P. chilensis*, *P. cuneifolia*) and 3 representative open areas nearby in 4 random plots in the study area (Quebrada de las Vacas). It is important to note that shrub individuals, as well as nearby open areas, were different in each sampling year to avoid potential legacy

Download English Version:

<https://daneshyari.com/en/article/4392759>

Download Persian Version:

<https://daneshyari.com/article/4392759>

[Daneshyari.com](https://daneshyari.com)