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Restricted oats grazing and its frequency of allocation affects calves´ performance on native grasslands

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SUMMARY

Nutritional constraints of rearing calves on native grasslands during their first winter is a common problem in Uruguay due to insufficient quality and quantity of forage. Winter supplementation on beef cattle grazing native grasslands using grains or their by-products has been studied before, but little attention has been given to restricting the access of animals to an adjacent enhanced forage basis, such as oats forage. Thirty-six castrated Hereford calves grazing native grasslands during their first winter were randomly allotted to one of the following treatments: (a) Everyday (E), with access to an adjacent oats forage crop for 4 hours a day (28 hours/week); (b) Monday-through-Friday (MthF), with access to the same crop for 5 hours 36 min per day (28 hours/week); (c) Control (C), where animals did not have any access to oats. The experiment was separated in two Phases: Phase I where treatments were applied (winter), and Phase II, after the treatments were applied (spring), to evaluate eventual carry-over effects. Restricted grazing on oats affected herbage mass and sward height of native grasslands in both experimental phases (P<0.01), being greater for E than C and MthF. Average daily gain (ADG) was affected in Phase I (P<0.01) by time-restricted grazing access to oats, being greater for E (745 g), followed by MthF (645 g) and then by C (377 g). During Phase II, ADG was greatest (P<0.05) for E (673 g), while MthF and C presented no differences between them (508 g, on average). When considering the whole evaluation period (Phases I & II), animals from E and MthF groups gained 59 and 28% more respectively, than animals from the control group, being all significantly different between each other (P<0.01). The use of deferred native grasslands as a nutritive basis combined with a restricted access to an oats forage crop proved to be an interesting technological tool to improve calves´ performance during winter. Positive feedbacks between pasture supplementation and native grasslands were identified, which could contribute to a better management of this forage basis in extensive production systems.

El pastoreo restringido de avena y su frecuencia de asignación afecta el desempeño de terneros pastoreando campo natural

Palabras clave adicionales

Forraje como suplemento.
Verdeo invernal.
Recría razas carniceras.
Campos.
Suplementación infrecuente.

RESUMEN

Las restricciones nutricionales de los terneros de recría sobre campo natural durante su primer invierno es un problema común en Uruguay, dada la insuficiente calidad y cantidad del forraje. La suplementación invernal del ganado de carne utilizando granos o sus subproductos y pastoreando sobre pasturas nativas, ha sido estudiada previamente, pero muy poca atención se le ha dado a el acceso restringido de animales a una base forrajera mejorada adyacente, como lo puede ser un verdeo de avena. Treinta y seis terneros machos castrados pastoreando sobre campo natural durante su primer invierno fueron asignados al azar a uno de los siguientes tratamientos: (a) Diario (D) con acceso a una parcela adyacente de avena por 4 horas al día (28 horas/semana); (b) de Lunes a Viernes (LaV) con acceso al mismo verdeo por 5 horas 36 minutos por día (28 horas/semana); (c) Testigo (T), en el que los animales no tenían acceso alguno al verdeo de avena. El experimento fue dividido en dos fases: la fase I en donde los tratamientos fueron aplicados (invierno) y la fase II, luego que los mismos fueran aplicados (primavera), a los efectos de evaluar un eventual arrastre de efectos. El acceso restringido a la avena afectó la disponibilidad y altura del forraje del campo natural en ambas fases evaluadas (P<0,01), siendo mayor para D que T y LaV. Las ganancias medias diarias (gmd) fueron afectadas durante la fase I (P<0,01) por el acceso restringido a la avena, siendo mayor para D (745 g), seguido por LaV (645 g) y luego por T (377 g). Durante la fase II, las gmd fueron mayores (P<0,05) para D (673 g), mientras que LaV y T no presentaron diferencias entre ellos (508 g en promedio). Al considerar la totalidad del período de evaluación (fases I y II), los animales correspondientes a D y LaV ganaron 59 y 28 % más respectivamente, que los animales correspondientes a T, siendo todos significativamente diferentes entre sí (P<0,01). El uso de campo natural diferido como base forrajera, combinado con un acceso restringido al forraje de avena demostró ser una tecnología válida para mejorar el desempeño de los terneros durante el invierno. Se identificaron retroalimentaciones positivas entre la suplementación con forraje y el campo natural, lo cual podría contribuir a un mejor manejo de esta base forrajera en los sistemas extensivos ganaderos.

