Impacts of Livestock Preference and Frequency of Grazing on Production and Nutritive Value of Pastures in Chile

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Impacts of livestock preference and frequency of grazing on production and nutritive value of pastures in Chile

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Abstract. Cattle are selective grazers since they only consume some plants or some parts of a plant from the pasture and avoid others. Grazing preference is affected by characteristics of the pasture such as the botanical composition, pasture surface height, herbage mass, phenological stage, digestibility, fibre content, protein and ash content. Three studies were conducted in southern Chile to determine how: 1) grazing preferences of dairy cattle was influenced by pasture mixtures and fertilisation; 2) grazing selectivity was related to tiller features; and 3) grazing leaf-stage influenced pasture quantity and quality. For the first study, fertilised pastures had higher herbage mass, pasture height, *Bromus valdivianus*, metabolisable energy and crude protein content and had lower fibre content. Grazing time (GT) and bite number (BN) were positively related to metabolisable energy, crude protein content, pre-grazing herbage mass and pasture surface height, explained by the contribution of *Lolium perenne* and *B. valdivianus*. For the second study, selective grazing was enhanced by pasture heterogeneity and tiller volume may have favoured grazing probability at a similar nutritive value. For the third study, pastures grazed at a 2.5 leaf-stage yielded a higher herbage mass than those grazed at 1.5 leaf-stage, while increasing leaf-stage decreased pasture quality. Integration of the information on grazing preference and selectivity, and grazing frequency will help to refine grazing management for southern Chile.

Keywords: Polyphyletic pasture, grazing preference, selective grazing, leaf-stage, forage quality.

Introduction

This paper will investigate three studies in southern Chile (Valdivia; 39º47`S, 73º13`W) to determine how 1) grazing preferences of dairy cattle was influenced by pasture mixtures and fertilisation; 2) grazing selectivity was related to tiller features; and 3) leaf-stage influenced pasture quantity and quality. The experimental findings will be discussed in context with the existing literature.

Grazing preference

Cattle are selective grazers since they only consume some plants or some parts of a plant from the pasture and avoid others (Mayland and Shewmaker 1999). Preference is an important component of the selection process by the grazing animal (Stuth 1991) and has been defined by Hodgson (1979) as the discrimination that animals show between types of pastures or their components, when these have the same probability of being grazed.

Studies conducted with cattle grazing different forage species and also considering the different parts of the plants, have shown that grazing preference is affected by characteristics of the pasture such as the botanical composition (Rutter *et al*. 2004), pasture surface height (Ginane *et al*. 2003), herbage mass (Bailey 1995), phenological stage (Ginane *et al*. 2003), digestibility (Hodgson and Brookes 1999), fibre content (Griffiths *et al*. 2003), protein content (Bailey 1995) and ash content (Phillips *et al*. 1999).

Materials and Methods

In the south of Chile, grazing preference was assessed with dairy cows (grazing time, bite number and bite depth) with evaluations of dry matter production and pasture nutritive quality for established pastures with different forage species with fertiliser application (200 kg N/ha, 150 kg K/ha, 30 kg P/ha and 1000 kg/ha of lime per year) or without fertiliser application (Balocchi *et al.* 2010). They established three types of pastures: (a) polyphyletic pasture (POL), composed of *Bromus valdivianus* Phil., *Holcus lanatus* L., *Agrostis capillaris* L., *Arrhenatherum elatius* spp. bulbosum (Willd) Spenner and *Lotus uliginosus* (Schkuhr), (b) mixture of *Lolium perenne* L., *B. valdivianus* and *Trifolium repens* L. (LBT), and (c) mixture of *L. perenne* and *T. repens* (LT). Herbage accumulation and nutritive value were measured at each grazing event using the methodology of Griffiths *et al*. (2003), considering three strips delineated with double-stranded non-electrified fence. Dairy cows previously trained to be familiar with the experimental arrangement were used. Grazing preference was evaluated once each season over two consecutive years.

Results and Discussion

Fertiliser application maintained high herbage mass production over time (Table 1) and when fertiliser was not applied, pasture condition decreased, resulting in low density of desirable forage plants and the invasion of broad leaf species (Table 2). The fertilised polyphyletic pasture was dominated by *B. valdivianus* and showed similar yields to LBT and LT. This high contribution of *B. valdivianus* in fertilised pastures has been previously reported by López *et al*. (1997) with *B. valdivianus* and *L. perenne* dominating

Table 1. Annual accumulated herbage mass for three different types of pastures. Significance indicated by ******P*≤0.001. **Values followed by different letters in a column signify significant differences.

