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Research Paper

Demonstrating control of forage allowance for beef cattle grazing Campos grassland in Uruguay to improve system productivity

Demostración de la mejora en la productividad de los sistemas ganaderos a través del control de la oferta de forraje sobre pasturas de Campos en Uruguay

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Abstract

While low-cost technology can be applied within beef cattle systems to improve economic output and decrease economic risk, methodologies to increase adoption by farmers deserve attention. Here we report 4 case studies where low-cost, high-impact technology was applied on commercial farms in an endeavor to demonstrate increased physical output in what we describe as 'Producer Demonstration Sites'. Forage allowance (FA) affects forage growth, forage intake by animals and energy partitioning to maintenance or production. We decided to demonstrate the benefits to production from controlling forage allowance at specific recommended levels. While we focused on FA, other management tools, e.g. suckling restriction and energy supplementation of cows prior to breeding, were tested in different contexts and time periods to improve the critical responses mentioned. While increases in production from 3 of the farms were demonstrated, only 2 of the farmers showed interest in implementing the strategies on their farms subsequently. We conclude that control of forage allowance improved energy intake and animal productivity. For this approach to be successful and increase adoption, it is important to involve the farmers in discussions regarding the proposed changes from the outset as well as the monitoring of progress during the demonstration.

Keywords: Animal management, cattle performance, research validation, spatial-temporal arrangement, stocking rate, subtropical pastures.

Resumen

Aunque existe tecnología de bajo costo para que los sistemas ganaderos incrementen su rentabilidad y disminuyan el riesgo económico, los métodos para incrementar su adopción por los ganaderos requieren mayor atención. Aquí reportamos cuatro casos de estudio donde tecnología de bajo costo y alto impacto fue aplicada en ganaderías comerciales para demostrar cómo incrementar la productividad física, en lo que llamamos 'Sitios Demostrativos'. La oferta de forraje (FA) afecta la producción y consumo de forraje por los animales así como la partición de los nutrientes hacia mantenimiento o producción. Decidimos demostrar los beneficios de controlar la FA en niveles específicos recomendados por resultados experimentales. Aunque nos enfocamos en la FA, otras herramientas, ej. restricción del amamantamiento y suplementación energética durante el entore, fueron recomendadas en diferentes contextos y momentos para mejorar la respuesta animal. Aunque demostramos incrementos en la productividad en tres de los cuatro casos, solamente dos ganaderos se mostraron interesados en continuar implementando las medidas subsecuentemente.

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Concluimos que el control de la FA mejoró el consumo de energía y la productividad animal. Para que este tipo de aproximación resulte en mayor adopción, es importante involucrar a los ganaderos en las discusiones sobre los cambios propuestos así como también en el monitoreo durante el progreso de la demostración.

Palabras clave: Arreglo espacio-temporal de la carga animal, manejo animal, pasturas subtropicales, desempeño animal, validación de tecnología.

Introduction

In Campos grassland (Allen et al. 2011) low net income of beef systems (Aguerre et al. 2015) and degradation of natural grassland by over- or under-stocking are major problems confronting livestock farmers. Beef grazing systems are subject to high variability in herbage production between and within seasons primarily because of rainfall and temperature variability and animal energy requirements due to physiological stage in breeding females (lactation, gestation, mating) or stage of growth in fattening cattle. However, manipulation of forage allowance [FA, in kg DM/kg live weight (LW); Sollenberger et al. 2005] coupled with suckling restriction, flushing and weaning for cow-calf systems and sown perennial pastures with grazing-time restriction and allocation for fattening systems could reduce the impact of variability in the feed resource on animal production. Management of FA requires variation of stocking rate ('put-and-take' method) at paddock or system scale, and measurement of forage mass. Previous authors have found that criteria for variation of stocking rates on farms normally are not based on experimental information, which may reduce the opportunity to improve animal production (Paparamborda 2017). Forage allowance (FA) experiments demonstrated the benefits of its control, improving animal production per ha in beef cow-calf systems by increasing individual animal production at lower or equal stocking rates (Claramunt et al. 2017; Do Carmo et al. 2018).

To control FA from paddock to paddock through time, stocking rates have to be varied. In years of below-average rainfall, areas of stockpiled forage may be needed to maintain stocking rates (Derner and Augustine 2016), and/or supplementation in combination with stockpiled forage may be adopted, because sales are not possible without adverse economic consequences (Derner and Augustine 2016). The farm area allocated for forage conservation will depend on the potential accumulation of forage per ha, the period without forage production owing to dry or cold conditions when feeding is needed, the number of animals to be retained during the critical period (essential nucleus of the system, sales planning) and average stocking rates achieved under different FA levels for many years. Given the variability in forage production between years, maintenance of a more or less equal number of livestock and level of production can be achieved only with stockpiled forage (which leads to moderate stocking rates at the system scale) and/or supplementation (with concentrates) during the critical years. Feeding of stockpiled forage can be combined with nitrogen fertilization of native pasture (C4 plants, to increase herbage accumulation) in spring in areas where high responses to N fertilizer are achieved due to deep soils with good water availability (Derner and Augustine 2016).

For beef cow-calf systems, Soca et al. (2007) and Do Carmo et al. (2016) at the School of Agronomy, Universidad de la República (Uruguay) proposed that the breeding and calving seasons and hence cow energy requirements be synchronized with the pattern of forage production (Funston et al. 2016). This would also ensure satisfactory body condition scores (BCS) at calving. They recommended that the breeding season commence at the beginning of summer (December) to achieve high annual pregnancy rates. Short-term suckling restriction and energy supplementation at the beginning of the breeding season were recommended for primiparous and multiparous cows calving in lower BCS than recommended (Soca et al. 2013; Do Carmo et al. 2016).

