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Vegetation Response to Grazing Pressure in the Puna Flat, NW Argentina

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Vegetation response to grazing pressure in the Puna flat, NW Argentina.

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Key words: Puna grasslands, Grazing Pressure Index, Plant Functional Types

Abstract

Puna grasslands are located at a high-altitude flat plateau in the Northwest of Argentina. It is an arid territory (100 to 300 mm rainfall/year) at 3,000 to 4,000 m a.s.l. The vegetation is scarce, where Andean pastoralist communities produce meat and wool, specialized in llama (*Lama glama*) and sheep-breeding, although they do breed multi-species herds that may also include goats and cattle. There are erosion processes in the Puna, where shepherds and their animals could be synergetic factors with natural very hard climatic conditions. In this work we assess the effect of ovine and lama grazing on the plant communities in the Puna grasslands.

Considering that stockyards are used in a very complex way along the year, having differences between those used in winter or in summer, or used for many months or only one month, etc. we built up a Grazing Pressure Index taking in account all these factors in each sampling point. We sampled 28 paired transects (14 in sites with high grazing pressure, and 14 in sites with low grazing pressure) in 2 different ecological sites (grassy grassland and shrubby steppe). Focusing our work on the community functionality, we analysed Plant Functional Types (PTF) measuring their cover, richness and diversity. Our results do not show significant differences on PFT cover, richness or diversity between sites at different grazing pressures. It could be the result of a low grazing pressure or a long grazing pressure history that had configured the TFP associations.

Introduction

Puna grasslands are located at a high-altitude flat plateau in the Northwest of Argentina, near the Cordillera de los Andes (Turner and Mon 1979; Hong et al. 2018). It is an arid territory (100 to 300 mm rainfall/year) at 3,000 to 4,000 m a.s.l. (Cabrera 1957), included into the "Dry Puna Type" (Carilla et al. 2018). The vegetation is scarce, dominated by a shrubby steppe, where Andean pastoralist communities produce meat and wool, specialized in llama (*Lama glama*) and sheep-breeding, although they do breed multi-species herds that may also include goats and cattle (Quiroga Mendiola and Cladera 2018).

Some approaches in ecology state that a disturbance like grazing pressure on arid ecosystems should cause negative changes on landscapes like erosion and plant species loss. Usually the recommendations to prevent soil erosion and plant species loss are based on livestock reduction. A more complex standpoint is used here to better understand the relationship between pastoralism and natural vegetation in the Puna of NW Argentina. In this work we aimed to study the relationship between grazing pressure and the natural grasslands status. We assess the structure and cover of plant functional types assembles in relation with (1) the proximity from grazing shelter and (2) a grazing pressure index (GPI) estimated taking into account many variable strategies that families have in accord to their field condition: water availability, relief, vegetation, exposition, seasons, frost time and main winds, etc. and plus, the communal land that is ruled by their own use agreements.

Study Site and Methods:

This study was carried out in Suripujio, a little aboriginal herder's community in Yavi Jujuy Province, NW Argentina, close to Argentina-Bolivia's frontier. Natural grasslands are managed through short transhumance changes between two different ecological sites (ES). These are the so-called "Ciénego" (a high altitude grassy grassland with permanent or semipermanent water fluxes) and the "Tolar" a dry steppe with patchy vegetation, dominated by short shrubs (*Baccharis* sp and *Fabiana* sp). Each family has several stockyards inside each ecological site, and makes varied movements ruled by many different environmental, climatic or socio-economic criteria (Quiroga Mendiola 2015).

In order to capture ecological functionality changes, we utilized Plant Functional Types (PFT). This approach is appropriate to understand ecological functionality of an ecosystem (Díaz et al. 2002). We collected and identified all the species present in the study site. Each species identified was described in accord of 11 principal vegetation traits that results from arid environments and grazing pressure (Cornelissen et al. 2003). We used 8 plant traits: bioform (herbaceous dicots; graminoids; etc.); life cycle (annuals or perennials); Raunkiaer life form; plant growth form (short basal; erect leafy; pulvinate; etc.); plant height; clonality; spinescens and pubescence; and 3 leaves traits: presence/absence; longevity (perennial or deciduous) and sclerophylly. We applied hierarchical clustering analysis, using a final matrix of 71 species, 11 traits (Standardized data and Average Linkage with Euclidean distance, INFOSTAT 2007).

