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Nutritional parameters for assessing pasture condition in the semiarid rangelands of Argentina

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Abstract

Range condition is usually estimated from the palatability and ecological attributes of rangeland species. The aim of this research was to assess whether the inclusion of nutritional parameters improves the estimation of range condition in the semiarid *Prosopis caldenia* Burk rangeland of La Pampa, Argentina. Plots (24 ha) containing rangeland in different condition (fair and good) were grazed at low stocking rates during fall, winter and spring of two successive years. The aerial biomass (kg DM ha^{-1}), *in vitro* dry matter digestibility (IVDMD) and crude protein content (% CP) of monthly samples of each species were determined. The percentage of total biomass (% TB) and % CP were estimated for each of six IVDMD ranks. In both years, and across nearly all IVDMD ranks, the % TB was different ($p < 0.05$) for the two range conditions, though % CP was similar ($p > 0.05$). The carrying capacity of good rangeland was 2.5 times greater than that of fair one when total aerial biomass and expected animal performance were similar. Taking nutritional parameters into account improves estimates of range condition in *P. caldenia* rangeland.

Key words: forage quality, range condition, rangeland management, *Prosopis caldenia* Burk. rangeland.

Resumen

Parámetros nutricionales como estimadores de la condición de pastizales semiáridos de Argentina

La condición del pastizal es habitualmente estimada en función de especies clasificadas por selectividad animal y atributos ecológicos. El objetivo de este trabajo fue evaluar si la inclusión de parámetros nutricionales mejora la estimación de la condición para la utilización ganadera de un pastizal semiárido de un bosque de *Prosopis caldenia* Burk. situado en La Pampa. Dos parcelas de 24 ha para cada condición contrastante (regular y buena) fueron pastoreadas a baja carga durante el otoño, el invierno y la primavera de dos años consecutivos, registrándose mensualmente la biomasa aérea (kg DM ha^{-1}), la digestibilidad *in vitro* de la materia seca (DIVMS) y el contenido de proteína bruta (% PB) de cada especie. A partir de la DIVMS y biomasa de cada especie, se calculó la proporción de la biomasa aérea total (% BT) en seis rangos de DIVMS, y en cada uno de ellos se calculó el % PB. Durante ambos años y en casi todos los rangos de DIVMS, el % BT fue diferente ($p < 0,05$) entre condiciones, mientras que el % PB de la biomasa en cada uno de ellos fue similar ($p > 0,05$). Estos resultados permitieron inferir que, aunque la biomasa total absoluta fue similar entre condiciones, la condición buena ofreció 2,5 veces más biomasa para categorías de animales que requieren DIVMS igual o superior al 40%. La inclusión de parámetros nutricionales mejoró la estimación de la condición de estos pastizales para fines ganaderos.

Palabras clave: calidad del forraje, condición del pastizal, manejo de pastizales, bosque de caldén.

Introduction

Traditionally, the assessment of range condition has been based on the present state of vegetation, estimated by the presence and abundance of species classified according to ecological attributes (Dyksterhuis, 1949), and soil protection, in relation to potential natural plant community for a named site (Jacoby, 1989). However, when rangelands are used for grazing, the concept of «condition» has its drawbacks since it takes into account no agronomic variables that allow the assessment for animal production (Jacoby, 1989; Du Toit, 1995).

The INTA-FAO (1986) proposed a classification (the Huss method) of the Argentinean rangelands based on the presence and abundance of desirable, less desirable and undesirable species. Desirability is measured in terms of agronomic attributes, such as: the species' palatability and livestock selectivity, and in

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terms of ecological attributes, such as: dominance, grazing resistance and perenniality. Compared to criteria based only on ecological attributes, this is a step forward in the assessment of rangeland grazing capacity. However, the inclusion of objective variables with direct influence on livestock production would improve the assessment of range condition (Du Toit, 2000).

The aim of this work was to determine whether the inclusion of nutritional variables could improve estimates of the grazing capacity of rangelands of different condition [good and fair condition according to the method of Huss (INTA-FAO, 1986)]. The study area was located in the central, temperate, semi-arid region of Argentina, known as «caldenal» region. The biomass distribution of the two range conditions was assessed in terms of dry matter digestibility, in order to find differences in nutritional quality among them.

