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Grassland diversity in the Mediterranean zone of Chile is greatly affected by land use system and grazing intensity

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SUMMARY – The anthropogenic savannas ("Espinales") represent the most widespread agro-ecosystem of the Mediterranean area of central Chile. It presents a complex and heterogeneous, savannas-like structure, with herbaceous and woody strata. The intensive land use of the "Espinales" has reduced the woody cover (mainly *Acacia caven*) affecting the herbaceous vegetation. Grassland communities were studied in 29 plots of 1000 m², with a wide range of woody cover and geomorphologic situations. The effect of grazing intensity was studied in a long-term experiment of seven stocking rate treatments (1 to 4 sheep ha/year). At any woody cover, grasslands were dominated by grasses followed by composites. The relative abundance of legumes was very low. The relationship between woody cover and grassland diversity (Shannon index) was unimodal in flatland areas. Grazing intensification had large effects on the structure of grassland. As grazing intensity increased grassland diversity decreased; composites became the predominant family in detriment of grasses. Legumes were usually scarce and were not affected by grazing intensity. The overgrazed community allows higher native species richness than exotic ones, possibly due to the greater defence traits against herbivores of this group of species.

Keywords: Espinal, herbaceous vegetation, Shannon index, stocking rate, woody cover.

RESUME – "La biodiversité des pâturages dans la zone méditerranéenne du Chili est affectée par le système d'utilisation de la terre et par l'intensité de pâturage". Les savanes anthropiques ("Espinales") représentent l'écosystème agricole le plus répandu de la région Méditerranéenne du Chili. Il présente une structure complexe et hétérogène, de type savane, avec des strates herbacées et ligneuses. L'utilisation intensive des terres des "Espinales" a réduit le couvert ligneux (principalement *Acacia caven*), affecté la composition et diminué la productivité de la végétation herbacée. Des communautés herbacées ont été étudiées dans 29 parcelles de 1000 m², avec une large gamme de couverture boisée et situations géomorphologiques. L'effet de l'intensité du pâturage a été étudié dans le cadre d'une expérience de longue durée avec sept niveaux de charge animale (1 à 4 moutons hectare⁻¹ an⁻¹). Dans tous les cas de couvert ligneux, les pâturages présentaient une prédominance des graminées suivies par les composées. L'abondance relative des légumineuses était très faible. La relation entre la couverture ligneuse et la diversité des pâturages (indice de Shannon) était unimodale dans les zones planes. L'intensification du pâturage a des effets marqués sur la structure du pâturage : plus le pâturage augmente et plus la diversité floristique des prairies diminue. Les composées sont devenues la principale famille dominante au détriment des graminées. Les légumineuses déjà rares initialement, n'ont pas été affectées par l'augmentation du pâturage. La communauté surpâturée permet de maintenir une richesse plus élevée que les espèces natives, peut-être à cause des plus fortes caractéristiques de défense contre les herbivores de ce groupe d'espèces.

Mots-clés : Espinal, charge animale, couverture boisée, indice de Shannon, végétation herbacée.

Introduction

The predominant vegetation formation in the sub-humid area of the Mediterranean-type climate region of Chile is an anthropogenic savannas called Espinal, dominated by the spiny, stump-sprouting legume tree, *Acacia caven* ("espino"). The herbaceous strata have a high diversity of annual (native and exotic) and perennial (mostly native) species (Ovalle *et al.*, 1990; Sax, 2002). The traditional land use systems consider continuous grazing of grassland and cutting of *A. caven* every 40-60 years for charcoal in flatlands, and itinerant rotation with cereal crops in hillsides (Ovalle *et al.*, 1990; Ovalle *et al.*, 1996). In flatlands the continuous grazing (and the lack of cropping) allows the development of higher cover of *A. caven* and better soil conservation (Ovalle *et al.*, 1996), but on hillsides where the

pasture-crop rotation is frequent, the "Espinales" are in general more degraded and present lower cover of *A. caven*, greater water erosion and soil nutrient depletion. In both physiographic positions, *A. caven* trees are periodically cut but the disturbed areas recover their woody cover with time.

