Animal 17 (2023) 100865

Contents lists available at ScienceDirect

Animal

The international journal of animal biosciences

Pasture brome and perennial ryegrass characteristics that influence ewe lamb dietary preference during different seasons and periods of the day

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ARTICLE INFO

Article history:
Received 31 May 2022
Revised 11 May 2023
Accepted 12 May 2023
Available online 19 May 2023

Keywords:
Ewe behaviour
Food choice
Forage
Nutritive value
Selective grazing

ABSTRACT

Under the current scenario for climate change, *Bromus valdivianus* Phil. (**Bv**), a drought-resistant species, is an option to complement *Lolium perenne* L. (**Lp**) in temperate pastures. However, little is known about animal preference for Bv. A randomised complete block design was used to study ewe lamb's preference between Lp and Bv during morning and afternoon grazing sessions in winter, spring, and summer by assessing the animal behaviour and pasture morphological and chemical attributes. Ewe lambs showed a higher preference for Lp in the afternoon in winter ($P < 0.05$) and summer ($P < 0.01$), while no differences were found in spring ($P > 0.05$). In winter, Bv, relative to Lp, had both greater ADF and NDF ($P < 0.001$), and lower pasture height ($P < 0.01$) which negatively affected its preference. The lack of differences in spring were due to an increase in ADF concentration in Lp. In summer, ewe lambs showed the typical daily preference pattern, selecting Lp in the morning to ensure a greater quality and showing no preference during the afternoon to fill the rumen with higher fibre content. In addition, greater sheath weight per tiller in Bv could make it less desirable, as the decrease in bite rate in the species was likely due to a higher shear strength and lower pasture sward mass per bite which increased foraging time. These results provided evidence on how Bv characteristics influence ewe lamb's preference; but more research is needed on how this will affect preference for Lp and Bv in a mixed pasture.

Implications

Lolium perenne L. and *Bromus valdivianus* Phil. have asynchronous growth, with *L. perenne* greater in winter, and *B. valdivianus* greater in summer. The hypothesis was that grazing ewe lambs prefer *L. perenne* during winter and *B. valdivianus* during summer. Evaluation of both species showed no preference in spring; during winter, ewe lambs preferred *L. perenne*; in summer, *L. perenne* was preferred in the morning and *B. valdivianus* in the afternoon. The grazing preference suggested that ewe lambs adjusted their diets to changing pasture conditions to minimise the effect of low nutritive value or pasture quantity.

Introduction

Mixing Bromus valdivianus Phil. (pasture brome; **Bv**) with *Lolium perenne* L. (perennial ryegrass; **Lp**) pasture is one option to reduce the risk of severe pasture growth rate diminishment, and to increase pasture persistence, due to climate variations such as drought events, (Keim et al., 2015; García-Favre et al., 2022). *Bromus valdivianus* is a perennial grass with a conservative or stress-tolerant strategy, allowing it to continue growing during summer when soil water availability is low (López et al., 2013; Keim et al., 2015; García-Favre et al., 2022). Bv can harvest water from deeper soil layers compared to Lp (Ordóñez et al., 2018), being well adapted to free-draining soils (López et al., 1997). Conversely, under waterlogging that can occur during winter in some temperate regions, Bv growth and survival reduce (Stewart, 1996). In a one-year study in Chile, Bv accumulated similar herbage mass to Lp, but had a greater CP content; and although the metabolisable energy (**ME**) content of Bv was lower than Lp, values in both species were above 10 MJ/kg DM (Calvache et al., 2020). Despite the potential benefits of including Bv in grazing systems and its commercial availability in New Zealand (Nichols et al., 2016), it has not been widely adopted.

The increasing frequency and severity of summer droughts in regions of New Zealand as a consequence of climate change (Henessy et al., 2007), have adversely affected the production and persistence of rainfed Lp pastures (Woodward et al., 2020).