Treatments	Season 2002-2003 (kg DM/ha)	Season 2003-2004 (kg DM/ha)	Season 2004-2005 (kg DM/ha)
Lolium + *Bromus* + *Trifolium* - no fertiliser	6081 b	4905 d	3305 b
Lolium + *Bromus* + *Trifolium* - with fertiliser	10919 a	13144 b	9299 a
Lolium + *Trifolium* - no fertiliser	7094 b	5398 cd	3582 b
Lolium + *Trifolium* - with fertiliser	12094 a	12509 b	10165 a
Polyphyletic - no fertiliser	7187 b	5880 c	4239 b
Polyphyletic - with fertiliser	11858 a	15762 a	10985 a
Significance	***	***	***

Table 2. Pregrazing herbage mass of the pasture and individual species, measured over 4 cm (kg DM/ha). Average of four seasons. Significance indicated by* *P*≤0.05; ** *P*≤0.01, ****P*≤0.001; n.s. *P*>0.05. Lp: *Lolium perenne*, Bv: *Bromus valdivianus*, Hl: *Holcus lanatus*, Ac: *Agrostis capillaris*, OGr: other grasses; Leg: forage legumes, BL: broad leaf species. Values followed by different letters in a column within a year signify significant differences.

Pasture type	Herbage mass	Lp	Bv	Hl	Ac	OGr	Leg	BL
First year								
Lolium + *Bromus* + *Trifolium*	908	332 a	293 b	0.2 b	144	0	4.9	147 b
Lolium + *Trifolium*	1008	456 a	1.6 c	0.2 b	129	0	5.3	306 a
Polyphyletic	1196	8.9 b	841 a	96 a	103	4.3	0.2	105 b
Significance	n.s.	**	**	**	n.s	n.s.	n.s.	**
Fertiliser application								
With fertilisation	1378	503	528	53	63	2.8	3.4	132
Without fertilisation	697	29	299	11	185	0	3.5	241
Significance	**	**	*	*	**	n.s.	n.s.	*
Second year								
Lolium + *Bromus* + *Trifolium*	654.90	136 a	155 b	72 b	126	1,6	20	77
Lolium + *Trifolium*	735.60	197 a	82 b	179 a	112	2,9	38	109
Polyphyletic	851.04	53 b	265 a	32 b	160	4,4	33	137
Significance	n.s.	**	**	**	n.s.	n.s.	n.s.	n.s.
Fertiliser application								
With fertilisation	925.44	206	259	102	96	4,7	18	127
Without fertilisation	568.91	50	75	86	169	1,2	43	89
Significance	*	***	***	n.s.	n.s.	n.s.	n.s.	n.s.

in high fertility soils.

The three types of pastures had similar pre-grazing herbage mass, but differed in the contribution of the individual species (Table 2). Pasture type did not show a significant effect on the variables related to grazing behaviour of the cows in both years. In contrast, fertiliser application had a significant effect on all the variables evaluated, with the exception of residual pasture height in the second year (Table 3).

Fertiliser application resulted in a pasture with greater surface height. These results might be explained as dominant species in fertilised pastures, such as *L. perenne* and *B. valdivianus*, have an erect habit of growth and differs with *T. officinale*, *L. nudicaulis* and *H. radicata*, which were dominating non-fertilised pastures. Fertilised pastures had a lower fibre content and higher metabolisable energy and crude protein content (data not presented).

Grazing time, bite number and bite depth have been related to herbage mass, tiller density and pasture height (Gibb *et al*. 1997). Total bite number defines with greater clarity the behaviour of the grazing animals (Holmes *et al*. 2002), having a direct relationship to residual pasture height. Thus, an increase in total bite number results in a lower residual height and therefore a greater bite depth (Tharmaraj *et al*. 2003).

