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Cattle-Breeding Valley Plains and C_4 Spontaneous Grasses in North Patagonia

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Abstract: The climate of North Patagonia (Argentina) is semiarid and the region periodically suffers severe droughts that may last several years, decreasing forage offer and consequently cow livestock and productivity. In most of the cattle fields extensive grazing is usually continuous through the year-long. The absence of pasture rotational schemata affects rangeland health changing the composition of plants communities in detriment of the valuable species. When under a severe drought, the appreciated forage *Leptochloa crinita* (= *Trichloris crinita*) stopped reproduction and the population became scarce, a grazing schedule was designed in a cattle farm to avoid foraging during spring and summer in a paddock located in the valley plains, where the species was disappearing. Besides *L. crinita* populations, the sympatric presence of the Poaceae *Aristida mendocina*, *Distichlis spicata* and *Distichlis scoparia* is expected, each one in slightly different patches within the same area. The forage value differs between species but all of them are eaten by bovines. For ten years the plant communities were studied with the aims of determining the incidence of the patches on the paddock carrying capacity in early autumn and estimating the contribution of the four C_4 species to bovine diet by microhistology. Free of grazing during its growing period, *L. crinite* enhanced the area of its patches and the biomass production of its good quality forage and was consumed preferently. *A. mendocina* is not prized by cattle but contributed to the diet at the end of the foraging period. *Distichlis* spp. is important component of the cows' diet, especially in dry years. Management actions to preserve a valuable species may have side effects involving other community members.

Key words: Bovine diet, C_4 grasses, patches, management.

1. Introduction

The vegetation in the of Mid Valley plains in Río Negro, North Patagonia (Argentina) is an association of shrubs with herbaceous and the composition and plant cover of the communities varies [1, 2] depending mainly on the annual precipitation regime and on the grazing management. The rain interannual and interseason variability is high in this semiarid zone and severe drought may happen during several years, as the one that suffered from 2007 to 2014.

Extensive grazing is usually continuous through the year-long in the breeding fields with no dynamic manipulation of animal number based on the carrying capacity. Under these regimes of cattle use some valuable species as *Leptochloa crinita* (= *Trichloris crinita*) tended to disappear from the no-irrigated valley fields (Klich and Peralta, sent for publication).

The forage grasses characterized by a C_4 photosynthetic metabolism have their production concentrated in summer, they need soil humidity but are tolerant to certain drought, are efficient in the use of water and nitrogen, they have a high potential for DM (Dry Matter) production and the nutritional quality necessary to meet the demands of breeding cows. With the aims of increasing *Leptochloa crinita* (= *Trichloris crinite*) populations in the driest area of the valley plains, a grazing schedule was designed to avoid foraging during spring and summer [3]. While protecting the valuable C_4 forage grass by preserving the reproductive period from grazing, there were changes in the populations of other three C_4 species. The characteristics and simultaneous growth changes

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of *Leptochloa crinita*, *Aristida mendocina*, *Distichlis spicata* and *Distichlis scoparia* were studied and the patches areas and their biomass evaluated to determine the incidence of the C_4 plants on a paddock' production.

Grazing management schedules must be based on the knowledge of the forage offer. In cattle fields, livestock rotations require to preserve and even improve the valuable spontaneous grass populations. The results presented in these publications demonstrate that even when anthropogenic decisions are focused in increasing the well-known appreciated forage species in a specific zone, there are always side effects that might include the increment of other species that may be not so treasured but that can help to improve the forage offer of the parcel as a whole.

2. Material and Methods

2.1 Study Site

The research was carried out in a cattle-raising field on natural pastures in the Middle Valley, on the north boundary of the Río Negro, near the town of Choele Choel (39°30' S; 65°30' W) in the Department Avellaneda, North Patagonia, Argentina.

An 86-hectare paddock sited in the ecological site defined as valley plain [2], edging the ecotone between valley and plateau, was destined for the research. The simultaneous growth changes of *Leptochloa crinita*, *Distichlis spicata*, *Distichlis scoparia* and *Aristida mendocina* were studied after a planned rotational schema released the C_4 from grazing during their vegetative and reproductive seasons and allowed their consumption after frutescence.