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https://doi.org/10.1016/j.animal.2023.100865
1751-7311/

Under rainfed conditions, the introduction of Bv into perennial pastures is a viable option to retain production and persistence, and the use of Bv is likely to increase in future years. However, little is known about its animal preference or selection. Dairy cows grazing a mixed pasture of Bv, Lp and *Agrostis capillaris* L., actively and intensively selected Bv over Lp during autumn and spring, associated with taller tillers, and longer and greater number of leaves of Bv than Lp (López et al., 2016). No differences in selection were detected during winter due to a heavier grazing intensity (López et al., 2016). To date, there are no studies that have assessed the preference and selection of Bv under sheep grazing Bv and Lp pastures.

Animal preference is determined by their relative intake and discrimination among and within pastures without any environmental or physical restrictions to forage accessibility (Hodgson, 1979; Allen et al., 2011), whereas animal grazing selection is the preference modified by opportunity (Hodgson, 1979). In addition, sheep diet preference changes according to internal requirements, diurnal behaviour, pasture morphological attributes and nutritive value. Without antinutritional components and biochemical differences, sheep preference is first affected by the energy concentration of the species (Villalba and Provenza, 1999). They prefer species with higher ME content, which is associated with low NDF concentration (Balocchi et al., 2013). However, sheep can shift towards fibre-rich feeds (e.g., grass rather than legume) near sunset in order to maintain their rumen fill and avoid night grazing sessions, which constitutes an anti-predator behaviour (Edwards et al., 2008).

In temperate climates, pasture attributes, such as height, drive sheep bite mass and intake rate, which affect their preference and selectivity within species (Edwards et al., 1995; Szymczak et al., 2020). Therefore, rather than rejecting or eating a species, a partial preference between and within plant species is commonly observed in monoculture and mixed pastures (Parsons et al., 1994a; Edwards et al., 2008).

The lack of studies on sheep preference between Lp and Bv, and the likely increased use of Bv in Lp pastures in New Zealand grazing systems, stresses the need for research on any apparent animal preference, and/or partial preference, between both pasture species. The seasonal variability in herbage accumulation of Bv and Lp, along with the variability in nutritive value, driven by rainfall and temperature fluctuations (Keim et al., 2015) may affect the seasonal partial preference of both species by sheep (Somasiri et al., 2020). Addressing changes in animal preference may contribute to explaining the relative abundance of the species in a diverse pasture. The aim of the present study was to evaluate ewe lamb preference of Bv and Lp during the morning and late afternoon grazing sessions across winter, spring, and summer. It was hypothesised that ewe lambs prefer Lp during the winter, and Bv during the summer, associated with the relative herbage masses and nutritive values of the species. During the spring, when the two species are growing at a similar rate (i.e., from the vegetative to reproductive stage), and therefore, have similar nutritive values, a difference in species preference was not expected.

Material and methods

Experimental site

The study was carried out at Massey University's Pasture and Crop Research Unit (40°22′55.8″S 175°36′23.8″E) during winter and spring 2020 and summer 2021 on a Manawatu fine sandy loam (Dystric Fluventric Eutrochrept). The climate is classified as humid temperate with an annual rainfall and mean temperature of 917 mm and 12 °C, respectively. Monoculture pastures of *Lolium perenne* L. cv. Trojan and *Bromus valdivianus* Phil. cv. Bareno were established in October 2018. The total study area was 1944 m^2 divided into eight plots of 244 m^2 each (four plots of each pasture species). The pastures received 50 kg of nitrogen (N) fertiliser, as urea fertiliser (46-0-0) on 20 August 2020. The grazing frequency aimed to achieve a leaf regrowth stage (**LS**; fully expanded leaves per tiller) between 3.5–4.0 for Bv and 2.5–3.0 for Lp, in both cases aimed at allowing the species to recover their carbohydrate reserves postdefoliation (Fulkerson and Donaghy, 2001; García-Favre et al., 2021). The Bv and Lp leaf stage overlap in time and, therefore, grazing could occur simultaneously when both species were theoretically at their target LS (García-Favre et al., 2022). At each observation period (see below), the pastures were in the vegetative stage, avoiding reproductive stem elongation in spring. However, during the period of the study, there were climatic events that distorted the expected growth of both species, such that spring rainstorms and consequently the late spring flowering, and the late dry summer growing conditions altered the time of the evaluation events and the species were not always within their target LS.