For growing beef steers and heifers, grazing experiments in Brazil on Campos grassland showed the benefits on animal productivity per animal and per ha of controlling FA, although with high variability in average daily gain (ADG) (Soares et al. 2005; Mezzalira et al. 2012). When FA was changed for different seasons, i.e. 1 kg DM/kg LW in spring and 2–3 kg DM/kg LW in summer, autumn and winter, ADG during winter was improved (Soares et al. 2005). On farms, the farmer has the opportunity to vary the combinations of paddocks used, the timing of grazing, the classes of stock grazing at particular times and the actual FAs for different times and groups. For instance, beef cows can be used during winter (FA $\geq$3 kg DM/kg LW) to remove the mature dry forage, improving the pasture condition for growing-fattening steers during the next growing season. Monitoring of forage mass over time within and between paddocks is imperative for managers to assign appropriate stocking rates and animal categories based on pasture condition and FA standards. This allows for better decision making for each animal category and aids in coping with climate variability (Derner and Augustine 2016).

Three factors influence the production from grazing systems, namely: forage growth; forage intake; and energy partitioning to animal maintenance or production; and the 3 processes can be improved by controlling FA at a high level (Moojen and Maraschin 2002; Do Carmo et al. 2016). For this reason we focused primarily on managing FA, and applied the other tools (suckling restriction, nutritional flushing of breeding females, grazing time restriction and grazing sown pasture) when appropriate.

Our hypothesis was that manipulation of FA in any beef production system (cow-calf, growing or fattening) could improve production from the particular system, and also indirectly improve the other processes and positively affect the overall farming system. For this reason we focused on the most limiting process for each farm. Our objective was to demonstrate, within a technology transfer project, the benefits of manipulating FA in both cow-calf systems in association with other techniques (suckling restriction and flushing) and growing-fattening systems (joined with sown pastures and grazing time restriction). A further aim was to demonstrate the benefits of spatial-temporal management of paddocks by grazing with growing animals (spring–autumn, i.e. September–May) and beef cows (winter, i.e. June–August) through improved forage use efficiency. We aimed to increase acceptance of these strategies by demonstrating them on 4 commercial beef grazing systems as 'Producer Demonstration Sites'. In selecting the particular sites we considered the unique characteristics, restrictions and knowledge of each manager and employed a continuous dialogue in implementing the techniques proposed, in an easy way according to each manager.

Materials and Methods

Background

Technological proposals that focus on FA and its manipulation to improve animal production are available for growing cattle. When FA on Campos grassland was maintained between 2 and 3 kg DM/kg LW, ADG of growing steers varied from 0.25 to 0.5 kg/head/d on average, with annual gain per head varying between 91 and 180 kg (Moojen and Maraschin 2002; Soares et al. 2005; Mezzalira et al. 2012).

Forage allowance expressed as kg DM/kg LW has not been the most frequent expression of FA in Campos grassland experiments (Moojen and Maraschin 2002; Soares et al. 2005; Mezzalira et al. 2012). Rather, those works report FA as % of LW which require a time period specification, and affect the calculated value of stocking rate, although FA expressed as kg DM/kg LW is easy to explain and estimate, if data for forage mass (kg DM/ha) and stocking rate (in kg LW/ha) are available. We collected data for forage mass, stocking rate and ADG of growing steers grazing Campos grassland from published papers as well as M.Sc. and Ph.D. theses (Grazing Ecology Research Group at UFRGS, Brazil) to develop 'rules of thumb' for FA, which would provide an optimal combination of ADG and stocking rate (Table 1). For beef cows, we developed FA standards based on research developed from 2007 (Do Carmo et al. 2016; 2018) plus previous information that recommended target forage height and BCS of cows during the lactation-gestation cycle (Soca et al. 2007; see Table 1). For fattening animals we were unable to locate grazing experiments for Campos grassland, and for this reason standards presented are a mixture of beef cow values and empirical experience collected in this project (Table 1).

Table 1. Forage allowance (kg DM/kg LW) standards derived from research results which might apply in commercial systems.

Animal category	Forage allowance per season			
	Spring[1]	Summer	Autumn	Winter
Growing steers or heifers (up to 300 kg LW)	1–2	2–3	2–3	2–3
Beef cows	≥6	≥6	≥6	3–4
Fattening steers (300–500 kg LW)	4–6	4–6	4–6	10

[1]Seasons were defined as: Spring = September, October and November; Summer = December, January and February; Autumn = March, April and May; Winter = June, July and August.

Producer Demonstration Sites and methodological procedures

From May to September of 2012, we spent time looking for 'partners' inside groups of farmers. Finally, we chose 4 farms, each one inside of one group of farmers as follows: Case 1 located at 31°35´ S, 56°30´ W; Case 2 located at 32°32´ S, 56°07´ W; Case 3 located at 32°34´ S, 54°40´ W; and Case 4 located at 33°28´ S, 55°26´ W. The study was conducted from November 2012 to July 2015. Rainfall on the farms or nearby is presented in Figure 1, and soil types and botanical composition of pastures on each farm are presented in Table 2.