Historic climatic data were obtained from the National Institute of Agricultural Technology [3] and rain precipitation was recorded in the field. Soil texture was described for each patch and for the matrix. Salinity and fertility were analyzed at the LANAQUI (Chemical Analysis Laboratory) with an ICP-AES (Atomic Emition Spectrometer), Shimadzu ICPE-9000 in soil samples obtained at different units and deepness.

Using satellite maps, GPS (Global Positioning System) situations and field measurements each year determined the surfaces occupied by the parches where each C_4 species grows by the matrix. The vegetation communities of patches and matrix were defined identifying the edible herbaceous species and the characteristics shrubs.

2.2 Carrying Capacity Based on NPP (Net Primary Production)

Previous studies on vegetation richness [4] had demonstrated the sympatric presence of the C_4 Poaceae *L. crinita*, *D. spicata*, *D. scoparia* and *A. mendocina*, each one in four slightly different patches within the same area. The study of the populations, paddock carrying capacity and bovine consumption under autumn grazing schedules with breeding cows lasted 10 years, from 2011 to 2020. The carrying capacity at the paddock level was calculated as the average carrying capacity of the different patches or vegetation units and the matrix of the paddock. Using 0.50 m^2 quadrats, plant biomass was estimated after harvesting the plants at 3 cm from soil surface, separating the material in the different species and drying up to constant weight. Biomass data were used to calculate NPP by surface unit (hectare) in autumn (April). Patches' Harvest Index, established as the percent of annual NPP consumed by domestic herbivore, was adjusted with local consumption measurements by weighing 10 complete plants of each species, cut at 3 cm from soil surface when they were completely developed and then repeating the measurement in 10 other plants of each species, once they were consumed by the breeding cows and obtained the percent consumed for the C_4 species. The HI (Harvest Index) for the matrix was obtained as an average of consumption of the different plant components.

2.3 Feed Analysis

For each of the four forage species studied, determinations were made on spring and in autumn for

CP (Crude Protein), ashes, NDF (Neutral Detergent Fiber), ADF (Acid Detergent Fiber), ADL (Acid Detergent Lignin). Digestibility (D) and metabolizable energy were calculated.

2.4. Diet Microhistological Studies

Plant epidermal characteristics helped to identify the components in the fecal samples and confirm animal consumption [5]. The data were used to determine the preference of animals as the feces were analyzed a week after the cows entranced to the paddock. In feces samples obtained by the end of the grazing period it was possible to identify which are the less desirable plants that the animals consume when there are few options.

2.5 Statistical Analysis

Analysis of variance procedures was used to evaluate statistical differences between years of data sample. Calculated means were separated using Turkey test. Analysis was made using the programs Infostat v. 2017 and Excel from Microsoft 365.

3. Results and Discussion

The climate is cold temperate, semi-arid. The average annual precipitation was 303 mm and the rains during years 2006 to July 2020 are presented in Fig. 1 and show the interannual and interseason variation. The drought lasted from 2006 to 2014. Rains in 2012 surpassed mean values but occurred in the hot summer and were not much useful. Since 2014 annual rains exceed historic mean.

In the higher valley plains, the soils are alluvial, and some areas are occupied by relicts of river courses which suffer occasional flooding. Each of the C_4 species dominates patches in specific topographic/edaphic places. *Distichlis* spp. grows in the poorly permeable loamy lime soils, pH 8.5, EC (Electric Conductivity) of 4 Mmhos/cm and 1.05% OM (Organic Matter). These conditions are those of the depressed areas of old river courses mostly occupied by *D. spicata* while the presence of *D scoparia* is detected only in the borders. Surrounding the ancient river course in the area where *L. crinita* is usually present, the soil is sandy