Experimental design and treatments

The study was set out in a split plot design with four blocks, in which the main plots were the two pastures species (*L. perenne*; Lp and *B. valdivianus*; Bv) and the subplots (split) were the two grazing observation periods (grazing after sunrise; **AM** and grazing before sunset; **PM**). These two observation periods (2.5 hours each) were selected to match the peak daily grazing activities of sheep (Champion et al., 1994; Penning et al., 1991). Each block contained two contiguous equal-sized areas of each pasture species, which were further divided into two subplots (122 m^2 each for AM and for PM observation periods). The total plot area was 244 m^2, formed by 122 m^2 of each species; no fence was placed between the pastures to enable ewe lambs to have free access to both pasture species at their choice. In addition, the access gates to each block (at AM and PM) were located in the area where the pastures were adjacent, thus half of the gate was in each pasture (Fig. 1).

The ewe lambs were regularly grazed on both species to avoid the novelty effect of an unknown species (Parsons et al., 1994a; Tamura et al., 2010). In between the AM and PM, ewe lambs grazed in a buffer zone with an Lp-based pasture and a water trough. The observations were carried out from 27 to 30 July 2020 (winter), 20 to 23 September (spring) and 1 to 4 March 2021 (summer). On day 1 of each season, AM and PM observations were taken in the subplots of block 1; on day 2, the observations were repeated in block 2, and so on for blocks 3 and 4. The AM and PM observation periods varied among the three seasons due to seasonal change in daylight hours, such that, winter observations were made between 0730–0930 h and 1500–1700 h; spring, 0700–0900 h and 1730–1930 h; summer 0700–0900 h and 1800–20:00 hr.

The same group of 10 Romney non-pregnant ewe lambs was used at all the grazing events. Five to 10 non-core ewes lambs were added to the main flock to achieve a target grazing pressure (relationship between animal live weight and forage mass per unit, as defined by Allen et al. (2011)), of ~25%. Grazing pressure was set low to avoid ewe lamb competition, which could reduce the ability of the ewe lambs to display preference (Clark and Harris, 1985). The ewe lambs were placed in the plots 30-min before the observations began to acclimatise them to their surroundings.

Animal measurements

The behaviour of the ewe lambs was assessed as grazing, chewing, not eating, or lying/sitting, following the procedure of Pain et al. (2015). Briefly, a trained person observed and recorded the