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INTRODUCTION

The most common livestock production system in the Campos region of southern South America is based on the utilisation of native grasslands through direct grazing all year round. Animal performance in these grasslands-based production systems is largely determined by forage intake and its nutrients concentration (Da Trindade et al. 2016). During winter, nutritional constraints occur mainly due to a low forage production (Berretta et al. 2000) or its inadequate quality (Royo Pallarés et al. 2005) to match the nutrient requirements of weaned beef calves to achieve a moderate average daily live weight gain (ADG) (NRC, 2016).

To address this issue, supplementing beef cattle during winter has been suggested as a technological valid alternative. Winter feed supplementation had a direct impact on increasing productivity and economic results of extensive and semi-extensive farms (Toro et al. 2009). Traditionally, research on supplementation on native grasslands of beef calves has focused on the use of grains and their by-products such as maize grain or rice bran (Pordomingo et al. 1991, Bailey et al. 2001, Mcmullen et al. 2015, Terevinto et al. 2015). Nonetheless, an alternative to supplementing animals grazing on native grasslands is to provide a restricted access to an improved forage located on a subjacent paddock (Espinoza et al. 2001; San Buenaventura et al. 2001). Furthermore, restricted grazing has been indicated as an effective technique to improve the growth rates of weaned lambs grazing native grasslands during summer (Piaggio et al. 2015). Improved pastures such as annual oats crop can contribute with an important amount of forage of high quality in a short period during winter time (Braunwart et al. 2001). Hence, this crop would be a potential feed resource for restricted winter grazing. Thus, the performance of weaned calves grazing native grasslands during winter can be improved by complementary restricted access to an improved forage resource.

It has been reported that altering the time allocation at pasture when restricting grazing time, affects animal grazing behaviour and performance (Gregorini et al. 2009; Molle et al. 2017). However, Soca et al. (2014) found that restricting daily grazing access to improved pastures on dairy cows had a significant effect on total grazing time, but in this case, no significant effect was found on herbage dry matter intake nor on animal performance. This means that it is possible to achieve the same level of animal performance when shifting from a daily basis to a less frequent access to pasture, considering the same weekly allocation time. Nevertheless, there is a lack in the knowledge on the effect of the weekly allocation of restricted grazing of an oats crop on beef calves performance during winter, particularly when the diet of weaned calves is mainly based on deferred native grasslands (from autumn to winter).

We hypothesized that time-restricted access to an enhanced nutritional forage basis, would increase the average daily weight gain (ADG) of weaned calves, regardless of the frequency of this access within the duration of a week. To test this hypothesis we evaluated the effect of restricted access to an oats crop under two weekly grazing frequencies on animal performance during winter and its possible carry-over effect throughout the spring.

MATERIALS AND METHODS

Experimental site and design

All procedures in this experiment were carried out according to the recommendations set by the Uruguayan Honorary Animal Ethics Committee. The study was conducted at "Glencoe" Experimental Unit of INIA Tacuarembó Research Station, which is located in the northern region of Uruguay (S32° W57°, 110 m altitude). The climate of this region is temperate to subtropical, with a mean temperature that ranges from 12°C in winter to 25°C in summer, and an average annual rainfall of 1500 mm (Cruz et al. 2014). The predominant native vegetation –referred to as "Campos grasslands"– is a biome that includes East Central Argentina, Southern Brazil and Uruguay (Soriano 1991) and is dominated by C4 and C3 grasses (Lezama et al. 2006).

The experimental forage basis was a basaltic native grassland on medium to shallow soils, where calves grazed at a stocking rate of 2.2 animals/ha. Additionally, animals were allowed to graze, with different frequencies, on adjacent oats forage crop paddocks. Based on their age and live weight (LW), calves were distributed into three experimental treatments: (1) "Control" (C; n = 12); grazing only on native grasslands, in which animals did not have any access to an oats forage crop; (2) "Monday-through-Friday" (MthF; n = 12); grazing on native grasslands, in which animals had access to an oats forage crop only Monday through Friday (5 days a week, 5 hours 36 minutes of grazing time a day, 28 hours a week); (3) "Everyday" (E; n = 12); grazing on native grasslands, in which animals had a daily access to an oats forage crop (every day of the week, 4 hours of grazing time a day, 28 hours a week). Grazing on oats paddocks started at 9:30 am. Thirty-six castrated male Hereford calves of eight months of age with an initial LW of 139 ± 16 kg were allocated in one of the six experimental groups according to a completely randomised design with two paddock replications. Each native grasslands paddock was 2.7 ha.