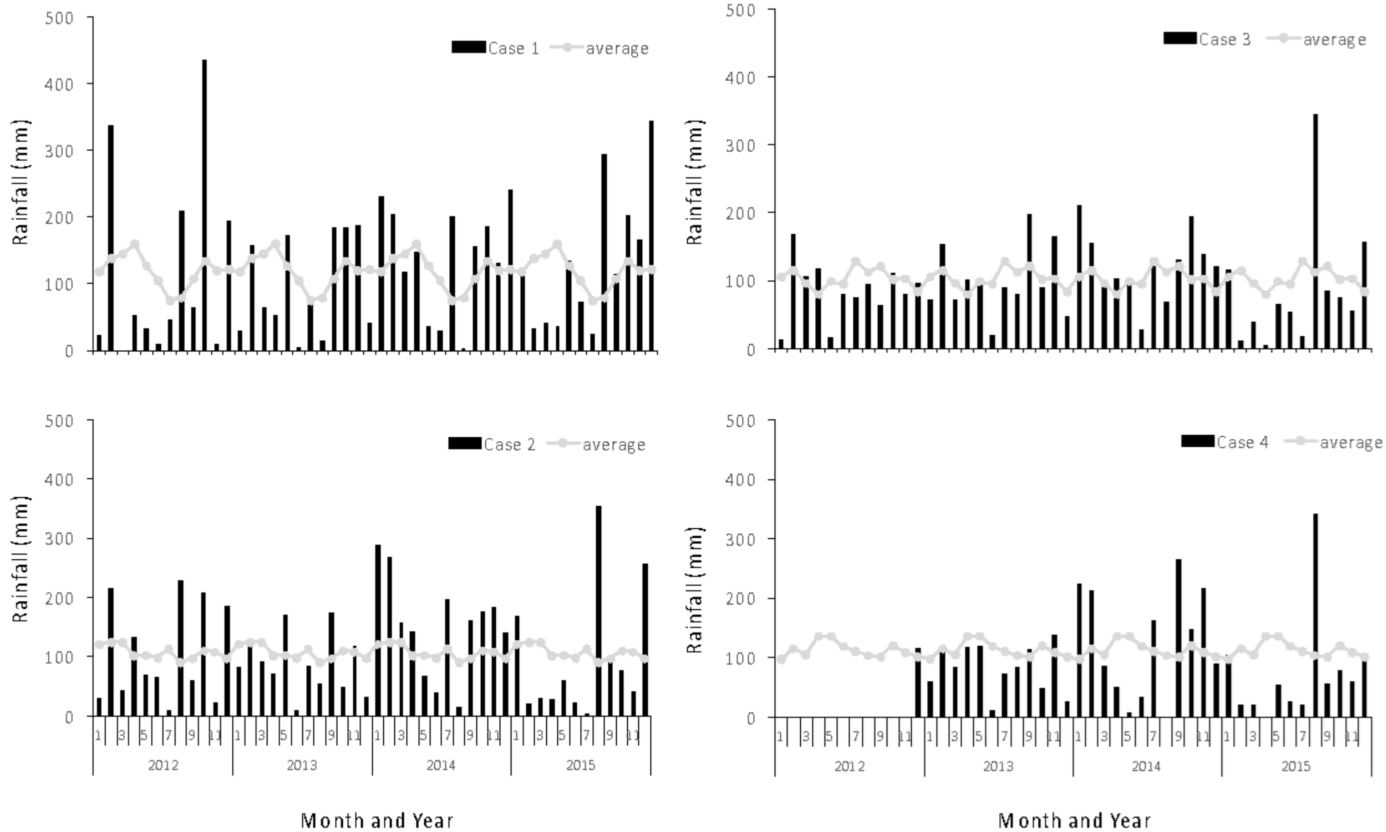

Figure 1. Monthly rainfall (2012–2015) near the farm (Cases 1 and 2) and on the farm (Cases 3 and 4) compared with the medium-term average (1961–1990) for the nearest city to each farm. Rainfall data for Case 4 during 2012 were not available.

Table 2. Soil and vegetation characteristics where 'Producer Demonstration Sites' were established.

	Soils[1] (USDA classification)	Vegetation (% of each species)
Case 1	Udorthents and rock outcrops (mainly); Hapludolls in minor proportion	*Paspalum notatum* (17%), *Bothriochloa laguroides* (14%), *Schizachyrium spicatum* (10%), *Aristida echinulata* and *Piptochaetium montevidense* (5% each), *Coelorachis selloana* and *Cyperus* sp. (4% each)
Case 2	Hapludolls, Argiudolls and Hapluderts (mainly) and Udorthents and rock outcrops (lower proportion)	*Paspalum notatum* (25%), *Bothriochloa laguroides* (12%), *Schizachyrium spicatum* (10%), *Coelorachis selloana* and *Trachypogon montufari* (7% each), *Aristida venustula* and *Cyperus* sp. (6% each)
Case 3	Dystrudepts and rock outcrops	*Paspalum notatum* (28%), *Cynodon dactylon* (10%), *Axonopus* sp. and *Paspalum plicatulum* (8% each), *Piptochaetium montevidense* and *Setaria* sp. (5% each)
Case 4	Argiudolls, Hapludolls, Hapludalfs and rock outcrops	*Axonopus* sp. and *Paspalum notatum* (20% each), *Bothriochloa laguroides*, *Cyperus* sp., *Paspalum dilatatum* and *Coelorachis selloana* (5% each)

[1]Soil information is based on Durán et al. (1999).

For cow-calf systems, manipulation of FA was coupled with suckling restriction (calves heavier than 70 kg fitted with nose plates for 11 days starting at the beginning of the breeding season) and flushing of cows (2 kg of rice bran, on a fresh basis, for 20–25 days, after suckling restriction; Soca et al. 2013) at the beginning of the breeding season and weaning of calves in March-April. Suckling restriction was applied only to calves heavier than 70 kg (Soca et al. 2007) and all calves received suckling restriction at different times (in Case 3 in 2 groups, based on weight of calves).

For fattening steers, even when very high FA on native pastures was applied during autumn-winter, loss of live weight was observed. In order to overcome this phenomenon, we proposed grazing pastures of ryegrass (*Lolium* spp.) or fescue (*Festuca* spp.) during this period (fescue is a perennial grass and is the cheaper option, but has lower initial forage production), since they produce high quality forage during the autumn-winter period. Restriction of grazing time has the potential to increase carrying capacity of the pasture under use (Soca et al. 2010), and introducing animals to the pastures at dusk has the potential to improve forage utilization (Gregorini et al. 2006). For these reasons, we promoted restricted grazing time (18:00–6:00 h), to achieve high stocking rates on the ryegrass without affecting animal performance (Gregorini et al. 2006).