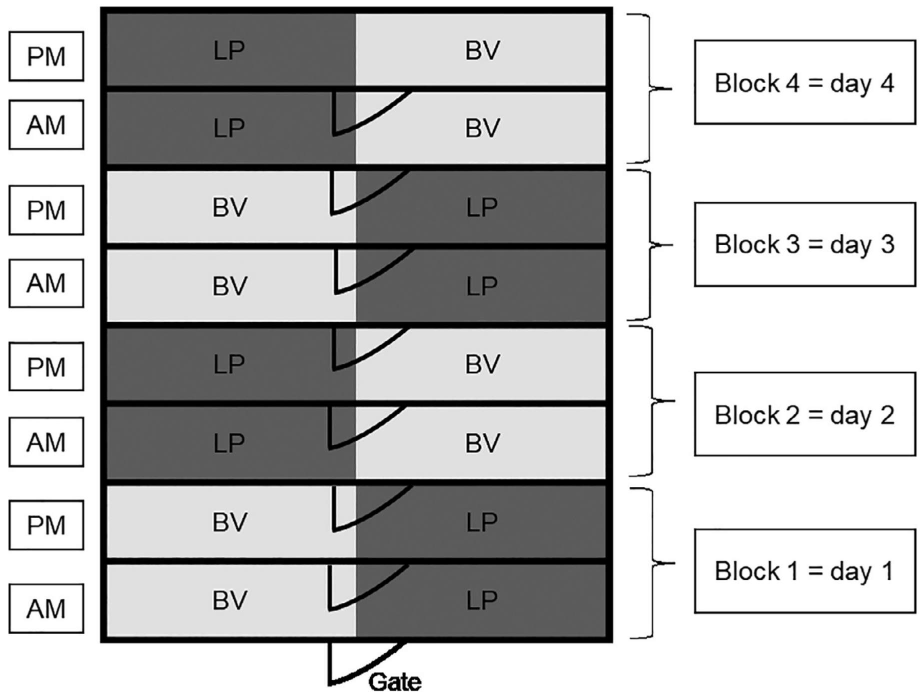

Fig. 1. Experimental design diagram for the ewe lamb grazing study. Fences are illustrated as continuous black lines (—). Abbreviations: BV, *Bromus valdivianus* monoculture; LP, *Lolium perenne* monoculture; AM, morning observation plots; PM, afternoon observation plots.

number of ewes within each pasture and their individual activities (i.e., grazing, chewing, not eating, or lying/sitting) at 5-min intervals (Rook and Huckle, 1997). Grazing time was defined as the period when the ewe lamb was actively grazing or selecting forage with its head down. Chewing time as when the ewe lamb was chewing the recently grazed pasture and the ruminal bolus with its head up. If the ewe lamb was head up with no visible herbage in its mouth, it was recorded as not eating, whereas if the ewe lamb was sitting or lying on the ground, it was recorded as lying/sitting. Diet preference was calculated as the percentage of time a ewe lamb grazed each pasture species (i.e., percentage of time relative to the sum of all activities in both pastures [100%]) (Penning et al., 1991). Bite rate was recorded using the "20 bites method" described by Forbes and Hodgson (1985), which counts the time ewe lambs took for 20 bites. It was recorded at the beginning, middle and end of the 2 h period per ewe lamb, between the 5-min activity assessments by a trained person. If the time between two consecutive bites was longer than 15 seconds, then the measurement was cancelled and restarted (Balocchi et al., 2002).

Pasture measurements

Herbage mass in each block was measured the day before the observation, by cutting at ground level three quadrats (20 × 50 cm). The samples were oven dried at 70 °C for 48 h or until they reached constant weight. Before grazing, 20 random readings of the pasture surface height were recorded for each plot of pasture species using a sward stick (Rhodes, 1981). In addition, lamina and sheath weight per tiller were measured on 10 random tillers per species in each plot, by cutting them at ground level. The leaf regrowth stage was determined at the laboratory and lamina and sheath components were separated from each tiller, oven dried (60 °C for 72 h or until constant weight) and weighed following the same procedure described above. The percentage of lamina dry weight per tiller in each AM and PM observation period was determined by cutting five laminas per species at the ligule position and immediately taking them to the laboratory to be weighed fresh, then dried and reweighed. The dry weight percentage was calculated by dividing the lamina dry weight by the fresh weight.

The difference in nutritive value between the total above-ground pasture mass and the diet selected by ewe lambs was assessed in each plot at each observation period. The total pasture nutritive value was assessed before grazing, such that, in each plot, a composite sample of 10 subsamples of the pasture comprised of a 10 cm diameter frame cut to ground level. The diet nutritive value was assessed as a composite sample of 10 subsamples collected during the PM observation period, simulating the horizon of the pasture consumed by ewe lambs during the AM grazing, the material was collected by using the hand-plucking method (De Vries, 1995; Pain et al., 2015).