The study consisted of two phases: i) Phase I, in which treatments were implemented from 15th June to 7th September, and ii) Phase II, in which all animals remained on their originally assigned native grasslands paddocks from 7th September to 28th November, to test eventual carry-over effects of the treatments applied on Phase I. The forage of the native grasslands paddocks was differed from the previous autumn into winter (60 days of forage accumulation), with a previously intensive grazing session at the end of the summer to promote the removal of dead matter of these paddocks. Animals had *ad libitum* access to fresh clean water and to mineral self-fed blocks (containing 4% P, 14% Ca and 1% Mg) located on the native grassland paddocks. Oats forage crop was sown with a no-till cropping system on March (autumn) with *Avena byzantina* cv. LE 1095a using a 100 kg/ha sowing density and fertilised with 75 kg/ha of urea (46% N). The oats crop was rotationally grazed, with a total oats area of 2.5 ha and using an average stocking rate of 9.6 animals/ha. The occupation periods of each plot ranged between 7 and 10 days. The criterion utilised to remove the animals off their plots was the remaining post grazing sward height. When the sward height was 10 cm or less, calves of both E and MthF groups were removed to new grazing plots . All oats paddocks were re fertilised with 50 kg/ha of urea immediately after the first grazing session.

Forage mass and height, and chemical composition of pastures

Offered forage biomass on native grassland paddocks was estimated every 21 days by clipping five 0.35 m^2 quadrats at ground level. Green forage mass of every sample was stored in a sealed nylon bag immediately after clipping and then each bag was opened one by one in the laboratory to be weighed, thus minimising the possibility of dehydration. To estimate dry matter (DM) percentage, two subsamples from the remaining pool of samples were dried at 60 °C until a constant weight was reached. Then, using the fresh weights of each sample and the estimated DM percentage of the two subsamples, herbage mass per hectare (kg/ha) was estimated. Forage height was measured in the same sites and at the same time as biomass was estimated, reading 15 determinations with a steel ruler. Oats pre and post grazing herbage mass was estimated by clipping five 0.1 m^2 quadrats at ground level at the beginning and at the end of each grazing session. The oats pasture underwent four grazing periods, each of which lasted 21 days in average. Oats forage height and herbage mass determinations were performed in the same way as previously described for native grasslands samples.

For both native grasslands and oats forage crop, Crude Protein (CP) content was estimated according to AOAC (1990) (KJELTEC 2200 FOSS distiller), while Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were estimated according to the methodology described by Van Soest (1982) (ANKOM A 2000 I). Additionally, 2 subsamples of the forage samples described above for both forage basis were used to estimate botanical composition, manually separating dead from green forage.

Animal behaviour and live weight

Animal behaviour was recorded in three occasions during Phase I, on days when treatments MthF and E grazed on oats paddocks. It was assessed during daylight hours through three observers, who periodically rotated between treatment groups in order to avoid an eventual observer bias. These observers registered every 15 minutes the following animal activities: grazing, rumination, rest and water consumption. After that, the total amount of time spent at each activity was estimated, in order to calculate the proportion of time allocated to each of them (Montossi 1995). Only statistical results of grazing and rumination will be presented.

Animals were weighed at the beginning of the experiment and every 15 days in the afternoon (LW) to calculate average daily LW gain (ADG). Shrunk live weight (SLW) was measured at the beginning and at the end of the each Phase (16 hour fasting).

Statistical analysis

Normality of residuals and homogeneity of variances were verified at the beginning of statistical analysis. In a complete randomised design, with three treatments and two replications per treatment, forage and animal data sets were analysed using mixed models with InfoStat software (Di Rienzo et al. 2008). In the forage data model, a repeated measurement in time was used, where treatment was included as a fixed effect and each plot as a random effect. In the animal data model, treatment was included as a fixed effect while each animal was fitted as a random effect. Individual ADG was calculated arithmetically and then compared using a variance analysis per Phase and for the total period of the experiment. Treatment effect was considered significant when P<0.05, by Fisher´s test. Least square means, pooled standard errors and level of significance are presented for the estimated variables.