On the other hand, to alleviate climatic variability in grasslands with shallow soils where conditions for forage production are 'narrow' (high risk of drought), applying nitrogen fertilizer to native pastures during spring and summer (growing season) can greatly contribute to improved forage production and we recommended it in one case (Case 1).

In 'real systems' the concepts exposed above are often not applied, possibly due to ignorance or lack of 'know how' to apply appropriate management options, perceptions of greater effort involved or that the extra income does not justify the effort involved.

Measurements of forage mass and height were obtained by the 'comparative yield method' (Haydock and Shaw 1975) using a 5 or more points scale (depending on the range of heterogeneity of the herbage), with samples spanning the range being harvested and dried in a forced-air oven at 60 °C until constant weight. Using data from the harvested samples as reference points, a systematic sampling procedure (>100 points per paddock) was used to visually estimate the average forage mass. Forage height was measured with a ruler (in the 5 point scale quadrats) at the level below which 80% of the vegetation was estimated to occur visually, ignoring tall stems (Stewart et al. 2001).

Body condition score (BCS) for beef cows was estimated visually using the system of Vizcarra et al. (1986), and unfasted live weights of animals (LW) were used.

In Table 3 general information on the 4 farms at the beginning of the project is presented.

Case 1. As shown in Table 3, productive performance was already high, i.e. pregnancy rate was high and age of steers at slaughter indicated that ADGs would be in the range of experimental reports for growing steers and heifers (as explained above). However, the objective was to increase output of fattening steers, and we saw an opportunity to improve fattening by altering the system of paddock use by the various animal categories. Some paddocks were traditionally assigned to a particular animal category, e.g. 1 paddock was used exclusively by steers, because it was considered a 'good' paddock given the combination of deep (30–40%) and shallow (70–60%) soils, and water availability (water from a stream across the paddock). We proposed to graze this area with steers only during spring-autumn and introduce pregnant beef cows during winter, in order to remove the mature dry forage accumulated during the spring-autumn period. Forage allowance during winter was monitored monthly and kept at 3–4 kg DM/kg LW (Do Carmo et al. 2018), which is a low FA for beef cows. High stocking pressure is needed to adjust the coefficient following a growing season when FA was high, e.g. if herbage mass is 2,500 kg DM/ha and desired FA is 3 kg DM/kg LW, then 833 kg LW/ha should be placed in the paddock. At the end of winter, mature forage was removed by the cows, herbage mass being decreased from 1,852±1,118 kg DM/ha (average ± standard deviation) at the end of autumn to 994±923 kg DM/ha at the end of winter and a new cycle of steer fattening commenced, with FA adjusted to ≥6 kg DM/kg LW. In previous years, steers lost weight in this paddock during winter; with the rearrangement, shifting steers to other paddocks, which were grazed until the end of summer and destocked to accumulate forage during autumn, allowed steers to either maintain or lose less weight during winter. Experimentally we used this protocol of lower FA during winter to consume the forage generated during the growing season, with an increment in the stocking rate (lower FA) of the paddock (Do Carmo et al. 2018).

As a further measure, owing to the high percentage of shallow soils and climatic variability, we encouraged the manager to increase forage production by applying N fertilizer to the paddock (22 ha) with the deepest soils and the greatest water storage capacity. This strategy was designed to reduce the effects of rainfall variability on livestock energy intake, and ensure forage was available in the event of severe climatic conditions. Greater herbage production without increasing stocking rate can result in increases in individual forage intake or stockpiled forage.

Other management technologies suggested, like levels of FA or suckling restriction, were already being applied by the farmer. The FA proposed for steers and beef cows (Table 1) was similar to that employed by the manager from his own experience. Production from the farm in kg LW (sales – purchases – deaths +/- differences in total weight of animals during a year; i.e. 100–110 kg LW/ha annually) was relatively high compared with the national average, i.e. 64% weaning rate and 70 kg LW/ha per year (Paparamborda 2017).

Table 3. General information for each farm and each beef process at the beginning of the technology transfer project.

	Case 1	Case 2	Case 3	Case 4
Farm size (ha)	450	2,200	260	360
Average stocking pressure (kg LW/ha)	230–260	300–320	250	230–320
Historic pregnancy rate (%)	85–95	85–95	70	---
Season of breeding	Summer	Summer	Summer and Autumn	---
Age of steers at slaughter (years)	3–3.5	3–3.5	---	---
Age of heifers at first joining	2	2	2–3	---
Forage mass (kg DM/ha) at the beginning	1,600	6,000	978	3,000
No. of breeding cows	80	200	94	---
No. of steers	129	800–900	---	270

Case 2. On this farm all animal processes were practiced, e.g. breeding cows and growing and fattening steers, and production was near 140 kg LW/cow/year, suggested as the desirable goal (Moojen and Maraschin 2002; Soares et al. 2005; Mezzalira et al. 2012). Since pregnancy rates in the cow-calf operation were already high (Table 3) and we observed that forage mass remaining on pastures at the end of grazing by steers was higher (6,000 kg DM/ha) than was needed (2,500–3,000 kg DM/ha), we focused on refining the growing and fattening process. Our aim was to increase stocking pressure and have steers consume a greater percentage of available pasture, thereby increasing production per ha, but without changing liveweight gains per animal.