The intensive land use of the "Espinales" for grazing, charcoal or cropping reduce woody cover, which has negative effects on biomass production of grassland and on the stocking rate capacity (Ovalle *et al.*, 2006). The overgrazing has also negative impacts on grassland productivity and sustainability (del Pozo *et al.*, 2006). Here, we present results on the effects of woody cover and grazing intensity on the relative abundance of main families, and plant diversity (Shannon index).

Material and methods

The studies were conducted in the subhumid portion of the Mediterranean climate region of Chile. The area was located near the Experimental Center of Cauquenes-INIA (35°58'S, 72°17'W); 140 m a.s.l.), VII Region, in the eastern part of coastal mountain range. Long term average of the minimum temperatures of the coldest month (July) is 4.8 °C and of the maximum temperatures of the warmest month (January) is 29 °C. Mean annual rainfall is 695 mm. Fire occurs sporadically in the area and is not used as a management tool.

Effects of woody cover

Twenty nine plots of 25 x 40 m² were selected. They involved five different woody cover classes (0-10%, 11-25%, 26-50%, 51-75% and 76-100%, consisting mainly of *A. caven*), occurring on hillsides or flatlands. Hillsides corresponded to well-drained areas with slopes greater than 10% and flatlands to plain areas occasionally inundated during winter. In each plot, cover of the woody strata (trees and shrubs) was estimated from cartography of the vegetation on a scale of 1:200. A point quadrat survey of the vegetation (Daget and Poissonet, 1971) was carried out in each sampling unit in spring (October-November). Species abundance (only herbaceous species) was evaluated as the relative frequency of contacts every 4 cm in three lines of four meters in length, within the plot. At each point the number of hits for each species was recorded. The total number of hits per species in the five transects was divided by the total number of hits for all species to give a relative frequency measure of abundance for that species in the plot.

Effects of grazing intensity

Seven stocking rate treatments, 1, 1.5, 2, 2.5, 3, 3.5 and 4 sheep ha⁻¹ year⁻¹ (Suffolk Down breed) were established in 32 ha. To obtain the desired stocking rates, the area was fenced in seven rectangular plots with sizes ranging from 10 ha for the lowest rate to 2.5 ha for the highest one. In each plot 10 sheep (2 individuals of 2, 3, 4, 5 and 6 years old) were placed for continued grazing along the whole year. Every year, six-year-old sheep were replaced by two-year-old ones of similar weight (45-48 kg live weight per animal), in order to maintain the age structure of the flock. The treatment of 4 sheep ha⁻¹ year⁻¹ needed additional food to maintain this stocking rate and was not considered in this analysis. Therefore, 3.5 sheep ha⁻¹ year⁻¹ represented the maximum stocking rate that can support this system. The study was conducted during eight years. For vegetation surveys, each plot was divided in five sampling units according to the structure and composition of the plant community, determined by cartographic analysis of the vegetation on a scale of 1:200. Presence/absence of herbaceous plant species was recorded every 4 cm along a 4 m permanent transect and the species abundance calculated.

Results and discussion

Grassland communities were dominated by grasses followed by composites particularly on flatlands (Fig. 1a). Grazing intensity had a strong effect on the relative abundance of grasses and composites; as stocking rate increased composites became the predominant species in detriment of grasses (Fig. 1b). Legumes were usually scarce in these grasslands and seem not to be affected by

grazing intensity, neither by woody cover. Probably, the low phosphorus availability of these soils is limiting the relative abundance of legumes (del Pozo *et al.*, 1994).