Grazing time (GT), bite number (BN) and bite depth (BD) were subjected to a canonical variate analysis. Preference (GT and BN) was found to be positively related to metabolisable energy, crude protein content, pre-grazing herbage mass and pasture surface height, explained by the contribution of *L. perenne* and *B. valdivianus*. Preference appeared to be negatively related to NDF content and the contribution of *H. lanatus.*

Selective grazing

Selective grazing has been defined as the preferential defoliation of plants or parts of plants by grazing animals, modified by the characteristics of the field, such as geomorphology and fencing (Hodgson 1979). Selectivity is regulated by the interaction between the landscape

Table 3. Pasture surface height (cm) and grazing behaviour, average of four seasons. Significance indicated by * *P*≤0.05; ** *P*≤0.01, ****P*≤0.001; n.s. *P*>0.05. PSH: Pasture surface height (cm); GT: Grazing time (sec/plot); BN: Bite number (n°/plot); RPH: Residual pasture height (cm); BM: Bites per minute (number/minute); BD: Bite depth.

Pasture type	PSH	GT	BN	RPH	BM	BD
First year						
Lolium + Bromus + Trifolium	13.4	48.1	40.8	7.9	50.9	5.5
Lolium + Trifolium	12.4	55.7	52.4	7.6	56.4	4.8
Polyphyletic	13.9	50.8	47.8	7.9	56.5	5.9
Significance	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Fertiliser application						
With fertilisation	14.7	63.9	56.8	8.3	53.3	6.5
Without fertilisation	11.7	34.8	37.1	7.3	63.9	4.5
Significance	*	**	**	*	**	*
Second year						
Lolium + Bromus + Trifolium	16.3	47	47.6	10.5	60.8	5.8
Lolium + Trifolium	16.0	54	56.5	9.8	62.7	6.2
Polyphyletic	15.5	52	50.8	9.5	58.6	6.0
Significance	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Fertiliser application						
With fertilisation	18.0	64	63.2	10.0	59.3	8.0
Without fertilisation	14.0	38	40.1	10.0	63.3	4.0
Significance	***	***	*	n.s.	*	*

heterogeneity, characteristics of the grazing animal and pasture which can cause patchiness and pasture heterogeneity, accentuating changes in the botanical composition, plant architecture and density, and pasture nutritive value (Stuth 1991).

Pasture heterogeneity normally varies across seasons. Seasonal environmental constraints on plant growth are constantly changing, mainly as the interaction between temperature and rainfall (López and Valentine 2003; López *et al*. 2009). For example during Summer drought, species such as *B. valdivianus* and *Dactylis glomerata* L. tend to grow more than *L. perenne*. When water restriction diminishes during autumn, *L. perenne* normally increases in the pasture. During summer animals select *B. valdivianus* and *D. glomerata*, which are actively growing. Physical soil features and grazing animals (through disturbance, *i.e.* animal trampling) may also increase pasture heterogeneity (Vallentine 2001). Other studies have shown that grazing cows select species according to the season of the year and nutritional value of forages (Hirata *et al*. 2010).

When animals have the possibility, they consume forage of higher nutritive value. This capability depends on the manner that they physically select a plant or a part of a plant, i.e. sheep and goats grip the forage with the lips and cut it with the teeth, while bovines take and cut with the tongue, thus sheep and goats have a better possibility to select different components of plants (Vallentine 2001). Studies with bovines have, however, shown them to be capable of selecting pasture species during grazing.

Materials and Methods

Grazing selectivity was assessed between *L. perenne*, *B. valdivianus* and *A. capillaris*, in a naturalised pasture grazed by 300 cow/ha for a period of 6 hours, from June to December. Full details are in López *et al*. (2010). Measurements included total tiller lamina length of *B. valdivianus*, *L. perenne* and *A. capillaris* and tiller lamina number before and grazing.

Results and Discussion

Cows consistently selected *L. perenne* and *B. valdivianus* over *A. capillaris* (López *et al*. 2010). This might be related to tiller features that positively affect defoliation, such as tiller height, leaf number, lamina length and tiller total lamina length. Studies with sheep (López *et al*. 2003) and grazing European wild boars (Hodgkinson *et al*. 2011) have shown that, for vegetative tillers, tiller height has a strong positive relationship to grazing probability. But also, it seems that leaf number interacts with tiller height, such that, a greater number of leaves per plant is positively related to grazing probability. For instance, when *B. valdivianus* is in the 3.0 leaf stage, *L. perenne* is at the 2.5 leaf stage, whereas when *B. valdivianus* completed 5.0 leaf stage, *L. perenne* reached 4.0 leaf stage. However, the leaf stage of *A. capillaris* was similar to that of *L. perenne*, but with shorter lamina, and simultaneously *B. valdivianus* and *L. perenne* showed higher grazing probability than *A. capillaris* (López *et al*. 2010).