As in Case 1, paddocks were 'historically' assigned to different categories of animal, with paddocks containing deepest soils and probably greater forage production being assigned to steers all-year-round. In the first year FA for fattening steers (>400 kg LW) was increased from 5 to 8 kg DM/kg LW depending on ADGs during the previous month for spring-autumn, and during winter it was further increased to 10 kg DM/kg LW. However, ADGs were negative from May to August (autumn-winter) during the first year, so we proposed introducing 2 changes. The first was to graze beef cows on these areas during winter to remove the mature dry forage accumulated during the previous growing season when grazed by fattening steers (as in Case 1). Secondly, to overcome the problem of negative ADGs during winter with heavy steers we considered 2 possible options: the feeding of supplements or planting C3 pastures like ryegrass or fescue. We encouraged the manager to plant perennial ryegrass (first year), that behaves as an annual ryegrass without seed production, with the aim of planting perennial fescue pasture the following year in order to reduce the unit cost of the DM produced. During 2014, 40 ha were planted with ryegrass, and steers were allowed access to this pasture only from 18:00 h to 6:00 h as proposed by Gregorini et al. (2006) and Soca et al. (2010). During the day they returned to native pastures (stocking rate of 4 steers/ha, FA of 0.8–1.5 kg DM/kg LW) with water ad libitum. Stocking pressure on ryegrass was regulated via a 'put-and-take' method, to allow 2 or 3 kg DM/kg LW and/or 6–10 cm residual forage height.

Based on information from Soares et al. (2005) and Trindade et al. (2016) and the expectation of better performance when forage mass was in the range of 1,500–2,000 kg DM/ha, we allocated growing steers and heifers to paddocks with a higher percentage of shallow soils, where forage growth was lower and it was easier to maintain forage mass in this range. However, these paddocks were larger than 100 ha and distance from water points to some sections of the paddock exceeded 1 km, which can affect grazing distribution negatively. To make grazing distribution more even we encouraged farmers to drive their stock to distant grass areas and to place low-moisture protein supplements on these distant areas (Bailey et al. 2008).

Case 3. This farm occupied 860 ha divided into 3 separate 'fields', 2 of which were mostly grazed by livestock not owned by the land owner, so we focused on the 'field' (260 ha) grazed by his own livestock. The main activity there was a cow-calf operation. While previous records of calving and weaning rates and weights of calves were limited and it was not possible to reconstruct them, the owner claimed a weaning rate around 70%. The owner's first restriction on management changes was that total number of animals on the area could not be changed, but internal movement between paddocks within the 'field' was possible. The 'field' was comprised of 4 paddocks: 160 (Main), 80, 14 and 4 ha. The last 2 paddocks contained native pastures oversown with *Lotus subbiflorus* cv. El Rincón, and were used to fatten culled cows. We made all the measurements of forage on the Main paddock and focused on lactating or pregnant cows, the most energy-demanding category.

First, we measured forage mass (978±354 kg DM/ha) and cow BCS (4.4±0.63) in November 2012 (spring-summer; Figure 2). The herd in the Main paddock contained lactating cows, early pregnant cows, growing heifers and cows that had not calved the previous year (it is a common practice to maintain non-pregnant cows from one year to the next, even though they eat grass without producing calves). Target FA was 6 kg DM/kg LW in the Main paddock, to increase forage production and energy intake of lactating cows. At the same time, for lactating cows with calves heavier than 70 kg, suckling restriction (attaching a nose plate to the calf to prevent suckling) was applied for 11 days (Soca et al. 2013; Figure 2). To reach the desired FA of 6 kg DM/kg LW in the Main paddock, we relocated some animals based on physiological status (lactating or empty or pregnant) and energy stored in the body (body condition score). Pregnant cows, growing heifers, non-gestating non-lactating cows (empty dry cows) and cows with BCS greater than 4.5 (n=24 of 96 cows) and a bull were removed to the 80 ha paddock at the beginning of the breeding season (10 December 2012). Animals moved to this smaller paddock had lower energy requirements than lactating cows with BCS lower than 4.5. Forage allowance in the Main paddock in November 2012 was 4.4 kg DM/kg LW, which increased to 6.2 kg DM/kg LW after relocation of the less-demanding animals. This increment in forage allowance resulted in an increase in forage mass in the following month (1,272±755 kg DM/ha), helped by the average rainy spring-summer of this year (Figure 1). Thus, to maintain FA at the desired level, some animals had to be re-introduced from the 80 ha paddock.

Forage mass increased until March 2013 (2,398±781 kg DM/ha) because of high forage growth (average rainy summer), and the FA was maintained at 6 kg DM/kg LW until May 2013. During winter, C4 plants grew little, and we adjusted numbers to maintain FA above 3 kg DM/kg LW. We recommended feeding cows a rice bran supplement at the beginning of the breeding season in December-January (after suckling restriction period); however, this advice was not heeded.

During winter 2013, sheep (n=140) were introduced, in part to control weeds (*Senecio selloi* and *S. grisebachii*), and were maintained throughout the project period.

Case 4. This farm was composed of 5 separate 'fields', totaling 2,362 ha. We worked on a single paddock of 120 ha within a 'field' of 360 ha, and growing beef steers was the main enterprise. The owner insisted that the herd be managed as a whole, so we could not move a group of animals to other paddocks within the 'field'. This inflexible restriction virtually made all efforts futile. To control FA (relationship between forage mass and animal live weight per unit area), herd size or area of the paddock must be modified when changes in forage mass occur. In both years we adjusted stocking rate in May to provide FA of 6 kg DM/kg LW, which is not the best FA for growing animals (Table 1). Employing a lower level of FA may result in overgrazing for an extended period and make later adjustments impossible. After the FA adjustment in May, FA was monitored without the possibility of varying animal number.