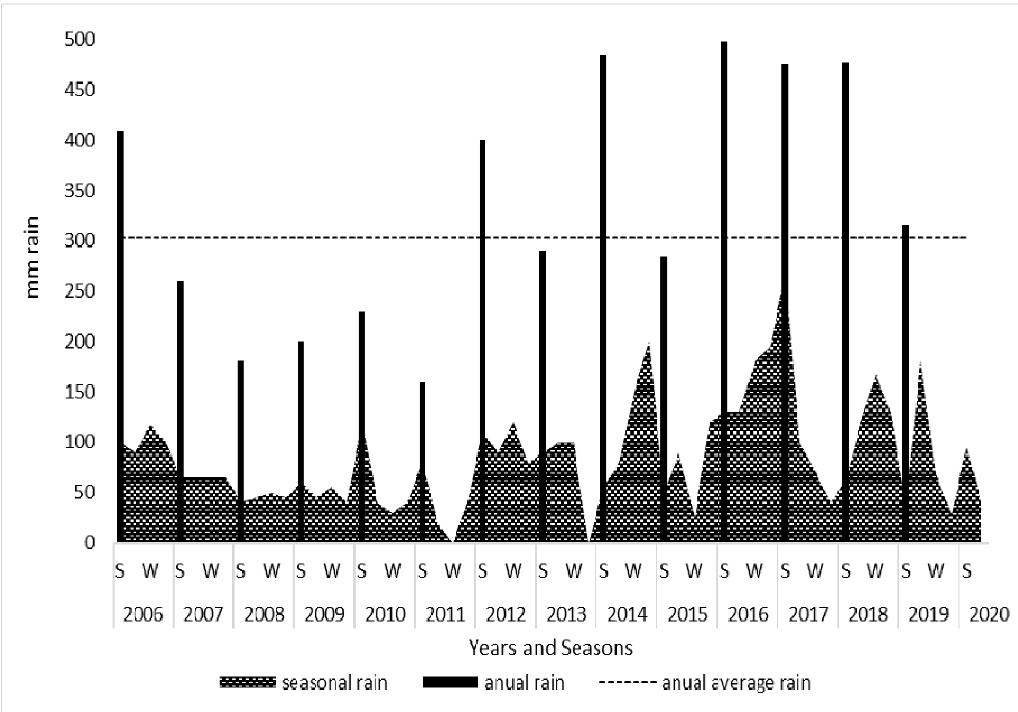


Fig. 1 Annual precipitations in the study area and their distribution along the seasons (S: summer, W: winter), compared to the historic mean of 303 mm.

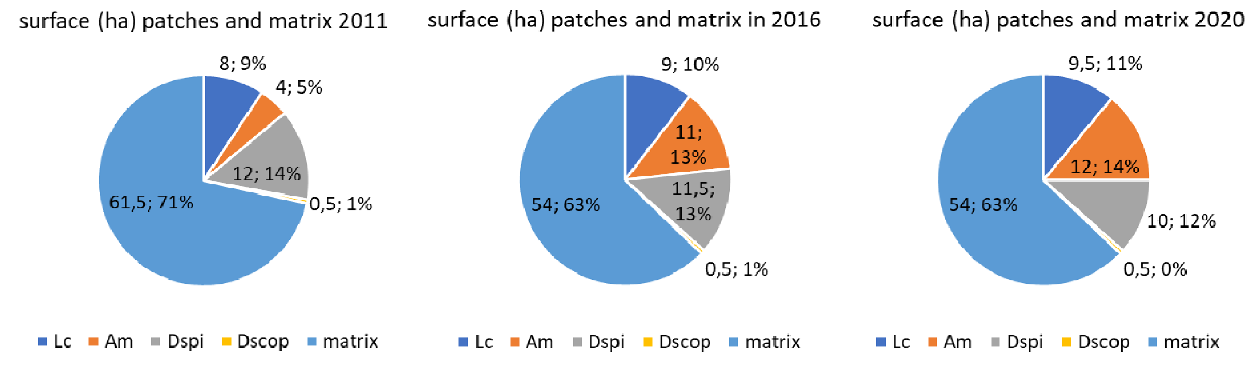


Fig. 2 Surface occupied by the patches with *L. crinite* (Lc), *A. mendocina* (Am), *D. spicata* (Dspi) and *D. scoparia* (Dcop) and by the matrix and percent of the complete area of the 86-ha paddock in 2011, 2016 and 2020.

loam, slightly alkaline (pH 8.3 to 8.8), EC less than 4 Mmhos/cm, no sodium or excess salt, with 0.5% to 1.2% OM. *A. mendocina* occupies the upper sandy area, pH 7.5 and 0.5% OM.

