Tree and grazing influence on herbaceous pasture diversity in the Dehesa agroforestry system

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Abstract

Mediterranean Dehesas are one of the European natural habitat types of Community interest (43/92/EEC Directive), associated to high diversity levels and producer of important goods and services. In this work, tree contribution and grazing influence over pasture alpha diversity in a Dehesa in Central Spain were studied. We analyzed Richness and Shannon-Wiener (SW) indexes on herbaceous layer under 16 holms oak (*Quercus ilex* ssp *ballota* (Desf.) Samp) trees (64 sampling units distributed in two directions and in two distances to the trunk) distributed in four different grazing management zones (depending on species and stocking rate). Floristic composition by species or morphospecies and species abundance were analyzed for each sample unit. Linear mixed models (LMM) and generalized linear mixed models (GLMMs) were used to study relationships between alpha diversity measures and independent factors. Edge crown influence showed the highest values of Richness and SW index. No significant differences were found between orientations under tree crown influence. Grazing management had a significant effect over Richness and SW measures, specially the grazing species (cattle or sheep). We preliminary quantify and analyze the interaction of tree stratum and grazing management over herbaceous diversity in a year of extreme climatic conditions.

Keywords: Mediterranean grazing, Richness, Shannon-Wiener index, Generalized linear mixed models, Linear mixed models, tree-grass interaction.

Introduction

Mediterranean Dehesas are one of the European natural habitat types of Community interest (43/92/EEC Directive) and, nowadays, they are a magnificent example of High Nature Value Farmland (Hoogeveen *et al.*, 2004). Dehesas are associated to high diversity levels and producers of important goods and services. The tree presence plays an important role within these ecosystems. On their canopy and roots influence area, trees can change species composition, herb layer structure, spatial distribution and biomass (Scholes and Archer, 1997). Trees create a softer microclimate (less thermic and humidity variations) beneath their crowns (Ludwig *et al.*, 2001). In addition, they provide shelter for livestock and wildlife that concentrate around trees and can have an important role in fertility distribution through dung deposition and grazing species selection at the ecosystem (Treydte *et al.*, 2009). The essential objective of Dehesa management and production is extensive livestock breeding (Olea and San Miguel, 2006); hence it is important to consider management decisions over tree-grass interaction in the ecosystem dynamics and functional studies, being aware that Dehesa management also depends on socioeconomic policies. In this work, we attempt to analyze

how tree contribution (through the study of the below-crown herbaceous species) and grazing influence (considering different grazing species and stocking rates) modify alpha diversity in a Dehesa.

Materials and methods

The study area is sited in a typical dehesa in Central Spain (39ºN, 5ºW), 350 m asl. The climate is continental Mediterranean. Soils are sandy (>80% of sand), acidic, and poor in organic matter (<1%). Sixteen holm oaks were selected for the study, distributed in two different grazing management zones (cattle or sheep grazing species) with two different stocking rates (medium or intensive). At each tree, 4 sampling frames were located (50 x 50 cm), considering two positions according to the proximity of the trunk (Distance; 0.5 radius or 1 radius -edge of the crown-) in two directions (Orientation: northeast and southwest). In total, 64 sampling units were studied. Floristic composition by species or morphospecies and species abundance were analyzed for each sample unit. Richness and Shannon-Wiener (SW) indexes were calculates. Generalized linear mixed models (GLMMs) and linear mixed models (LMM) were used to study relationships between alpha diversity measures and independent factors (grazing species, stocking rate, distance and orientation). The model approach in Zuur *et al*. (2009) was used for each alpha measure. The models with the best Akaike's Information Criterion (AIC, (Sakamoto *et al*., 1986) were selected from all, namely the models have less delta than 2 (Table 1). For data processing, analysis and presentation of results was used R programming environment (Version 2.14.1, R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org).

Results and discussion

The holm oaks selected for the study have mean (standard deviation) canopy radio of 6.8 m (1.3). Treydte *et al*., (2009) show that only large trees have an effect over understory; in our case, tree size was sufficient to provoke differences on herbaceous composition under the crown, even in an extremely dry year (298,1 mm, 50% lower than average rainfall of the last 20 years in farm), when the tree-climate interaction can have a very strong influence. Edge crown zone showed the highest values of Richness and SW index (P = 0.0178 and P = 0.0108) (Fig. 1). Edge crown has higher light availability than zones below the crown and allows the presence of light demanding species (Marañón and Bartolome, 1993). For the year of the study, no significant differences were found between orientations under tree crown influence. Grazing management had a significant effect over Richness and SW measures (P = 0.00185 and P = 0.0107) (Fig. 2), specially the grazing species (cattle or sheep). In this study area, sheep zone provide lower values of alpha diversity below canopy, especially when stocking rate is medium (P=0.0071). We did not find differences between stocking rates levels at the cattle grazing zones.