All the samples were immediately placed in a −20 °C freezer before freeze-drying. The freeze-dried samples were ground through a 1-mm sieve and sent to the Massey University Nutrition Laboratory (Palmerston North, New Zealand) for wet chemical analysis. These samples were analysed for *in vitro* DM digestibility [**DMD** (Roughan and Holland, 1977)], CP using Dumas method (Saint-Denis and Goupy, 2004), NDF (Mertens, 2002), ADF and lignin (Möller, 2009). In addition, the herbage nutritive value degree of discrimination in each parameter was calculated as the difference (**D**) between the nutritive value of the hand-plucking and the above-ground pasture mass samples (i.e., D-CP, D-NDF, D-ADF, D-lignin, and D-DMD).

Statistical analysis

The statistical analysis was performed using R Statistic software (Team, 2019). A linear mixed model, with lmer function from the lmerTest package (Kuznetsova et al., 2017), was used. Thus, a one-way analysis of variance (ANOVA) was performed on the measured variables to test the significance of the main factors: pasture type, observation period (only for behavioural variables) and their interactions. Pasture type and observation period were considered as fixed effects, whereas block was assumed to be a random effect. The flock mean was used for animal behavioural analysis. Statistically significant differences ($P \leq 0.05$) among least-square means were tested using *lsmeans* package (Lenth, 2016).

A canonical variate analysis was performed using Candisc package (Friendly et al., 2017). The variables included were the pasture morphological traits in the, AM and PM grazing time, and the difference between diet and above-ground herbage mass nutritive value. More details about canonical variate analysis can be found in López, et al. (2003). A regression analysis ($P \leq 0.05$) was performed to test the effect of pasture height on ewes' bite rate for all the three seasons together.

Results

Animal behaviour

Grazing time (grazing %) showed a significant interaction between pasture type and observation period in winter ($P < 0.05$). Ewe lambs displayed preference in AM and PM sessions, grazing 60% and 30% longer in Lp than Bv during the PM and AM, respectively. The rest of the activities did not show any significant interaction with pasture type. Chewing and lying time during AM were greater than PM ($P < 0.01$, and $P < 0.05$; respectively). Bite rate was 14.8% greater in Lp than in Bv ($P < 0.05$), and it was 27.5% faster during PM than AM ($P < 0.001$) (Table 1).

During spring, the ewe lambs grazing time was similar for both species, with a similar bite rate, but the lying time was greater on Bv than Lp ($P < 0.01$). Ewe lambs increased their grazing time and bite rate from AM to PM, by 38% and 31%, respectively ($P < 0.001$ and $P < 0.01$, respectively). Conversely, lying time decreased 64% from AM to PM ($P < 0.01$). During summer, there was a significant interaction for grazing time between pasture type and observation period ($P < 0.01$). Ewe lambs spent 51% less time grazing on Bv than on Lp during the AM, but they grazed the same proportion of time on each pasture during the PM. Chewing and lying time were greater during AM than PM ($P < 0.01$ and $P < 0.05$, respectively). Ewe lamb bite rate increased by 23.7% on Lp compared to Bv ($P < 0.001$), and 15.2% bite rate was 15.2% greater during PM compared to AM ($P < 0.001$) (Table 1).

Pasture morphological variables and nutritive value

The leaf regrowth stages were 3.6, 2.6 and 2.6 for Bv, and 2.8, 2.4 and 1.6 for LP in winter, spring, and summer, respectively (data not shown). Pasture height and accumulated herbage mass were

Table 1
Bite rate and percentage of time allocated to each pasture type (*Lolium perenne* and *Bromus valdivianus*) and to each measured activity (grazing, chewing, lying, and not eating) in ewe lambs during the morning and afternoon observation periods, and the lamina dry weight of pasture types in the morning and afternoon. Results are reported for winter, spring, and summer.