RESULTS

Herbage mass and height, and botanical and chemical composition of forage

Restricted grazing on oats affected herbage mass and sward height of native grasslands in both experimental phases (P<0.01, **Table I**). Both height and herbage mass were greater in the treatment with everyday access to oats (E) than the pasture of C and MthF treatments, regardless of the Phase. Forage mass and height were lower in C pastures, except for forage availability in Phase I, where no differences were detected between C and MthF. Access to oats only slightly affected the chemical composition of the native grasslands forage basis during winter (Phase I), where CP content was greater in C compared with E, while MthF presented an intermediate value (P<0.05, **Table I**). In Phase I, no differences (P<0.05) were found in ADF content, but NDF was higher in E than MthF and C, which presented similar values between them. In Phase II, no differences were found for neither the botanical composition nor the nutritive parameters of the pasture.

None of the oats sward pre-grazing parameters were affected by the frequency of animal grazing (P>0.05, **Table II**). On the other hand, post-grazing forage herbage mass and height were higher in MthF than in E, but no differences were found in their botanical and chemical composition, except for the ADF content, where E presented the greatest value.

Live weight and animal behaviour

When considering the total amount of time dedicated to either grazing or ruminating, animals in C grasslands paddocks spent more time grazing compared to E and MthF (P<0.01; **Figure 1a**), while no differences were found for rumination time between

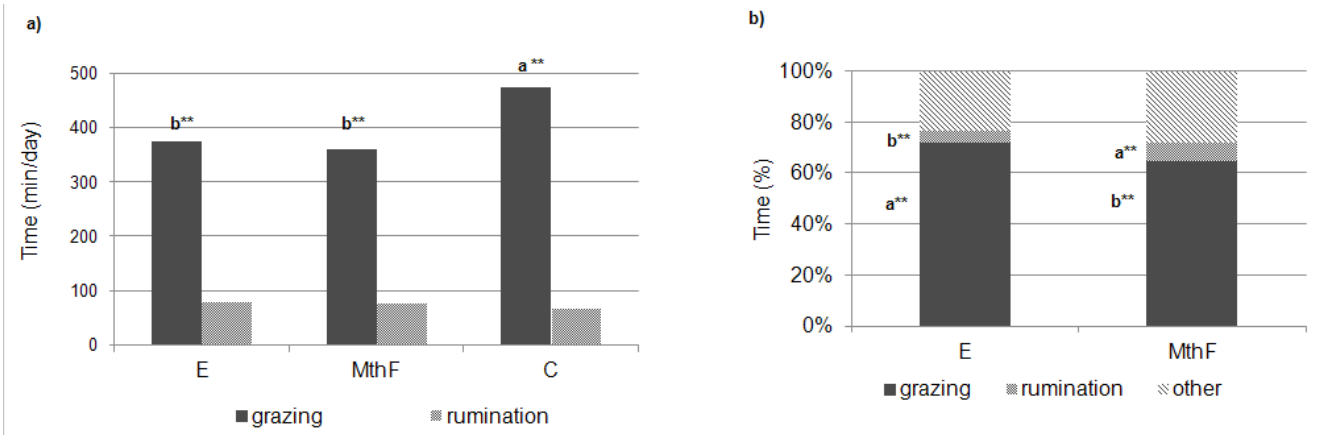

Figure 1. Animal behaviour when grazing (a) the overall average native grasslands and oats together, (b) oats under the effect of time-restricted grazing by Hereford calves, using an everyday grazing frequency (E) Monday-through-Friday grazing frequency (MthF) or no access to oats (C) (Comportamiento animal al pastorear (a) el promedio general de pastizales nativos y avena juntos, (b) avena bajo el efecto de pastoreo restringido en el tiempo de terneros Hereford, utilizando una frecuencia de pastoreo diaria (E) de lunes a viernes (MthF) o sin acceso a la avena (C). Means within the same activity with different letters significantly differ; ** = P<0.01.

treatments (P>0.05). When E and MthF remained on the oats paddocks, both grazing and rumination activities were affected by treatments (P<0.01; **Figure 1b**), where E presented the greatest grazing and the least rumination allocation times compared to MthF.