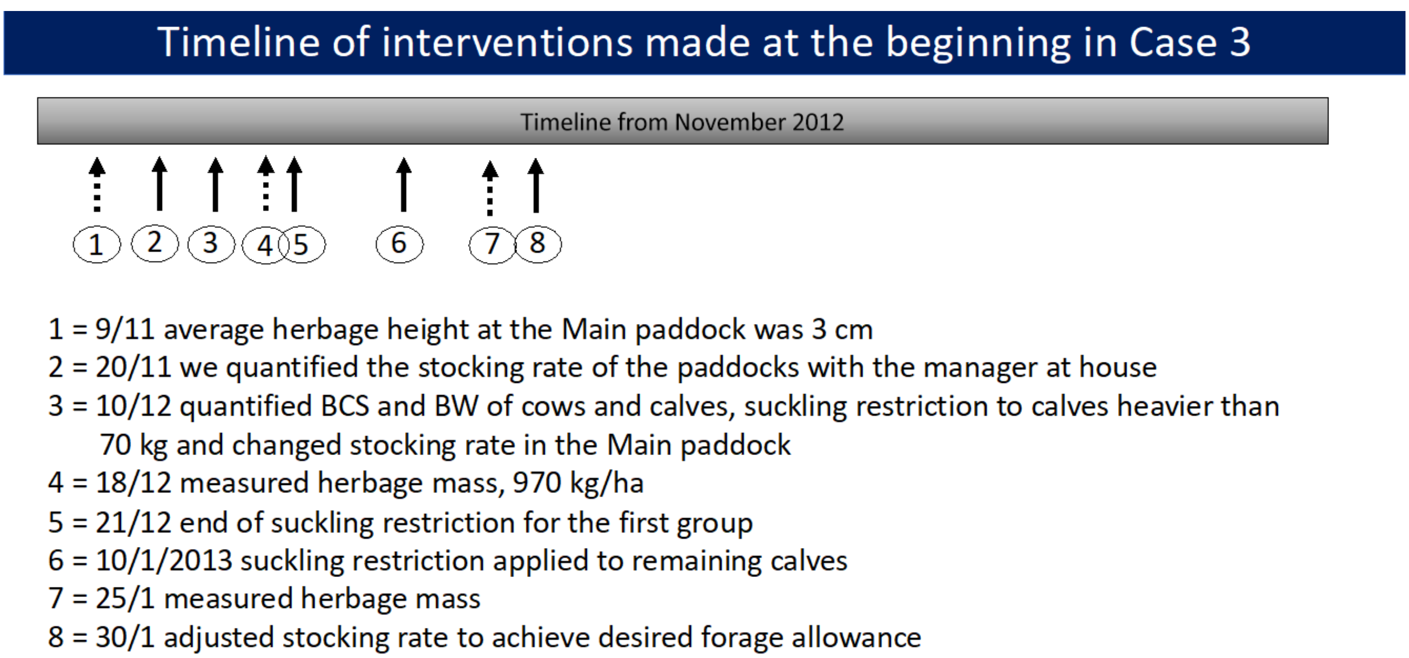

Figure 2. Sequence of tasks and decision-making activities at the beginning of the breeding season for Case 3. Dotted arrow represents forage measurements and solid arrow task or decision taken. Dates are expressed as day/month/year.

Results

Case 1

Since original management of the cow-calf and fattening systems approached the recommended strategies, increments in production were marginal, i.e. 8–9%, an increase of 10 kg LW/ha/yr from a base of 110 kg LW/ha. Changes of paddock and seasonal use by different animal categories plus applying nitrogen fertilizer to pasture were the innovations applied, as FAs already employed by the producer were close to recommended levels and were maintained. Suckling restriction (use of nose plates on calves), already a current practice on the farm, was applied along with feeding an energy supplement to flush cows before the breeding season during a short drought (December 2013 and 2014).

Case 2

On native pastures, positive ADGs ranged from 0.1 to 1.4 kg/d, depending on season and paddock, but our data recording did not permit us to determine if LW gain/year was improved, because we focused on finishing of heavier steers and not recording LW changes for single groups of animals throughout a complete year. Stocking pressure in paddocks under FA control during the fattening phase was 560±297 kg LW/ha, while the average on the farm was 342 kg LW/ha. Increments in LW production were 63 and 21% from the average of 120 kg LW/ha/yr for Years 1 and 2 at the paddock scale. Seasons greatly affected ADGs, which were -0.42, 0.9, 0.55 and 0.03 kg/hd/d during Winter, Spring, Summer and Autumn, respectively, for fattening animals, although these are not for the same animals in different seasons. For growing animals ADGs were -0.15, 0.5, 0.5 and 0.08 kg/hd/d during Winter, Spring, Summer and Autumn, respectively. On ryegrass pastures ADGs ranged from 0.8 to 1.1 kg/hd/d and stocking pressure from 825 to 1,487 kg LW/ha during 2014 and 2015. However during 2015 the growing season for ryegrass was limited by severe drought conditions (Figure 1) during Autumn-Winter 2015 that delayed the establishment and growth of the pasture.

Case 3

Mean calf weight at weaning in May was 153 kg with pregnancy rate (April) of 88%. For the second year, pregnancy rate was 90% and calf weight at weaning (April) was 168 kg. Pregnancy rates for Years 1 and 2 were 7 and 18% units, respectively, greater on the focus farm than on a large sample of farms in the area (47,000 cows analyzed). Stocking pressure (255±61 kg LW/ha) was maintained throughout the years, with any variation imposed by the manager and FA management. In Figure 3 we show the stocking pressure management within the Main paddock and the rest of the farm (and average of the farm) to adjust FAs to our recommendations. It shows the 'put-and-take' method on the farm as a whole, where stock numbers in the Main paddock and the rest of the farm were modified to maintain desired FAs. First, stocking pressure increased on the rest of the farm, although as forage mass increased in the Main paddock, stock were reintroduced to increase stocking pressure to maintain the desirable FA. The 'put-and-take' method was implemented taking into account physiological state and animal category, considering the energy demand or capacity to use body reserves. The product of weaning rate × calf LW at weaning represents the production of calf LW per cow exposed and values were 107, 135 and 151 kg LW/exposed cow, for the 'historical', Year 1 and Year 2, respectively.

Case 4

Despite the severe restrictions to desirable management, production was 120 kg LW/ha in this paddock, 20 kg above the average for the other 'fields'.