Item	Grazing (%)	Chewing (%)	Lying (%)	Not eating (%)	Bite rate (bites/min)	Lamina dry weight (%)
Winter						
Pasture type						
B. valdivianus	19.3[b]	3.0	8.5	6.4	32.6[b]	19.0[b]
L. perenne	38.8[a]	4.5	11.1	8.3	38.3[a]	19.8[a]
Significance	***	NS	NS	NS	*	*
OP						
AM	25.8	5.2[a]	14.9[a]	4.1[b]	29.8[b]	17.6[b]
PM	32.4	2.2[b]	4.6[b]	10.8[a]	41.1[a]	21.3[a]
Significance	NS	**	*	***	***	***
Pasture type × OP period						
B. valdivianus × AM	20.7[c]	4.5	11.7	3.1	26.5	16.5[c]
L. perenne × AM	30.9[b]	6.0	18.2	5.0	33.0	18.8[b]
B. valdivianus × PM	18.0[c]	1.5	5.3	9.8	38.7	21.6[a]
L. perenne × PM	46.8[a]	3.0	3.9	11.7	43.6	20.9[a]
Significance	*	NS	NS	NS	NS	**
Spring						
Pasture type						
B. valdivianus	32.5	1.1	18.9[a]	4.8	34.9	20.7[a]
L. perenne	30.3	1.4	8.3[b]	2.6	39.4	18.9[b]
Significance	NS	NS	*	NS	NS	**
Observation period						
AM	24.0[b]	1.7	20.0[a]	4.2	32.2[b]	18.0[b]
PM	38.9[a]	0.7	7.2[b]	3.2	42.1[a]	21.6[a]
Significance	***	NS	**	NS	**	***
Pasture type × OP period						
Significance	NS	NS	NS	NS	NS	NS
Summer						
Pasture type						
B. valdivianus	28.5[b]	3.6	8.9	2.5	47.5[b]	25.9
L. perenne	37.1[a]	3.8	13.6	2.1	62.3[a]	25.2
Significance	**	NS	NS	NS	***	NS
Observation period						
AM	25.1[b]	5.3[a]	16.7[a]	2.9	50.1[b]	22.2[b]
PM	40.6[a]	2.2[b]	5.7[b]	1.8	59.1[a]	28.9[a]
Significance	***	**	*	NS	***	***
Pasture type × OP period						
B. valdivianus × AM	16.5[b]	5.0	11.8	2.6	43.7	21.7
L. perenne × AM	33.7[a]	5.5	21.7	3.1	58.1	22.8
B. valdivianus × PM	40.6[a]	2.2	5.9	2.4	51.2	30.1
L. perenne × PM	40.5[a]	2.2	5.4	1.1	66.8	27.6
Significance	**	NS	NS	NS	NS	NS

Abbreviations: OP = Observational period, AM = morning, PM = afternoon. Values within columns with different superscript letters are significantly different at the following levels: *$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$; NS, not significant ($P > 0.05$).

higher for Lp compared to Bv during winter and spring ($P < 0.01$), but similar in summer. Dead matter was 2.2 times higher for Lp in winter, while Bv presented heavier lamina per tiller than Lp in winter (2.3 times; $P < 0.001$), spring (2.4 times; $P < 0.01$) and summer (3.7 times; $P < 0.05$), respectively. The weight of sheath per tiller was also greater for Bv compared to Lp in winter (2.6 times; $P < 0.01$) and spring (1.9 times; $P < 0.01$), with no difference in summer ($P > 0.05$). In addition, the lamina/sheath ratio was only significantly different for summer ($P < 0.001$), which was greater for Bv than Lp (Table 2).

The total above-ground herbage mass nutritive value changed between species across seasons. During winter, the Bv total herbage mass had a higher concentration of CP ($P < 0.001$), NDF ($P < 0.001$), ADF ($P < 0.001$), and lignin ($P < 0.01$), but lower DMD than Lp ($P < 0.01$); during spring, the Bv total herbage mass contained more NDF ($P < 0.05$) and lignin ($P < 0.05$) compared to Lp, whereas in summer, Bv contained greater ADF than Lp ($P < 0.001$) (Table 3). Ewe lambs selected a diet (i.e., hand-plucking samples) in winter with greater CP and NDF, but lower DMD when grazing Bv compared to LP ($P < 0.05$). Similarly, during the spring, the diet of ewe lambs grazing Bv had greater NDF ($P < 0.01$), ADF ($P < 0.01$) and lignin ($P < 0.05$), but lower DMD ($P < 0.01$) than the Lp diet. Lastly, during summer, the diet of Bv selected had greater ADF than the ewes' diet grazing Lp ($P < 0.001$) (Table 3).