When analysing LW evolution throughout Phase I, a tendency in the penultimate measurement was observed (8/23, P=0.054), where E was different from C but not from MthF, and in the final LW measurement of this Phase, C animals were lighter than the animals of both oats access treatments (P<0.05; **Figure 2**). During Phase II, all LW measurements were affected by treatments (P<0.05). Between the last measurement of Phase I and the next measurement (Phase II), animals from E and C slightly decreased their LW (2 and 3 kg, respectively), but for MthF this difference was 12 kg. By the end of Phase II, animals from E were heavier than C, while animals from MthF presented an intermediate LW value.

By the end of Phase I, final SLW and ADG were affected by time-restricted grazing access to oats (P<0.01, **Table III**), being greater in animals with access to oats forage (both frequencies) than animals grazing native grasslands only. In this Phase, final SLW was similar between oats access treatments, while for ADG, E animals presented greater values than MthF. By the end of Phase II, animals from E were the heaviest while those from C presented the lightest SLW, leaving animals from MthF in an intermediate position (P<0.01, **Table III**). In this Phase, ADG was greatest (P<0.01) for E, while MthF and C presented no differences between them (P>0.05). When considering the whole evaluation

Table I. Effect of time-restricted oats grazing by Hereford calves on quantity and quality of native grasslands forage basis (means; sem) (Efecto del pastoreo de tiempo restringido de terneros Hereford sobre la cantidad y calidad de la base forrajera nativa (medias; SEM).

Phase	Parameter	Treatment			sem	P
		E	MthF	C		
I (06/15 - 09/07)	Herbage mass (kgDM/ha)	1097 ^{a}	882 ^{b}	805 ^{b}	43.1	**
	Sward height (cm)	4.0 ^{a}	3.5 ^{b}	2.8 ^{c}	0.10	**
	Dead forage (%)	43 ^{ab}	38 ^{b}	46 ^{a}	0.03	**
	CP (%)	9.7 ^{b}	10.2 ^{ab}	10.4 ^{a}	0.19	*
	ADF (%)	41.4	40.8	40.1	0.92	ns
	NDF (%)	52.2 ^{a}	49.8 ^{b}	49.6 ^{b}	0.62	**
II (09/07 - 11/28)	Herbage mass (kgDM/ha)	1379 ^{a}	1005 ^{b}	625 ^{c}	61.8	**
	Sward height (cm)	5.5 ^{a}	4.3 ^{b}	3.0 ^{c}	0.30	**
	Dead forage (%)	40	40	45	0.02	ns
	CP (%)	10.4	10.5	10.6	0.42	ns
	ADF (%)	44.5	44.6	44.2	1.10	ns
	NDF (%)	54.6	54.4	54.7	1.69	ns

E, everyday oats grazing frequency; MthF, Monday-through-Friday oats grazing frequency; C, control treatment with no oats access; CP, crude protein; ADF, acid detergent fibre; NDF, neutral detergent fibre; $^{(a,b,c)}$ Means within a row with differing letters are significantly different; * = P<0.05; ** = P<0.01; ns= P>0.05.

period (Phases I & II), animals from E and MthF groups gained 59 and 28% more respectively, than animals from the control group, being all significantly different between each other (P<0.01).

DISCUSSION

This experiment sought to evaluate whether increases in the average daily weight gain of weaned beef calves could be attained by a time-restricted access to an enhanced nutritional forage basis during winter, regardless of the frequency of its allocation within the duration of a week. Furthermore, another objective was to evaluate if the supplementation using an improved pasture during winter would evidence a carry-over effect that might modify the animal performance at the end of the following season (spring). Our results indicate that, irrespective of the frequency of time-restricted access to oats, animal performance improved during winter, although the magnitude of the response was related with the oats access frequency of allocation. Moreover, the positive consequences of this type of supplementation presented a carry-over effect that lasted at least for another two and a half months in the spring, which in turn was related to the original frequency of oats grazing time allocation within the duration of a week.