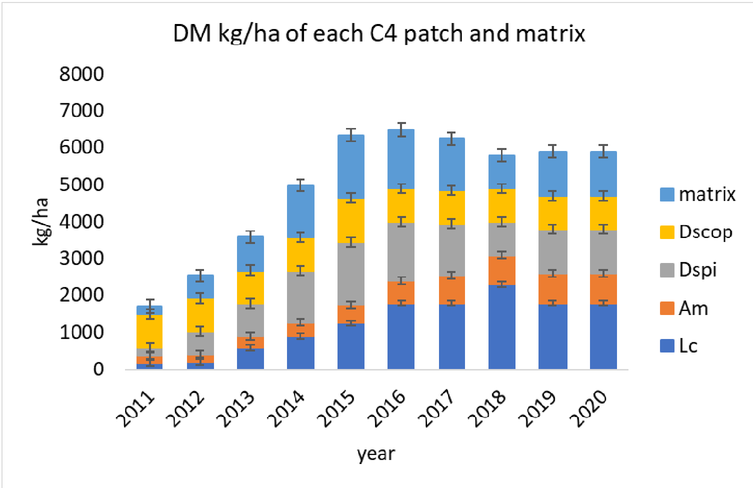
L. crinita and *A. mendocina* patches surface begun to increase after the second year free of spring and summer use and they enhanced more when the drought finished. The area of the patches occupied by the *Distichlis* spp. was not affected by drought or grazing management as this species is confined to the old river courses showing only small changes that fluctuate with soil humidity in the lowland areas. Fig. 2 shows the area of the patches and the matrix every five years and it can be appreciated that the sum of C_4 patches changes from 24.5 ha in 2011 to 32 ha ten years later, which means increment from 28.5% to 37% of the total paddock area of 86 ha. This change is mainly due to the increment in *A. mendocina* patch and to a lesser extent to *L. crinite* one.

HI for *L. crinita* is 90% as bovines consume nearly the totality of the foliage. *A. mendocina* has many curled leaves that remain in the plant after bovine harvest, so the average HI is 70%. *Distichlis* spp. is smaller plants that grows densely and produces between 1,700 and 2,000 DM kg/ha but that is consumed only up to 50%. The HI obtained for communities like those of the matrix is 60%.

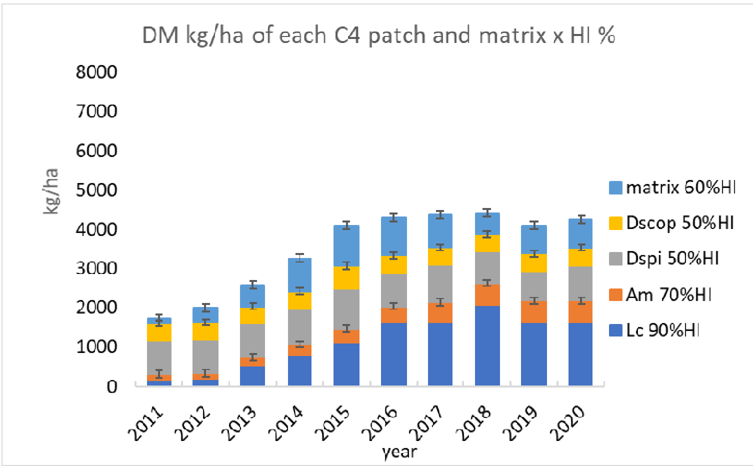
DM production per ha in each C_4 patch is presented in Fig. 3a as DM kg/ha produce each year. The total productivity was obtained for the area of each C_4 patch and the matrix and then the values were adjusted using the HI obtained for each case (Fig. 3b). The results in Fig. 4 show the contribution of each patch to the TDM (Total Dry Matter) production of the paddock.