The canonical variate analysis explained 86.5% of the total variability between the treatments with a significant Wilks' lambda ($P \leq 0.001$); CAN 1 explained 79.9% ($P \leq 0.001$) and CAN 2 explained 13.9% of the total variation ($P \leq 0.001$) (Fig. 2). Along CAN 1 the treatments were separated by pasture, such that Bv in spring and winter was positively related with increasing lamina and sheath weight. The negative direction of CAN 1 showed a positive association between Lp bite rate in summer, and herbage mass in spring. CAN 2 showed a positive association between Lp and grazing time during AM and PM sessions. In addition, there was a positive association between grazing time and D-ADF and D-NDF and between bite rate, D-DMD and dead matter proportion in pastures (Fig. 2). Lastly, there was a strong negative relationship between bite rate and pasture height for Lp ($r^2 = 0.93$, $P < 0.001$), and a significant but moderate negative relationship between Bv pasture height and ewe lambs bite rate, with a loss of relationship with Bv pasture heights greater than 15 cm ($r^2 = 0.63$, $P < 0.01$) (Fig. 3).

Discussion

The present study contributed to the understanding of the behavioural mechanisms affecting the ewe lambs' preferential grazing for two pasture species that can grow together in a diverse pasture. A partial preference of ewe lambs towards Lp was detected during winter, and regardless of the diurnal grazing sessions, but not during spring, when sward structure did not limit ewe lambs' ingestive behaviour. During summer, ewe lambs preferentially grazed Lp only during the morning, which revealed a diurnal pattern. Besides the productive benefits of incorporating Bv into Lp pastures (García-Favre et al., 2022), this partial preference aligns with the theory that animals seek to maintain a healthy rumen (Rutter, 2006) by grazing diverse species, despite the possibility of a monospecific diet (Parsons et al., 1994a) Therefore, the partial preferences of pasture species, under appropriate grazing intensities, could sustain both species in a mixture, even in winter when Lp is actively growing and Bv is stressed (Edwards et al., 2008; García-Favre et al., 2022).

The preference displayed by ewe lambs for Lp during winter was likely the result of a combination of pasture parameters. Sheep prefer taller pastures with higher herbage mass (Arnold, 1987; López et al., 2003), as befell Lp in winter. The energy content of the pasture, which is inversely related with the fibre content, also affects animal preference and relative energy intake of different species (Newman et al., 1995; Villalba and Provenza, 1999). The 4.7% more NDF and the 2.3% less DMD content in diet of Bv during winter could have reduced the animal consumption and partial preference between species, expressed in grazing time (Cuchillo-Hilario et al., 2018). Interestingly, ewe lambs were able to perform a high discrimination within Bv components (i.e., leaf blade and sheath) and partially compensate for the greater ADF and lignin of Bv compared to Lp (Table 3). However, this may have required extra energy expenditure to perform the discrimination (i.e., increasing walking and handling time), which could explain the lower partial preference for Bv relative to Lp (Parsons et al., 1994b; Garcia et al., 2003). The total nutritive value of the pasture reported in this study was obtained from samples cut at ground level. Therefore, the total pasture nutritive value may not reflect the pasture nutritive value easily available for the ewe lambs when grazing.