Supplementing ruminants with restricted access to an improved pasture can positively affect animal performance (Espinoza et al. 2001), as observed in our study. Based on the oats pasture structure of a pre-grazing herbage mass and sward height above 2 ton DM/ha and 15 cm, respectively (**Table II**), supplemented calves (E and MthF) had the opportunity to improve their relative intake considering both oats and native grasslands, than those only grazing the native grasslands paddocks with less than 1 ton DM/ha of herbage of 4 cm or less (**Table I**) (Freer et al. 2009). Oats forage also presented less dead material than native grasslands paddocks, allowing calves to increase their energy intake also through selectivity. Sward height, dead forage and herbage allowance can affect the energy intake (Illius and Gordon 1987) of beef cattle. Therefore, supplemented animals were presented with a better overall diet both in quantity and quality than non supplemented calves.

Considering that an increase in grazing time is an adaptive response to a decrease of the rate of intake caused by modifications on sward structure (Hodgson 1985), the longer period of time allocated to grazing activities registered for unsupplemented animals in our study (**Figure 1a**) indicates that their intake was probably more limited than that of the animals with access to oats. This is supported by previous findings (Realini 1998; Sarmento 2003) with beef cattle, where decreases in herbage intake increased grazing time allocation and biting rate in concordance with a decrease in bite size, in an attempt to compensate the lower herbage intake. Complementarily, in our study the access of calves to oats during winter decreased the grazing pressure on the native grasslands paddocks. This had a positive effect on the native grasslands herbage mass for E animals (**Table I**), indicating substitution of the native grasslands forage consumption by oats, without relevant changes in forage quality, further increasing the overall consumed diet for supplemented animals. Thus, through the combined effect of an oats forage supplementation with a lighter grazing pressure of native grasslands paddocks, supplemented animals were capable of enhancing their animal performance during Phase I (winter).

The positive consequences of supplementation through restricted grazing on ADG are in agreement with previous research with lambs grazing native grasslands and supplemented with an improved pasture of *Lotus uliginosus* (Piaggio et al. 2015). In that

Table II. Effect of time-restricted oats grazing by Hereford calves on quantity and quality of oats forage crop (means; sem) (Efecto del pastoreo restringido de avena en ngida en el tiempo pastando por los terneros Hereford sobre la cantidad y calidad del cultivo de forraje de avena (medias; SEM).

	Parameter	Treatment		sem	P
		E	MthF		
Pre-grazing	Herbage mass (kgDM/ha)	2159	2194	79.3	ns
	Sward height (cm)	15.8	16.0	0.51	ns
	Dead forage (%)	29	27	0.02	ns
	CP (%)	10.0	9.8	0.28	ns
	ADF (%)	36.0	34.9	0.67	ns
	NDF (%)	46.7	46.2	0.83	ns
Post-grazing	Herbage mass (kgDM/ha)	1475 ^{b}	1780 ^{a}	55.5	**
	Sward height (cm)	8.9 ^{b}	10.3 ^{a}	0.33	**
	Dead forage (%)	40	35	0.02	ns
	CP (%)	9.1	9.4	0.27	ns
	ADF (%)	35.5 ^{a}	33.7 ^{b}	0.59	*
	NDF (%)	48.0	47.0	0.82	ns

E, everyday oats grazing frequency; MthF, Monday-through-Friday oats grazing frequency; C, control treatment with no oats access; CP, crude protein; ADF, acid detergent fibre; NDF, neutral detergent fibre; $^{(a,b)}$ Means within a row with differing letters are significantly different; * = P<0.05; ** = P<0.01; ns= P>0.05.