Distichlis spp. area is free of shrubs, except some *Atriplex lampa* in the borders and low diversity in the herbaceous strata. *L. crinita* patches have more herbaceous diversity and plant cover and the presence of five xerophytic shrubs. *A. mendocina* patches exhibit poor diversity and low cover and the presence of the shrub *Larrea divaricata*.

When the contribution of the patches and matrix are compared (Fig. 4) it can be noticed that after the paddock started to be free of spring and summer grazing, even when drought was severe, *L. crinite* patches enhanced the DM production. Once rain values became normal, both *L. crinite* and *A. mendocina* contributed to a major extent to the paddock production and the result was a higher net productivity in the fall month of April when the parcel was used to feed breeding cows (Table 1). After considering the different HI%, the average weight of DM produced in each hectare of the padlock was calculated in the month of April and per day. Assuming that a cow unit needs around 12 kg DM per day, at the beginning of this research, two hectares per cow were needed per day and in the following years, after seasonal grazing and better rain record, each hectare could feed minimum two cows.



(a)



(b)

Fig. 3 (a) DM production per ha in each C_4 patch is presented as DM kg/ha produced each year; (b) The values were adjusted using the HI% obtained for each patch. Vertical bars represent one standard error of the treatments means.

Changes in receptivity of the paddock in the fall month of April were noticed the years after releasing from spring/summer grazing (2012/2014) as demonstrated by comparing the means by Turkey test. In later years (2015/2020), the biomass production slightly increased and maintained the values although annual rain was higher than historic means. Regression analysis between DM production and accumulated previous rains reflected low R^2. DM production vs. accumulated fall and summer rains showed a R^2 = 0.157 and y=105.11x + 41,193. When DM production was plotted vs. one-year accumulated rains it presented R^2 = 0.3502 and y = 66.325x + 36,218 and resulted in a R^2 = 0.6231 with y= 66.318x +11,924 when analyzed DM production vs. two previous years of accumulated rains.

The growth and production of the patches and of the total paddock were influenced by the grazing rotational schemata and by the accumulated rain when the sum of millimeters recorded in two previous years were considered.

In Table 2, the results of the feed analysis show that *L. crinita* has the highest protein content of the four grasses compared and the higher digestibility. *A mendocina* is poor in protein and the digestibility becomes extremely low in autumn, which explains why the cows only consume it when there is no other forage. *Distichlis* spp. data do not place the species as