Table 1. Models with the best Akaike's Information Criterion (delta<2) of richness and SW index related with other variables in the analysis of alpha diversity. AIC=Akaike's Information Criterion.

Alpha measure	Explanatory variables	AIC (top models)	Delta
Richness	Distance + Management + (1|Tree)	57.21	0.00
	Distance + Management + Orientation + (1|Tree)	57.73	0.52
Shannon Wiener	Distance + Management, random=~1|Tree	112.01	0.00
	Distance + Management + Orientation, random=~1|Tree	113.85	1.84

The tree random effect scarcely modifies the alpha diversity average among trees.

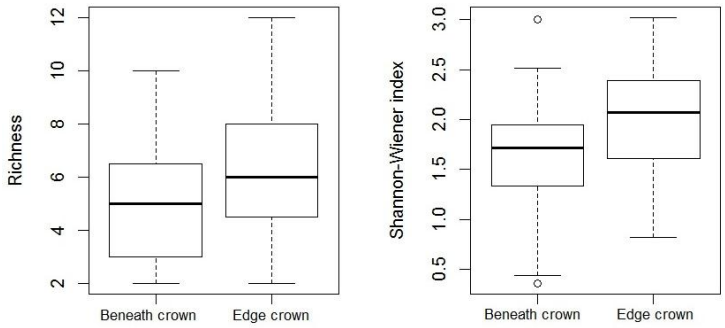

Figure 1. Alpha diversity variation according distance to the trunk

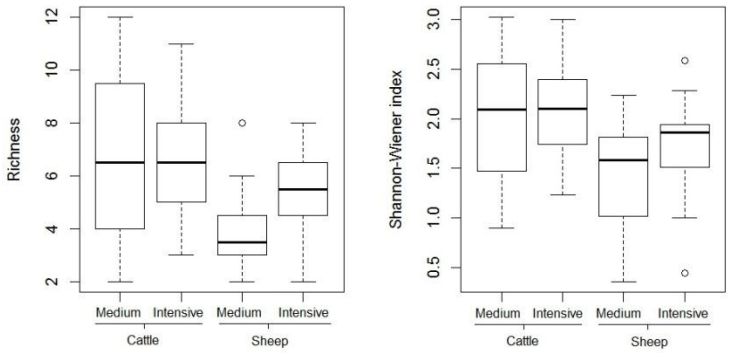

Figure 2. Alpha diversity variation according grazing species and stocking rate.

Conclusion

We quantified and analyzed the tree effect on herbaceous species alpha-diversity in a typical dehesa of Central Spain in a very dry year. Richness and SW index were higher at pastures under the edge crown, at any orientation. Management practices, through the combination of grazing species and stocking rate, also had a significant influence on alpha-diversity.

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References

Hoogeveen Y., Petersen J.E., Balazs K. and Higuero I. (2004). *High Nature Value Farmland - Characteristics, Trends and Policy Challenges in EAA Report*. 1/2004, ed. Agency, E.E.

Ludwig F., Kroon H., Prins H.H.T. and Berendse F. (2001). Effects of nutrients and shade on tree-grass interactions in an East African savanna. *Journal of Vegetation Science* 12, 579-588.

Marañón T. and Bartolome J.W. (1993). Reciprocal transplants of herbaceous communities between Quercus agrifolia woodland and adjacent grassland. *Journal of Ecology* 81, 673-682.

Olea L. and San Miguel A. (2006). The Spanish dehesa. A traditional Mediterranean silvopastoral system linking production and nature conservation. *Grassland Science in Europe* 11, 3-13.

Sakamoto Y., Ishiguro M. and Kitagawa G. (1986). *Akaike information criterion statistics*, Dordrecht: D.Reidel, The Netherlands, 290 pp.

Scholes R.J. and Archer S.R. (1997). Tree-grass interactions in savannas. *Annual Review Ecology, Evolution and Systematics* 28, 517-544.

Treydte A.C., Grant C.C. and Jeltsch F. (2009). Tree size and herbivory determine below-canopy grass quality and species composition in savannahs. *Biodiversity and Conservation* 18, 3989-4002.

Zuur A.F., Ieno E.N., Walker N.J., Saveliev A.A. and Smith G.M. (2009). *Mixed Effects Models and Extensions in Ecology with R*. Springer, New York, USA 574 pp.