1) First we tested vegetation response in relation with the proximity of grazing shelter, assuming that in far samples grazing pressures are lower than in near samples.
2) Then we built one Grazing Pressure Index using 8 variables taking into account that herders use ecological sites in many different ways: *Occupancy*: there are shelters abandoned many years ago, so we state 7 occupancy ranges from not occupied more than 20 years=1, to actually occupied = 7. *Season of Use*: Spring and Autumn are critical seasons for natural grasslands, so the values assigned were: Summer/ Winter= 1; Autumn/Spring= 2. *Season length use* (Number of days). *Number of animals per species*: Ranges 1 to 7 (less than 50 to more than 300 individuals). *Livestock species*: sheep is an exotic species (value=1), instead the native *Lama glama* is considered better adapted to the Puna grasslands (value=0.5). *Number of field rests along the year* (or number of movements between stockyards): there are 2 to 6 movements depending on the diverse families´ strategies. All this information was collected in land through walking in field interviews.

Grazing Pressure Index (GPI) on each sample point is= Grazing Pressure Rate /$\log_{10}$stockyard distance; where Grazing pressure rate= A/f, and A= [a (b*c) * (d*e)] +1.

We sampled 14 paired transects of 30 m length (7 in sites at high grazing pressure 100 m stockyard distance, and 7 at 700 m stockyard distance, that means, low grazing pressure) on each ecological site ("Ciénego" and "Tolar"). On each transect we measured lineal cover of each species, rocks, mulch or feces (Matteucci and Colma 1982). Field work was carried out at the middle to end of summer, when vegetation is in their better expression. We analysed each Ecological Site separately and considered only these PFT that were well represented in each site (PFT cover ≥ 10%). We explored cover variation at low and high grazing pressure (shelter proximity), using Wilcoxon test for paired samples. We explored the GPI using generalized linear models (GLM). We used Binomial distribution of errors for percentage variables, and Poisson distribution for counting variables. We used the *compare_mean* function of ggpubr package (Alboukadel Kassambara, 2020), the glm function, package and the Tidiverse package (Wickham et al., 2019) of free program R 4.0.0 (R Core Team, 2020).

Results

We found 8 Plant Functional Types: TFP1: succulent prickly plants, (Cactáceas); TFP2: aphylle shrubs; TFP3: shrubby phanerophytes, perennial leaves and dissemination by seeds; TFP4: shrubby nano phanerophytes, sharpy bracts, dissemination by seeds; TFP5: shrubby clonal phanerophytes, perennial leaves; TFP6: herbaceous dicots, short basal growth, sclerophyllous deciduous leaves, pubescent, sharpy bracts, non-clonal; TFP7: herbaceus, grasses and graminoids, long-lived, hemicryptophytes, tussocks, deciduous leaves without thorns, glabrous, rhizome or seed dissemination and TFP8: herbaceous dicots, hemicryptophytes, camephytes o therophytes, short basal growth, dissemination by seed or stolons not prickly and glabrous.

Ciénego has a total cover around 70%, dominated by TFP7 (67% of total cover) and TFP8 (33%). Tolar total cover is 50%, and it is more diverse: TFP8 (42%), TFP5 (27%) TFP3 (14%) and TFP7 (11%).

1) Grazing pressure and PFT richness and cover in plots near and far from shelters: Total cover, PFT richness, TFP7 (grasses and graminoids) and TFP8 (herbaceous dicots) cover did not show significant differences in far and near transects in Ciénego (Fig.1 a, b, c y d). Also TFP2 (very palatable species) didn´t show significant differences between near and far samples (Fig. 1 e). In Tolar total cover had a slight tendency of being lower at far than near samples (Fig. 2a), while PFT richness and PFT7, PFT8, PFT3 y PFT5 cover did not show significant differences (Fig. 2 b-c- d-e- f).