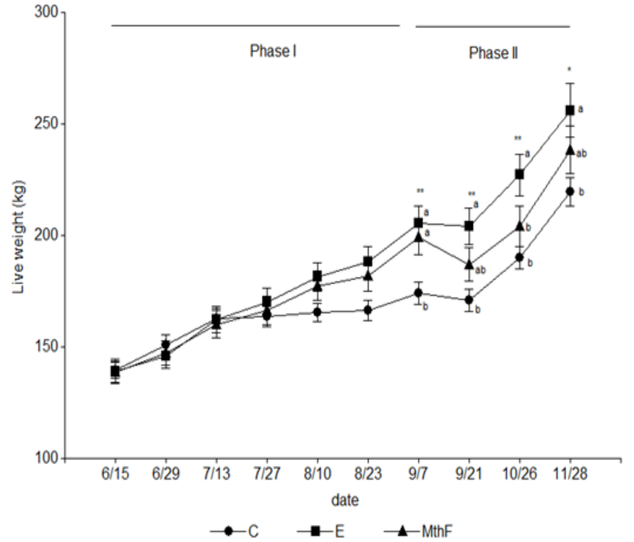

Figure 2. Evolution of live weight (LW) under the effect of time-restricted oats grazing by Hereford calves, using an everyday frequency (E), a Monday-through-Friday grazing frequency (MthF), or no access to oats (C) (Evolución del peso vivo (LW) bajo el efecto del pastoreo restringido de avena de terneros de Hereford, utilizando una frecuencia diaria (E), de lunes a viernes (MthF), o sin acceso a la avena (C). Means within the same date with different letters significantly differ; * = P<0.05; ** = P<0.01.

case, the limiting content of CP of the basal diet for lamb's growth explains the response to a high CP pasture supplementation. Protein supplementation has been shown to increase intake of low quality forages (Delcurto et al. 1990) and can improve the nutrient balance of the diet. Protein is typically considered the primary limiting nutrient for animals grazing dormant season native grasslands (Bodine and Purvis 2003) and in this study, despite the fact that the CP content of the whole oats plants was not higher than that of the native grassland´s (**Tables I** and **II**), supplemented animals were able to harvest an overall better diet both in quantity and quality compared to C animals, as discussed before. Besides, oats presented greater digestibility (lower ADF) than native grasslands and also more than 10 cm height on average, thus allowing the maximum intake to occur (Realini et al. 1999). The access of calves to an additional high-quality forage during winter had a positive effect on the native grasslands herbage mass without changes in forage quality by the end of Phase II, which in turn improved the selectivity and the intake of the animals during both evaluated phases. The greater herbage mass of native grasslands paddocks for E during Phase I could be related to the substitution of the native grassland consumption by oats, suggesting that intake was more limiting for MthF and C treatments during this Phase. Furthermore, different grazing pressures have been associated with differential development of buds and their underground burial as well as with plant reserve accumulation of native grasslands species (Esterich et al., 2016). Hence, through a differential indirect grazing pressure during Phase I, the sward on which C treatment was applied might have affected plant reserves to a degree that the following spring growth (Phase II) was significantly affected, resulting in lower dry matter production compared to the supplemented treatments, especially against E. These changes in the structure and stock of forage would be explaining the higher calves´ performance at the end of Phase II, which could be related to a greater total intake of native grasslands in E treatment.

Allocation of time at pasture can affect animal performance or grazing behaviour of animals entering restrictedly to an improved pasture (Gregorini et al. 2009; Molle et al. 2017). The live weight ADG of animals with access to oats was greater than that of animals in the control group at the end of Phase I (**Figure 2**); however, this response was related with the frequency of oats access within a week´s duration, being greater for E than for MthF animals (**Table III**). In contrast, Kennedy et al. (2009) registered no differences on milk production when evaluating different restricted grazing times (from 6 to 22 h) on dairy cattle. On the other hand, the decrease of total grazing time from 8 to 4 h, negatively affected milk production in a study carried out by Pérez-Ramírez et al. (2008). Differences on animal performance explained by modifications on time allocation may be detected when less than 6 hours per day are evaluated (Kennedy et al. 2009), where a positive correlation between time allocation and grazing time is found. In our study, MthF group was exposed to the oats forage more time each grazing day (5 h 36

Table III. Effect of time-restricted oats grazing by Hereford calves on shrunk live weight (SLW) and average daily gain (ADG) (means, sem) (Efecto del pastoreo restringido de avena de terneros Hereford sobre peso vivo vacío (SLW) y ganancia diaria promedio (ADG) (medias, SEM).