Material and Methods

The experiment was performed at a ranch in the Caldenal region (Luan Toro, La Pampa Province, Argentina, 65ºW, 36º10'S, 300 msm) along fall, winter and spring (April-November) of two consecutive years. Table 1 shows the historical means of the climatic variables for the area, and the rainfall of the experimental site from April to September.

The region is dominated by the woody species *Prosopis caldenia* Burk, and consists of open, deciduous forest. The grass component of this rangeland includes mostly perennial grasses that can be divided into three groups (Llorens, 1995; Cerqueira *et al.*, 2000): group 1 composed of short winter-growing grasses of good forage value that are very desirable for livestock, e.g.: *Poa ligularis* Nees ex Steud., *Piptochaetium napostaense* Speg. (Hack), *Nassela tenuis* (Phil.) Barkworth, *N. clarazzii* (Ball.) Barkworth and *Hordeum stenostachys* Godr; group 2, including summer-growing species of acceptable forage value although less desirable during fall-winter, e.g.: *Digitaria californica* (Benth.) Henrard, *Trichloris crinita* (Lag.) Parodi, *Aristida subulata* Henrard, *Bothriochloa springfieldii* (Gould.) Parodi, *Pappophorum caespitosum* R. E. Fr. and *Setaria pampeana* Parodi ex Nicora; and group 3, which includes medium height winter-growing species of low forage value which are undesirable for livestock, e.g.: *Jarava ichu* (Ruiz & Pav.) Kunth, *Nassella tenuissima* (Trin.) Barkworth, *Achnatherum brachychaeta* (Godr.) Bakworth, *Stipa ambigua* Speg., and *Nassella trichotoma* (Nees) Hack. Ex Arechav.

Experiments were performed on four plots, each with an area of 24 ha. Range of two plots was in good condition, while that of the other two was in fair condition. Range condition was assessed before experiments began by measuring the density of woody spe-

Table 1. Rainfall, temperatures, frosts, relative humidity and solar radiation in the area

	Accumulated rainfall April-September (mm)
Mean (cv)[1] 1921-2000[2]	165.1 (54.3)
Dry year[3]	49.0
Normal year[3]	160.0

	Mean temperatures[4] (ºC)					
	April	**May**	**June**	**July**	**August**	**September**
Mean	15.6	12.0	8.8	8.6	10.4	13.1
Mean maximum	23.0	18.6	14.7	14.9	17.8	20.5
Mean minimum	5.5	5.0	2.3	1.8	2.7	5.2
Absolute maximum	33.7	29.2	26.0	25.1	30.4	33.7
Absolute minimum	–4.0	–7.0	–9.6	–10.7	–8.8	–5.9
Days with frost[4]	0.7	3.7	9.8	11.1	7.8	3.1
Relative humidity (%)[4]	68	71	73	70	61	57
Solar radiation (cal cm^{-2}d^{-1})[5]	574	427.9	362.3	394.1	515.6	690.2

[1] cv: coefficient of variation. [2] Records for Luan Toro (36º10'S 65ºW) provided by the *Cátedra de Climatología, Facultad de Agronomía de la UNLPam.* [3] Records for the study site (36º10'S 65ºW) measured during the experimental period. [4] Records (1941-1990) for Victorica (36ª 15'S 65º27'W), *Cátedra de Climatología, Facultad de Agronomía de la UNLPam.* [5] Theoretical solar radiation for Victorica.

cies and the proportion of desirable and undesirable species with respect to total biomass (method of Huss; INTA-FAO, 1986). The density of *P. caldenia* was 482 ± 281 and 1,731 ± 849 plants ha^{-1} in the good and fair range condition, respectively. Desirable species made up 60% of total biomass in the good range, but only 30% of the fair one.

During the experimental period, the plots were grazed by adult non-pregnant, non-lactating beef cows at very low stocking rates: 6 and 12 ha per cow for the first and second year respectively. Stocking rate, which was very similar for all plots, was calculated with respect to short forage availability in fair condition plots at the start of each year's growing season. The lower stocking rate of the second year is explained by the lower availability of forage at the start of the grazing season. This was due to the negative effects of drought and the selective grazing on short winter species in the first year.