Another factor that influences grazing decisions is the lamina mass offered at tiller level. *Bromus valdivianus* offered a longer total lamina length and higher overall lamina mass than *L. perenne*, due to its greater number of leaves (López *et al*. 2010). Thus, tillers of *B. valdivianus* have higher apparent tiller mass intake when grazed by dairy cows. The interaction between the number of lamina

Table 4. Total tiller lamina length of *B. valdivianus* (Bv), *L. perenne* (Lp) and *A. capillaris* (Ac) and tiller lamina number before grazing and species probability of been grazed. Significance (Sig) indicated by * *P*≤0.05; ** *P*≤0.01, ****P*≤0.001; n.s. *P*>0.05. Values followed by different letters in a row for each characteristic signify significant differences.

	Total lamina length offered per tiller(mm)				Pregrazing lamina (number per tiller)				Grazing probability			
	Bv	Lp	Ac	Sig	Bv	Lp	Ac	Sig	Bv	Lp	Ac	Sig
Jun.	347 a	290 b	153 c	***	3.0 a	2.4 b	2.2 b	**	0.78 a	0.82 a	0.55 b	*
Sep.	365 a	258 b	154 c	***	3.0 a	2.4 b	2.5 b	***	0.93	0.91	0.73	n.s.
Oct.	497 a	350 b	166 c	***	2.9 a	2.4 b	2.6 b	**	0.97 a	0.90 a	0.68 b	***
Dec.	411 a	341 b	125 c	***	3.0 a	2.8 a	2.4 b	**	0.90 a	0.97 a	0.71 b	***
Mean	402 a	309 b	152 c	***	3.0 a	2.5 b	2.4 b	***	0.87 a	0.88 a	0.68 b	***

Table 5. Pregrazing and residual tiller features of *B. valdivianus* (Bv), *L. perenne* (Lp) and *A. capillaris* (Ac) and lamina length consumed by grazing dairy cows. Significance (Sig) indicated by * *P*≤0.05; ** *P*≤0.01, ****P*≤0.001; n.s. *P*>0.05. Values followed by different letters in a row for each characteristic signify significant differences.

	Pasture species				Total lamina length consumed per tiller (mm/tiller)				
	Bv	Lp	Ac	Sig		Bv	Lp	Ac	Sig
Pregrazing tiller height (mm)	150 b	178 a	114 c	***	Jun.	216 a	175 a	50 b	***
Residual tiller height (mm)	95	94	83	n.s.	Sep.	244 a	182 b	78 c	***
Residual lamina number	1.7 a	1.3 b	1.6 a	***	Oct.	345 a	249 b	72 c	***
Residual lamina length (mm/lam)	76 a	67 a	51 b	**	Dec.	260 a	264 a	59 c	***
Lamina length consumed (mm/lam)	61 a	58 a	10 b	***	Av.	258 a	207 b	63 c	***

per tiller and lamina length, led us to infer that tiller volume may favour grazing probability at a similar nutritive value (Tables 4 and 5).

Grazing Frequency

In rotational grazing systems, the grazing interval is a criterion that is related to pasture allowance and a given stocking density, and sets the rate of pasture utilisation (Poff *et al*. 2011). The grazing interval corresponds to the time between two consecutive grazing events; and across time (i.e. growing season or year) determines the frequency of grazing at paddock level. It can be based on day rotations, sward surface height, pre-grazing herbage mass, or leaf stage. Frequency of grazing has been shown to affect pasture production and nutritive value (Turner *et al*. 2006).

Materials and Methods

In the south of Chile (Valdivia; 39º 47` S, 73º 13` W) a three-year study was conducted to determine the effect of frequency of grazing on pasture production and nutritive value. In May 2006 a *L. perenne – T. repens* mixture was sown. Three grazing frequencies based on leaf stage (Donaghy *et al*. 2008) were set up (1.5, 2.5 or 3.5 leaf-stage). Pastures were grazed by lactating dairy cows, with stocking density of 300 cows ha^{-1} for a period of 6 hours, aiming for a residual herbage mass of 1200 – 1600 kg DM/ha.