2) Relation GPI/PFT cover and richness: Total cover was linearly and positively related to GPI in Ciénego (Fig. 3a), and diminishes at intermediate GPI values in Tolar (Fig. 4a). PFT richness was not related to grazing pressure in both ecological sites (Fig.3b and Fig. 4b). In Ciénego dominants PFTs and PFT2 are not affected by changes in GPI (Fig. 3 c-d-e). There are no significant effects in Tolar by GPI augmentation for PFT7 cover (Fig. 4c), while the lower PFT8 cover was registered at intermediate pressures (Fig. 4d). PFT3 (non-clonal shrubs) cover shows a slight tendency to diminish with GPI augmentation, and TFP5 (clonal) cover decreases with GPI increase (Fig. 4f).

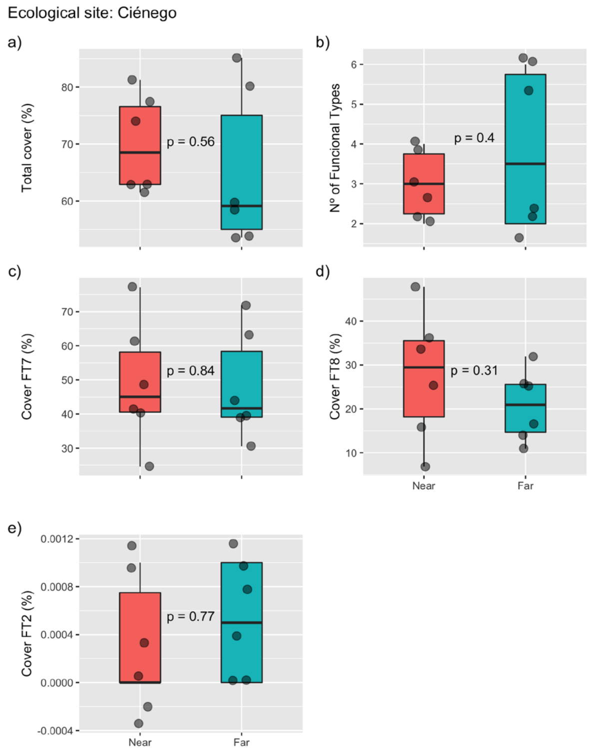

Figure 1: Total cover, PFT richness, and dominant PFT cover between samples near and far shelters in Ciénego.

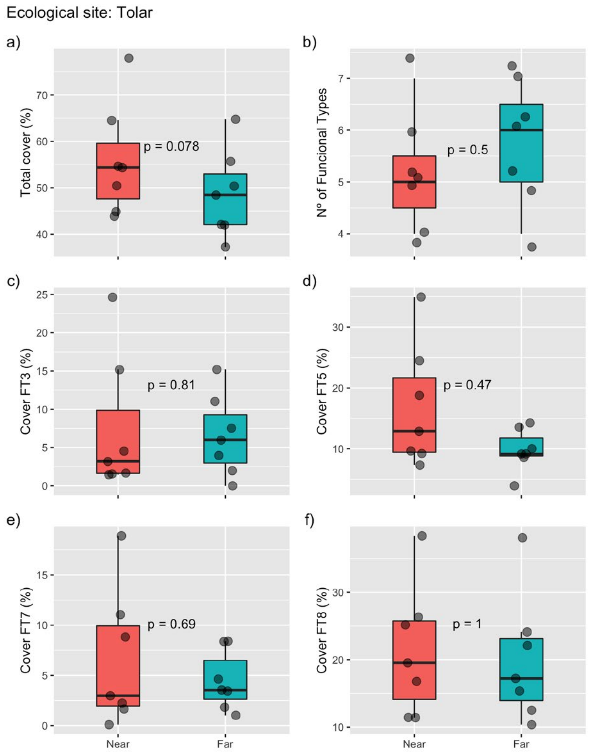

Figure 2: Total cover, PFT richness, and dominant PFT cover between samples near and far of shelters in Tolar.