The total dry biomass (kg DM ha^{-1}) at ground level of all herbaceous grasses was measured monthly in each plot (excluding those areas covered with shrub species) throughout the experimental period. This was performed by random sampling of areas stratified into transects 300 m long (separated by 200 m, 4 transects per plot); along each transect, five randomly selected quadrats of 0.25 m^2 were examined. The total number of samples per plot was 20 (n). This sampling intensity and the surface area examined in each quadrat agree with that described by other authors for this kind of rangeland (Estelrich and Cano, 1985; Cano *et al.*, 1988, 1990).

The collected material of each species was dried in an oven at 60ºC until constant weight was achieved. It was then ground in a Wiley mill with a 1 mm mesh. For each plot and each sampling time, samples of every collected species were taken for laboratory analysis. The *in vitro* dry matter digestibility (IVDMD) was determined by the method of Tilley and Terry (1963), modified by Alexander and McGowan (1966). Crude protein content (% CP, N × 6.25) was estimated using the semi-micro Kjeldahl method.

Analysis

For each year and plot, the biomass and the quality values of species at each collection date were grouped and the mean was calculated for each season of the year during the grazing period (fall, winter, and spring).

The following ranks were established according to different levels of IVDMD: rank I: IVDMD < 35%; rank II: IVDMD 35-39.9%; rank III: IVDMD 40-44.9%; rank IV: IVDMD 45-49.9%; rank V: IVDMD 50-54.9%; rank VI: IVDMD > 54.9%. For each rank, the percentage of the total available biomass (% TB) was calculated for the two range conditions, year and season, using the following equation:

$$\%\ TB_{rank\ x} = \left(\sum_{i=1}^{n}(species_i)\right)_{rank\ x} / TB * 100$$

where:

$\%\ TB_{rank\ x}$ = percentage of total biomass in rank x (%)

$Species_i$ = Total biomass of $species_i$ in rank x (kg DM ha^{-1})

TB = $\sum_{i=1}^{n}(species_i)$; total available biomass per ha (kg DM ha^{-1}).

The % CP of the biomass available in each IVDMD rank was also calculated.

Factorial analysis of variance was performed using each condition, year and season as the main effects. In the analysis of interactions, the treatment means were compared by the protected LSD test (Steel and Torrie, 1989).

Results and Discussion

Range condition affected % TB in nearly all the IVDMD ranks studied (Table 2). In fair range condition plots, half of the total aerial biomass was within rank I, doubling the % TB of the good condition plots (Table 3). On the other hand, starting at rank IV, good condition plots showed three times as much % TB than

Table 2. Probability values from the analysis of variance of the effects of range condition (C), year (Y) and season (S) on the production of biomass in different IVDMD ranks

IVDMD rank (%)	C	Y	S	C×Y	C×S	Y×S	C×Y×S
< 35	**	***	**				
35.0-39.9		*		*			
40.0-44.9	×						
45.0-49.9	*		**				
50.0-54.9	*		×	×	**		
> 54.9		*					

×: $P \leq 0.1$. * $P \leq 0.05$. ** $P \leq 0.01$. *** $P \leq 0.001$.

Table 3. Effect of range condition (G = good, F = fair), year (D = dry, N = normal) and sampling season (Fa = fall, W = winter and S = spring) on the production of biomass in different IVDMD ranks

IVDMD rank (%)	Proportion of total biomass (%)									
	Condition (n = 12)			Year (n = 12)			Season (n = 8)			
	G	F	SE[1]	D	N	SE	Fa	W	S	SE
< 35	21.0	48.6	4.7	19.2	49.7	4.7	15.1	52.3	37.2	5.7
35.0-39.9	17.3	25.9	4.7	29.2	13.8	4.7	18.8	18.6	27.3	5.8
40.0-44.9	25.1	13.4	4.2	24.2	14.4	4.2	19.7	17.0	21.4	5.1
45.0-49.9	24.1	8.7	4.4	19.5	13.5	4.4	32.3	4.9	11.6	5.4
50.0-54.9	11.0	2.7	2.8	7.9	6.5	2.8	11.3	7.1	2.0	3.4
> 54.9	1.5	0.6	1.1	0.0	2.1	1.1	2.8	0.1	0.4	1.4
Total biomass[1] (kg DM ha^{-1})	2,972.7	3,152.5		2,476.0	3,644.9		2,608.2	4,611.6	1,965.2	

SE: standard error. [1] Total biomass of all herbaceous grasses species sampled.

fair condition plots (Table 3). In fact, this tendency began in rank III, where condition had a marginally significant effect ($p < 0.1$) on % TB (Table 2). In summary, over the fall-winter-spring period, the percentage biomass in the > 40% IVDMD ranks was 2.5 times greater in the good than in the fair range condition (Fig. 1).