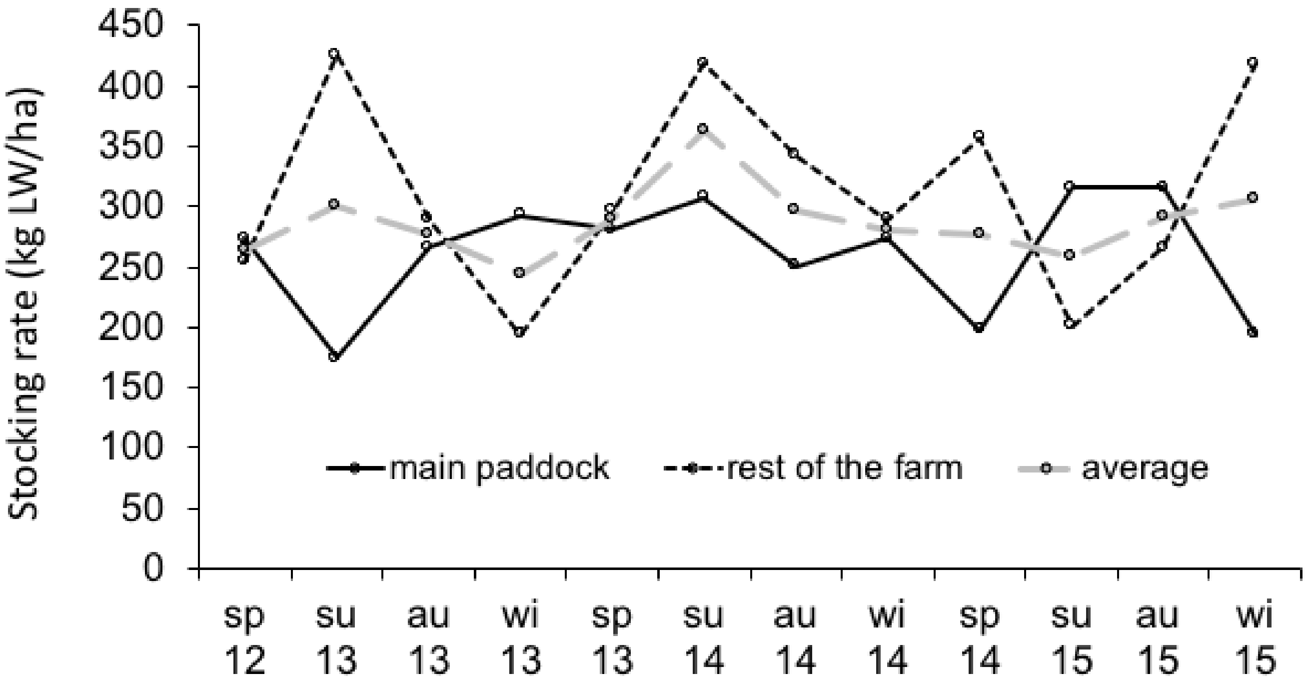

Figure 3. Stocking pressures (kg LW/ha) in the Main paddock and the rest of the farm (rest of property). Sp = spring, su = summer, au = autumn and wi = winter; numbers 12 to 15 represent the years 2012 to 2015.

Discussion

For selection of the co-operating producers, we met many groups of producers to explain our ideas and try to encourage them to follow the recommended process on the demonstration site. However we clearly failed to engage the groups of producers effectively and 2 of those who agreed to work with us (Cases 3 and 4) failed to accept our recommended management strategy.

Interaction with farm managers was challenging because their definition of success affected their willingness to implement change. Most of the recommended changes involved low-cost methods, which were easy to implement and directly impacted animal production, taking into account the 'constraints' of the farm or farmer. Animal production increased on all farms, but with differences due to plasticity-adaptability of the decision making of the farmer to change management. Economic output was not measured, but should have increased, because increments in animal production were achieved without greater cost (with the exception of sowing ryegrass in Farm 2 and applying N fertilizer in Farm 1, the other management changes do not impose additional costs and could decrease work load; Albicette et al. 2017), but greater decision-making was involved, addressing issues of time and space and different animal categories and physiological stages.

Case 1

Probably the most important change in the farm operations was the change in paddock use in winter by different animal categories, which allowed better individual performance for fattening steers, since previously they grazed the senescent herbage from the previous growing season resulting in weight loss. Whereas the reproductive performance of beef cows grazing on senescent herbage during gestation period is not affected, in spite of a reduction of their BCS from 5 or plus 5 to 4 or plus 4 (Do Carmo et al. 2016), the performance of steers grazing in another paddock on forage accumulated during autumn improves. Most of the other low-cost technologies were being applied on the farm before our intervention in the decision-making process. For the manager, adjusting stocking pressure to accommodate differences in available pasture was easy to apply because he had already done so on the farm, with quite good results in terms of increased animal production. However, the results and information obtained would have been enhanced if there was better trust between the parties; trust can be built up only over time, and the project term was short, which did not allow the development of the necessary trust to demand higher quantification of the process and outputs. The manager was kind, but a reserved person, and we were interested in: maintaining the relationship with him and his group; and making progress in terms of management of herbage and livestock, even with low registry of stocking rate and LW to make the process easy for the manager. The group of producers which he represented did not get involved with the management of the farm during the study, and did not participate in the discussions between us and the farmer on the farm. We have no information on whether they adopted any of the strategies subsequently.