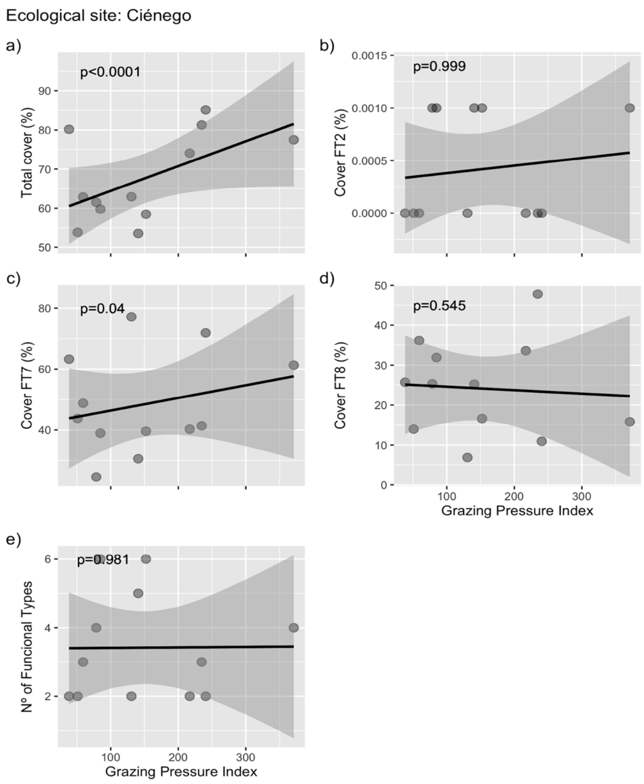

Figure 3: Total cover, PFT richness, PFTs in relation to the grazing pressure index in Ciénego.

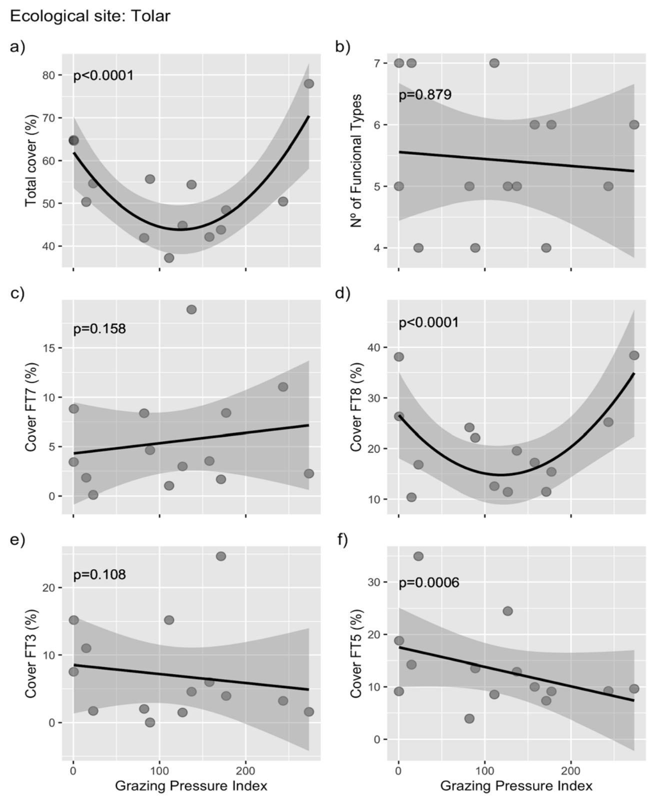

Figure 4: Total cover, PFT richness, PFTs in relation to the grazing pressure index in Tolar.

Discussion

In grassy grasslands total cover and grasses, graminoids and herbaceous dicots cover increases at higher grazing pressures. It could be explained because of the effects of organic fertilizer (feces) and soil removal by livestock, creating microsites for regeneration. Besides, it could be expressed as a kind of co-structuration (Pucheta et al. 1997; de Knegt et al. 2008), called by Andean aboriginal cultures “mutual-breeding” between pastures and livestock (Rengifo Vazquez 2003). Clonal and non-clonal shrubs cover diminish with grazing pressure increase, evidencing the sensibility of these shrubs to anthropic action, probably most by their uses as firewood than by livestock herbivory. Future studies are possible to separate firewood extraction and grazing. In general, our results do not show very significant differences in PFT cover and richness between sites at different grazing pressures. It could be the result of a low grazing pressure or of a long grazing pressure history that had configured the TFP assemblage and cover (Pucheta et al. 1997). The long term of co-structuration of pastures and flocks could be actually at a kind of equilibrium probably well managed by local aboriginal herders, through a heritage of ancient knowledge about environment, livestock and economy.

It was very useful the Grazing Pressure Index, because it allowed us to detect more changes and variability of responses than the near/far methodology. Plus, GPI is probably more accurate to the real conditions of range management.

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