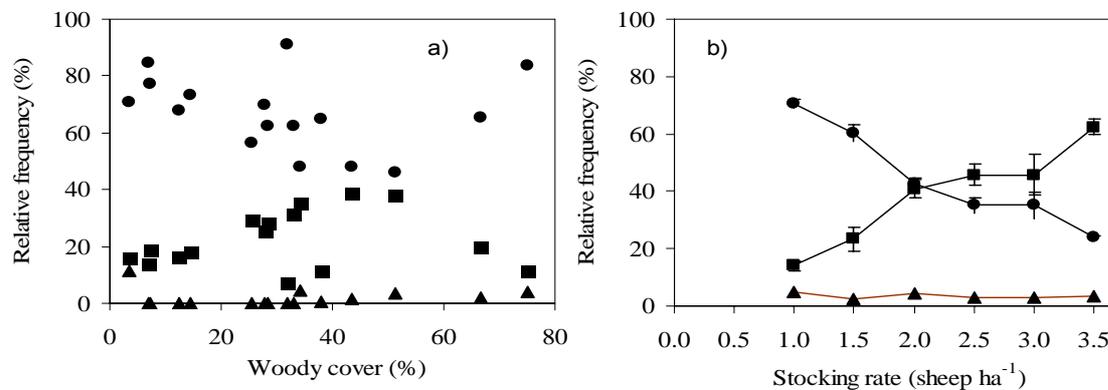


Fig. 1. Relative frequency of grasses (●), composites (■) and legumes (▲) as affected by woody cover in flatlands (a) and stocking rates (b). In b) values are mean of the 3rd, 4th, 6th, 7th and 8th growing seasons.

Plant diversity showed a unimodal relationship with woody cover in flatlands but not in hillsides (Fig. 2a). In areas of low woody cover and therefore with recent land perturbation (ploughing or tree cutting), the characteristic species were *Avena barbata*, *Taeniatherum caput-medusae* and *Aira caryophyllea* (Ovalle *et al.*, 2006). In areas of high woody cover, grasslands were strongly dominated by *Lolium multiflorum* (Poaceae), and this explains the decline in plant diversity at high woody cover.

With increasing grazing intensity plant diversity decreased significantly (Fig. 2b). At high grazing pressure grasslands were dominated by *Leotodon leysseri* (Asteraceae); the abundance of the more palatable species decreased (e.g. *L. multiflorum*) and they are replaced by less palatable and nutritive ones, like *L. leysseri*. This is also small-size specie with leaves in a basal rosette, attributes that favour protection against herbivores (Lavorel *et al.*, 1997).

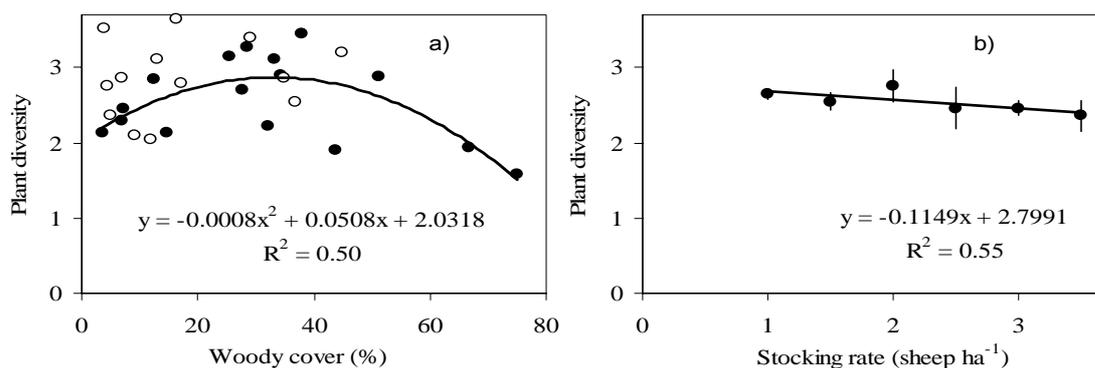


Fig. 2. Plant diversity as affected by woody cover (a) and stocking rates (b). In (a) flatlands (●) and hillsides (○) are shown.

The abundance of exotic plants was far superior to native ones independent of the stocking rates. However, the species richness of native species increased with grazing intensity (del Pozo *et al.*, 2006); higher grazing intensity results in a 5-10% of bare soil gaps, thus generating more opportunities for colonization of small size plants, of both introduced and, specially, native species.

Native species tend to be small-size annuals with low palatability in comparison with the introduced ones, and probably better defensive mechanisms against herbivores based on plant architecture (size, location of leaves, growth form, etc.) and chemical defenses (i.e. low palatability).

Conclusions

Land use system and grazing intensity have a great impact in the structure and diversity of grassland communities in the Mediterranean area of central Chile. The intensive land use of the "Espinales" have reduced woody cover (mainly *Acacia caven*) affecting the herbaceous vegetation. In flat land areas, the maximum value of herbaceous diversity is attained at medium woody cover (around 40%). As grazing intensity increase over 1 sheep ha⁻¹ grasses are replaced by composites and plant diversity is reduced significantly. However, the overgrazed community allows maintaining higher native species richness than exotic ones, possibly due to greater defense traits against herbivory of this group of species.

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