Case 2

We started the project as a contest with the manager, as we managed 1 paddock (61 ha) and he managed the adjacent paddock (51 ha); the commitment was to not reduce ADG, but stocking rate could be changed according to our criteria. After 2 months of equal ADGs but greater stocking rates in the paddock under our control because of high forage mass (it was the opposite situation to Case 3, where we had to decrease the stocking rate in the Main paddock at the beginning), the manager decided to change the grazing management on the farm, and we were able to control the management of a larger area, up to 350 ha (5 paddocks). For native pastures, previous information about ADGs during fattening was unavailable, but Soares et al. (2005) had shown that ADGs for growing steers were greater during spring (0.8–1.4 kg/d) and summer (0.4–0.8 kg/d) than during autumn (-0.1 to +0.1 kg/d) and winter (-0.2 to -0.6 kg/d). Mezzalira et al. (2012) reported much lower ADGs on a similar experimental field (managed for more than 30 years under the same FAs), while Soares et al. (2005) reported on the same study and showed significant 'year' effects on ADGs under the same FA treatments. However other factors could be involved, e.g. paddock size in the experiments (Soares et al. 2005; Mezzalira et al. 2012) was lower than 10 ha while paddocks on the farm were from 50 to more than 100 ha. In the larger paddocks distance to watering points exceeded 1 km in some sections, which could result in uneven grazing and lower FAs on areas grazed. On this farm, stocking rate in the paddocks under our control had to be increased from the beginning, because forage mass was very high, and we had the opportunity to increase stocking pressure while maintaining ADGs, as a result of adjusting FA.

Paddock size affected the ability to graze a particular paddock with different animal categories (cows vs. steers) in different seasons (growing season and winter), because cow numbers were too low to apply this management in paddocks of 120 ha or greater. Therefore we used the cow herd in paddocks of 40–60 ha, to remove mature dry forage in winter. Adjusting animal categories grazing a given area allowed higher stocking pressures to be maintained than in paddocks grazed only with growing animals throughout (560 vs. 345 kg LW/ha).

At a system level, potential changes in overall production were not achieved because it was not possible to increase the total number of animals on the farm. For many periods of time more than 800 ha (of the total 2,200 ha) were ungrazed, showing the potential to increase the overall stock numbers without decreasing individual performance and as a consequence, increasing overall production. The management of FA, incorporating paddock condition-animal category or paddock condition-animal physiological state combinations, was performed on only 16% (350 from 2,200 ha) of the farm, and could be extended to the remainder to further improve the efficiency of forage utilization, as in Case 3. The 'put-and-take' method was applied before we arrived, based on the farm manager´s own criteria and not on experimental evidence. He became highly involved with the forage mass measurements and application of FA standards for management (Table 1), showing a great willingness to apply these principles and extend them to the other 'field' of 900 ha. A constraint on the area to which FA management can be applied is the capacity to perform estimates of forage mass in one day, timing for trips from and to the experimental station, and also the amount of forage mass samples to process and store. However the manager had found a way to apply the FA management by using paddocks, where the herbage mass was quantified, as a 'reference' to adjust FA in other paddocks without herbage mass quantification. His group of producers were more engaged in the management discussions which were held, although we do not know if it resulted in changes in management on their farms in terms of FAs and subsequent changes in production.

Case 3

Increments in pregnancy rate and calf weight at weaning were a product of FA management, herbage use efficiency matching energy requirements with FA and pasture condition and suckling restriction. Production of calf LW/cow exposed to bulls increased by 27–55% if one adopts a baseline pregnancy rate of 70% and calf weaning weight from the first year of 150 kg. Ruggia et al. (2015) and Tittonell et al. (2016) reported average increments of 20% for many farms employing the same approach (management and decision making changes with no input increments). In this case, the manager did not get involved with the measurements of forage mass and livestock management, which is the central issue of the strategy; he left all decision making in our hands, with the sole restriction of not changing the overall stock numbers. Although techniques were not completely applied, as we recommended, the impact on animal production was high. The failure of the manager to become fully involved with the demonstration was probably partially our fault, because communication was less than ideal. The benefits of the management changes were not well communicated, in the sense that the overall work load related to monitoring the health and nutritional status of the animals has the potential to decrease if planning and quantitative information (forage mass, cow BCS, FA management) are taken into account for decision making (Albicette et al. 2017). Despite increases in production the farmer was unwilling to change his existing management strategy and would have reverted to his old system when the study concluded. This illustrates the complexity of the process to convince farmers to alter their decision making processes, which may have been practiced for decades, even when economic benefits can be demonstrated.

Case 4

The inflexible management kept ADGs and production levels almost constant compared with the average, and at values lower than potentially achievable if flexible management could be applied (Soares et al. 2005). Owing to constraints imposed by the manager (fixed stocking rate or management of steers as a single group) the FA levels applied were higher than the recommended levels, as insurance against possible gaps between forage production and forage demand from animals, limiting potential improvement in meat production.

The manager considered that the proposed decision making process was highly complex or not compatible with his livestock management. This attitude is unfortunate as increases in animal production and economic outcome rely on improved management of FA coupled with other techniques that allow increased energy intake by growing animals.

Our commitment with his group of farmers, combined with the desire to change his mind about FA management, kept us on the farm until the end of the project. Otherwise we would have abandoned this kind of manager because it was an unproductive relationship. Trust between producer organizations and research institutions can be built up only with time (years working together) and experiencing both good (like Case 2) and bad outcomes (like this one). It is important to highlight both situations (good and bad) in terms of innovation, to make us more astute in choosing a cooperator to demonstrate new technology and to determine which characteristics of a farmer are important, to improve the effectiveness of the technology transfer process.

Conclusions

Extension theory suggests that demonstrations of research technology on commercial farms make the results more acceptable to other farmers than if it is implemented on a research facility. The control of forage allowance was possible without changing the average stocking rate of the farms by reallocation at paddock level and taking into account the animal energy demand. It is important to involve the manager and preferably surrounding farmers in discussions of the project from the outset, discussing the basis for the changes to be implemented. If possible, these same people should be involved in any measuring and monitoring that occurs during the exercise. In this way all involved are fully aware of the physical inputs needed to accurately estimate pasture availability and monitor animal performance to assess the benefits of the strategies implemented.

Despite our best intentions we were unsuccessful in convincing the cooperating farmers in Cases 3 and 4 to accept our recommendations, which highlights the difficulties involved in achieving technology adoption, even when the recommended methods for most effective technology transfer are utilized.

"Any change, even a change for the better, is always accompanied by drawbacks and discomfort": Arnold Bennett.

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