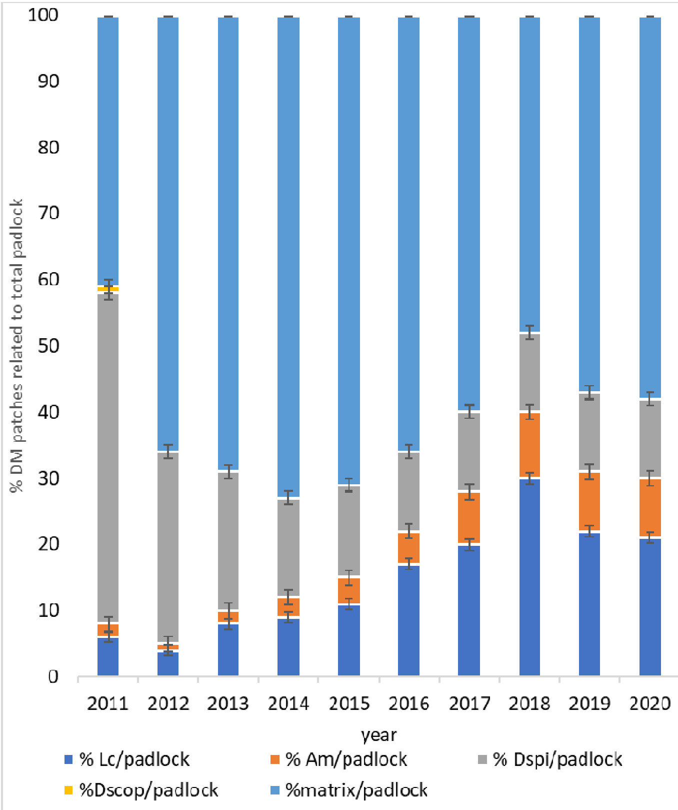


Fig. 4 The percentual contribution of each patch to the total DM production of the padlock. Vertical bars represent one standard error of the DM determination means for patches and matrix.

Table 1 TDM production of the paddock, DM per hectare and kg DM per ha for each day of the month of April.

year	TDM (kg)	DM (kg/ha)	DM (kg/ha.d)
2011	19,805	230	7
2012	34,565	401	13
2013	48,135	559	18
2014	67,850	788	26
2015	81,090	942	31
2016	80,330	934	31
2017	75,200	874	29
2018	67,155	780	26
2019	70,620	821	27
2020	69,620	809	26

Letters are valid for the three columns of measurements. Only means with different letters in each column, are significantly different at $p < 0.05$ level, compared by Turkey test.

valuable forage but they are important resources during drought. The calculated metabolizable energy in fall was 2.09, 1.08, 1.75 and 1.90 Mcal/kg DM for *L. crinite*, *A. mendocina*, *D. spicata* and *D. scoparia* respectively.

Microhistologycal analysis in feces, shows that in dry years, for example in 2013, *Distichlis* spp. (both species together because it is not possible to differentiate them in feces) can supply up to 13% of cows diet, while *L. crinita* participated with 1.5% and *A. mendocina* with 0.1%. In 2017 *Distichlis* spp. and *L. crinita* contributed both with 9.50% of the diet. *A. mendocina* provided 3% of the diet at the end of the grazing period.

Table 2 Chemical composition (% DM basis) and IVDMD (*In Vitro* DM Digestibility %) of grasses*.

C_4 sp	CP (%)	Ash (%)	NDF (%)	ADF (%)	ADL (%)	IVDMD (%)
L. crinita	15.01/11.47	9.95/9.69	69.85/66.66	33.20/28.38	4.28/2.17	57.74/67.79
A. mendocina	7.00/7.74	11.96/10.28	80.97/69.68	44.42/32.70	5.92/4.18	29.79/61.33
D. spicata	10.94/10.59	10.59/10.13	73.68/71.20	34.55/32.55	6.01/3.59	48.36/51.02
D. scoparia	12.26/11.80	12.86/12.12	65.30/63.97	29.52/24.31	3.93/2.05	62.65/64.43

* 2014 autumn/spring.

4. Conclusions

Ehleringer and Monson [6] recommend that plants with a C_4 photosynthetic pathway must be considered in the improvement of rangeland management in arid areas, due to their ability to thrive in extreme conditions. In the site studied, by managing the grazing periods it will be possible to increase the population of C_4 plants that are adapted to unfavorable weather conditions and poor soils. *L. crinita* is a valuable species that has good forage nutritional values, high digestibility, and contributes to significant grazing biomass because of the size and foliage.

Rotational cattle management practices, and the provision of fresh drinking water (to counteract the effect of the leaf salt glands), permit the use of the saline environments where *Distichlis* spp. abounds and so they are important components of the cows' diet, especially in dry years. *D. scoparia* seems to have the higher nutritional value of these two halophytes, but its biomass production is scarce, and the distribution area is limited to the borders of lowland places. This grazing rotational schema will also result in increased populations of species not prized by cattle, such as *A. mendocina*, and although cows do not eat this species at the entrance to the paddock, they finally consume them when the offer of the more palatable plants starts to diminish. Protecting semiarid C_4 grasses from grazing in their growing cycle seasons permits their use as deferred forage and increases the resources by the enhancement of the productivity of a heterogeneous paddock.

Acknowledgements

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