Phase	Parameter	Treatment			sem	P
		E	MthF	C		
I (06/15 - 09/07)	Initial SLW (kg)	130.0	129.5	131.0	4.51	ns
	Final SLW (kg)	192.5 [a]	183.7 [a]	162.7 [b]	6.28	**
	ADG (g/a)	745 [a]	645 [b]	377 [c]	0.33	**
II (09/07 - 11/28)	Final SLW (kg)	247.7 [a]	224.7 [ab]	204.9 [b]	8.95	**
	ADG (g/a)	673 [a]	515 [b]	500 [b]	0.44	*
I & II (06/15 - 11/28)	ADG (g/a)	709 [a]	573 [b]	446 [c]	0.33	**

E, everyday oats grazing frequency; MthF, Monday-through-Friday oats grazing frequency; C, control treatment with no oats access; SLW, shrunk live weight; ADG, average daily gain; (a,b,c) Means within a row with differing letters are significantly different; * = P<0.05; ** = P<0.01; ns= P>0.05.

min) than E animals (4 h), but in this case the positive correlation mentioned by Kennedy et al. (2009) was not found, at least on a daily basis. In fact, MthF animals actually spent less relative time in grazing activities than E animals (**Figure 1b**). In addition to a lesser amount of time spent grazing, the average intake per hour on oats of MthF animals could have been lesser than their counterparts on E group, according to Dougherty et al. (1989). These authors stated that during a grazing session, dry matter intake of cattle is constantly declining, explained by a decrease on hunger and an increase in satiety from consuming herbage at 0.65 to 0.51% LW h-1 after three hours of grazing (with smaller bite size and biting rate), and that it is related with the herbage allowance. Correspondingly, the greater herbage mass and height of native grasslands paddocks in E during Phase I (**Table I**) could be related to a greater substitution rate of the native grasslands consumption by oats in this group, also suggesting that overall oats forage intake was lower for MthF and demonstrating that these animals were not capable to counteract the two days that they were not supplemented compared to E. This greater overall oats consumption for E animals than MthF was reflected on animal performance (**Table III**) and the effect was carried over to the following season (Phase II).

In general, as the level of an energy supplement increases, forage intake decreases (Caton and Dhuyvetter 1997). Correspondingly, as discussed before, the supplemented animals of our study (E and MthF) presented a higher total dry matter intake and a certain level of substitution of native grasslands by oats. In the first 14 days after oats access was withdrawn for supplemented treatments (end of Phase I), the LW of MthF animals registered a considerable performance drawback (**Figure 2**). Comparatively, animals which had an everyday access to oats (E) presented virtually no LW gain, as did control (C) animals at the same stage, suggesting these two similar performances that supplement cessation does not necessary imply a drawback on ADG. According to previous discussion, MthF animals were already in nutritional disadvantage compared to E – because of their incapability to compensate the intake decrease due to the two-day interruption to oats grazing exposure – and the supplement withdrawal may have only intensified this effect. At least for MthF in the first 14 days after supplementation cessation, our results match the findings of Smith and Warren (1986), who identified an inverse linear relationship between LW gained during supplementary feeding and LW gained 90 days after it. Animals from group E and MthF presented similar LW by the end of Phase I (**Table III**), although their native grasslands paddocks showed different average herbage mass and sward height (**Table I**). The superior structure and greater herbage mass of native grassland paddocks on E by the end of Phase I, were sufficient for animals to maintain their LW until the apparent "break of the season", situation that was not observed on MthF animals who decreased their live weight in this short period of time. The inferior nutritional conditions generated during winter (Phase I) for MthF compared to E animals were carried over to the next season (spring, Phase II), which was reflected in lower ADG both during spring and on average throughout the whole experiment.

CONCLUSIONS

The use of deferred native grasslands as a nutritive basis combined with restricted-access to an oats forage crop proved to be a technology tool to improve weaned beef calves´ performance during winter. The positive effect of this pasture supplementation on both animal and native grasslands production continued throughout the following season (spring) and it was related with the grazing time allocation of oats. Oats access frequency of allocation within a week´s duration may have affected herbage intake, the structure and stock of forage of the native grasslands paddocks and subsequently the calves´ performance, both during winter and afterward in spring.

A daily frequency access to oats by beef calves in winter positively affected native grasslands´ production as well as animal performance in the following season compared to a Monday-through-Friday option. Nonetheless, the latter frequency presented higher overall animal and pasture performance than the unsupplemented treatment, which means that it is possible to save the time and effort associated with the animal transferring activities from one paddock to another of two labour-consuming days of the week and still achieve better results than non-supplementing. The trade-off between labour cost and animal performance can be taken into consideration when the livestock farmer decides to implement a winter supplementation using a cultivated pasture.

The existence of a positive feedback between pasture supplementation and native grasslands was also identified, which may be an element to take into consideration to improve pasture management of grassland-based production systems in the future.

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