Nevertheless, some interactions were detected between range condition, year, and sampling season (Table 2). The % TB in rank II was greater ($p < 0.05$) in the fair range condition during the first year (41.5 ± 9.1 compared to 17.8 ± 4.7 for the good condition range). In rank V, the % TB was greater ($p < 0.05$) in the good range condition in the fall, with both types of rangelands becoming equal during the winter and spring as the grazing season progressed (Fig. 2). This result can be explained by the intense and selective grazing endured for the species in this IVDMD rank, plus their scant contribution to the total biomass. This is particularly the case of the fair rangeland, in which the % TB for an IVDMD of 50.0%-54.9% was less than 3% (Table 3). Figure 2 shows

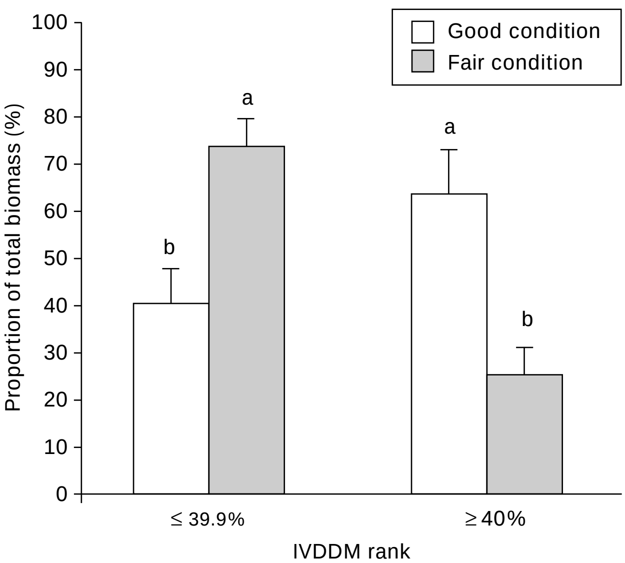

Figure 1. Proportion of total biomass with up to 39.9% and above 40% *in vitro* dry matter digestibility in two range conditions (good and fair). Mean of the two years and three seasons (n = 12). Between columns, different letters express statistical significance ($p \leq 0.05$).

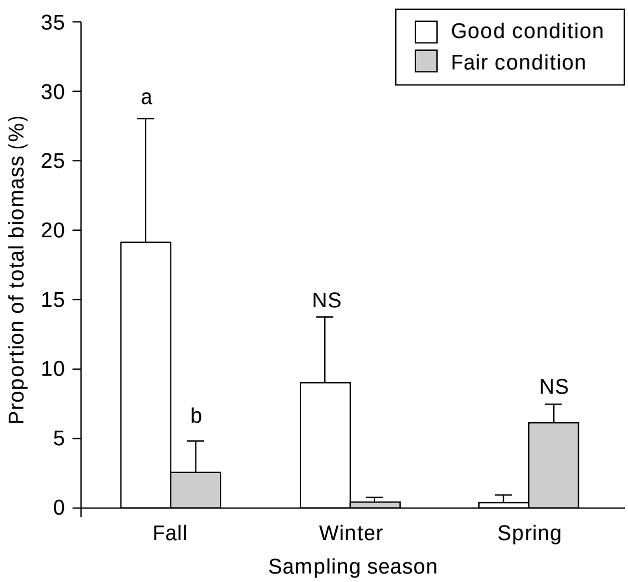

Figure 2. Effect of interaction between range condition and sampling season on the proportion of biomass in the 50-54.9% IVDMD rank. Mean of two consecutive years (n = 4). Between columns, different letters express statistical significance ($p \leq 0.05$). NS: not significant.

that in spring, the fair range condition improves its percentage biomass in this rank compared to fall and winter. This result might be explained by the greater indices of species selectivity registered in this IVDMD rank for the fair range condition (Cerqueira *et al.*, 2000). This would set up a spring regrowth free of old material, with a greater proportion of leaf area (Rabotnikof *et al.*, 2001).