Results and Discussion

Results showed that pastures grazed at a 2.5 leaf-stage yielded a higher herbage mass than those grazed at 1.5 leaf-stage (Table 6). However, an interaction between frequency of grazing and year of evaluation was observed. For the first year, there were no effects of grazing frequency on total herbage mass accumulation (THA). For the second year a higher THA for 2.5 and 3.5 leaf-stage was measured, and that for the 2.5 leaf-stage was higher for the third year. This is partially in line with Fulkerson and Donaghy (2001), who indicated that near the 3 leaf-stage herbage mass accumulation (DM basis) and pasture persistence are enhanced. Pastures grazed at 1.5 leaf-stage showed higher 'D value' (DOMD) than 2.5 and 3.5 leaf-stage (Table 7). A

Table 6. Effect of grazing frequency, year of evaluation and the interaction on total herbage accumulation (THA; kg/DM/year) Significance indicated by * *P*≤0.05; ** *P*≤0.01, ****P*≤0.001; n.s. *P*>0.05.

Frequency		THA	
1.5 leaves		6872 b	
2.5 leaves		7790 a	
3.5 leaves		7201 ab	
Significance		*	
Sem		163.6	
Year			
2006 – 2007		9186 a	
2007 – 2008		6278 b	
2008 – 2009		6399 b	
Significance		***	
Sem		167	
	2006 - 2007	2007 – 2008	2008 – 2009
1.5 leaves	9337	5519	5762
2.5 leaves	9154	6596	7620
3.5 leaves	9069	6720	5815
Significance		***	
Overall sem		284.2	

Table 7. Effect of grazing frequency on 'D value' (DOMD; g dOM/kg DM), crude protein (CP; g/kg DM), neutral detergent fibre (NDF; g/kg DM) and water soluble carbohydrates (WSC; g/kg DM) Significance (Sig) indicated by * $P≤0.05$; ** $P≤0.01$, *** $P≤0.001$. Values followed by different letters in a column for each characteristic signify significant differences.

Frequency	DOMD	CP	NDF	WSC
1.5 leaves	741 a	211 a	413 b	91 b
2.5 leaves	730 b	198 b	426 ab	98 a
3.5 leaves	723 b	178 c	437 a	97 a
Significance	***	***	***	***
Sem	2.2	2.1	3.6	0.8

higher DOMD in plants defoliated at 1.5 and 2.5 than at 3.5 leaf-stage was found by Poff *et al*. (2011). Crude protein content tended to decrease with a lower grazing frequency, which was in accordance with Donaghy *et al*. (2008). Nevertheless, the interaction (not shown) indicated that there were seasons without differences among leaf-stages. Although mean NDF was higher at 3.5 than 1.5 leaf-stage, this was observed only during spring of year one and autumn of year three. It is expected that NDF content increases with lower grazing frequencies (Donaghy *et al*. 2008), as the sheath and stem proportions are positively correlated with NDF content and increased with longer grazing intervals (Chaves *et al*. 2006). These results suggest that within a vegetative stage of growth (1.5 to 3.5 leaf-stages), changes in cell wall structure were of less biological importance than was expected.

Water soluble carbohydrates (WSC) were higher in plants at 2.5 and 3.5 than at 1.5 leaf-stage, however this difference was not consistent across the period of evaluation. The lack of response in WSC content might be associated with climatic conditions, as differences among leaf stages depend on incoming solar radiation and temperature, which determines the net WSC accumulation (Fulkerson and Donaghy 2001).

Conclusions

Studies conducted in southern Chile sowed that fertiliser application significantly increased herbage mass production irrespective of the botanical composition of the pasture. Nutritive value was similar among pastures, and improved with fertiliser application. Dairy cow grazing preference was associated with fertiliser application and closely related to pre-grazing herbage mass, pasture surface height and pasture metabolisable energy, crude protein and fibre content, but not to type of pasture.

Selective grazing is enhanced by pasture heterogeneity. The result of the interaction between the animal perception from the landscape scale to plant level and its parts, constitute the base of the plant grazing and defoliation decision. The physical capability of each animal to separate and consume the desired herbage is an important part on the selective grazing and pasture heterogeneity.

Grazing frequency based on leaf-stage has an impact on pasture production and its nutritive value. Herbage mass accumulation, NDF and WSC content were positively correlated with longer grazing intervals, whereas CP content and DOMD were higher with shorter intervals. However, this trend is not always consistent over time.

To improve the understanding of how all these factors merge together, grazing management must be integrated. This should allow a good animal performance, high herbage mass and nutritive value, and a sustainable grazing system.

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