Year also had a significant effect on % TB in rank I, the latter being three times greater during the normal year than in the dry year (Tables 1 and 2). This can be due to the fact that during the normal year, total biomass was maintained while the absolute biomass of the species included in rank I increased ($p < 0.05$). This is not just a positive response to rainfall, but also the effect of the successive use of the rangeland for two consecutive years. It can be inferred that the drought of the first year caused great mortality among adult specimens of the most heavily grazed species, translating into a greater biomass of the less-consumed (and poorer in quality) species in the second year.

Season also had a significant effect on % TB in rank I (Table 2). An increase in % TB was seen in winter compared to fall, followed by a drop in spring (Table 3). This can be explained as an effect of selective grazing on the composition of the total biomass, and by the growth of desirable and better quality species in spring. As indicated by Bailey (1995), in heterogeneous environments, cattle more frequently select areas with greater mean quality. Therefore, total mean quality changes as the grazing season advances. As autumn becomes winter, the relative quantity of forage in this low IVDMD rank increased, with the animals consuming grasses of greater quality (Cerqueira *et al.*, 2000). With the arrival of spring, the % TB in this rank fell in comparison with the winter because of regrowth (Bruno *et al.*, 1985).

In contrast, in rank IV, the % TB showed completely opposite behaviour. Since this is a rank of greater quality, the % TB fell in winter because of grazing, and only increased slightly in spring because of regrowth.

The crude protein (CP) content of the biomass in each IVDMD rank was similar ($p > 0.05$) for the two range conditions (Fig. 3). Only rank I showed CP values below those recommended for the maintenance of adult non-pregnant, non-lactating beef cows (ARC, 1980).

In summary, the two range conditions differed in the proportion of biomass in the different IVDMD ranks, but not in the CP content in each rank. The differences between the range conditions were maintained over the two years across nearly all the IVDMD ranks. Sampling season only modified those differences at IVDMD rank V.

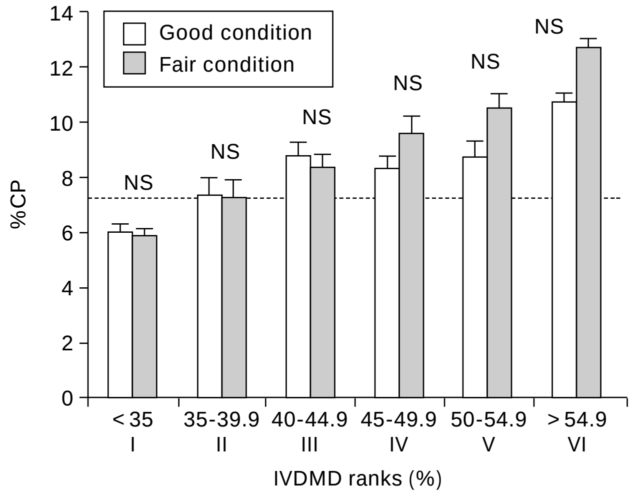

Figure 3. Crude protein content (%CP) of the biomass in different IVDMD ranks for two conditions (good and fair). NS: not significant. The dotted line indicates the minimum CP concentration required to maintain adult non-pregnant, non-lactating beef cows (7%).

The results show that the distribution of aerial biomass with respect to IVDMD is different for the two range conditions studied in the «caldenal» rangeland of semi-arid central Argentina.

The differences found in the nutritional quality of forage biomass, over the grazing period, points that stocking rates can be properly adjusted for each range condition, in order to achieve a desired livestock production. For example, although the total absolute biomass was similar in both range conditions studied here (Table 3), the better rangeland offered 2.5 times more biomass for animals that require an IVDMD of 40% or higher (Fig. 1).

As indicated by Du Toit (2000), ecological and subjective agronomic indices alone do not provide adequate estimates of rangeland grazing capacity. Estimates of range condition for stock raising are improved when objective agronomic variables – such as the aerial biomass of species and their nutritive value (IVDMD and % CP) – are taken into account over the grazing season.

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