It is worth noticing that by prioritising grazing before flowering, Bv was below its optimal LS during spring and could negatively affect herbage mass and pasture height, which were lower than Lp (Table 2). However, regardless of those differences, ewe lambs did not show preference between species during spring. Pain et al. (2015) reported that ewe lambs displayed no preference between adjacent monocultures of *Plantago lanceolata* L., *Cichorium intybus* L. and Lp when the offered pasture nutritive value was similar in spring. In the present study, Bv and Lp above-ground pasture presented similar dead matter, lamina/sheath relationship, CP, ADF and DMD. However, when assessing the diet selected by ewe lambs, differences in all nutritive value parameters but CP were detected, and therefore, they did not explain the similar preference in the

Table 2
Effect of pasture type (*Bromus valdivianus* and *Lolium perenne*) offered to grazing ewe lambs on pasture height, herbage mass, dead matter, lamina and sheath weight per tiller, and lamina/sheath ratio during winter, spring and summer.

Pasture type	Pasture height (cm)	Herbage mass (kg/ha)	Dead matter (%)	Lamina weight/tiller (mg)	Sheath weight/tiller (mg)	Lamina/Sheath
Winter						
B. valdivianus	14.4[b]	1 031[b]	4.2[b]	101.5[a]	54.6[a]	2.0
L. perenne	22.4[a]	1 893[a]	9.3[a]	42.8[b]	20.3[b]	2.8
Significance	**	***	**	***	**	NS
Spring						
B. valdivianus	17.8[b]	1 924[b]	6.35	140.7[a]	123.5[a]	1.5
L. perenne	26.0[a]	2 558[a]	6.45	56.7[b]	62.3[b]	1.2
Significance	**	*	NS	**	**	NS
Summer						
B. valdivianus	10.3	1 431	37.7	75.1[a]	38.8	2.2[a]
L. perenne	11.8	1 678	42.4	20.2[b]	27.6	0.9[b]
Significance	NS	NS	NS	*	NS	***

Values within columns with different superscript letters are significantly different at the following levels: $^{*}P \leq 0.05$; $^{**}P \leq 0.01$; $^{***}P \leq 0.001$; NS, not significant ($P > 0.05$).

Table 3
Effect of pasture type (*Bromus valdivianus* and *Lolium perenne*) presented to grazing ewe lambs in the above-ground herbage mass (cut to ground level) and in the herbage mass samples obtained by the hand-plucking method (data shown in brackets) during winter, spring and summer on CP, NDF, ADF, lignin content and DM digestibility.

Pasture	CP (%)	NDF (%)	ADF (%)	Lignin (%)	DMD (%)
Winter					
B. valdivianus	18.4^{a} (22.0^{a})	47.6^{a} (44.0^{a})	26.6^{a} (22.5)	2.6^{a} (1.9)	68.4^{b} (71.1^{b})
L. perenne	13.9^{b} (18.5^{b})	43.1^{b} (39.3^{b})	23.0^{b} (21.3)	1.6^{b} (1.6)	71.4^{a} (73.3^{a})
Significance	*** (*)	*** (*)	*** (NS)	** (NS)	*** (*)
Spring					
B. valdivianus	17.2 (21.5)	51.5^{a} (44.7^{a})	30.3 (26.8^{a})	1.9^{a} (1.9^{a})	69.4 (71.8^{b})
L. perenne	14.9 (21.0)	47.0^{b} (39.3^{b})	28.6 (23.3^{b})	1.6^{b} (1.3^{b})	71.3 (75.0^{a})
Significance	NS (NS)	* (**)	NS (**)	* (*)	NS (**)
Summer					
B. valdivianus	11.8 (18.3)	61.2 (49.5)	36.1^{a} (28.0^{a})	3.4 (3.0)	62.8 (68.6)
L. perenne	11.2 (17.0)	58.6 (47.7)	30.1^{b} (24.4^{b})	3.1 (2.7)	64.9 (70.5)
Significance	NS (NS)	NS (NS)	*** (***)	NS (NS)	NS (NS)

Abbreviations: DMD = DM digestibility.
Values within columns with different superscript letters are significantly different at the following levels: *$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$; NS, not significant ($P > 0.05$).

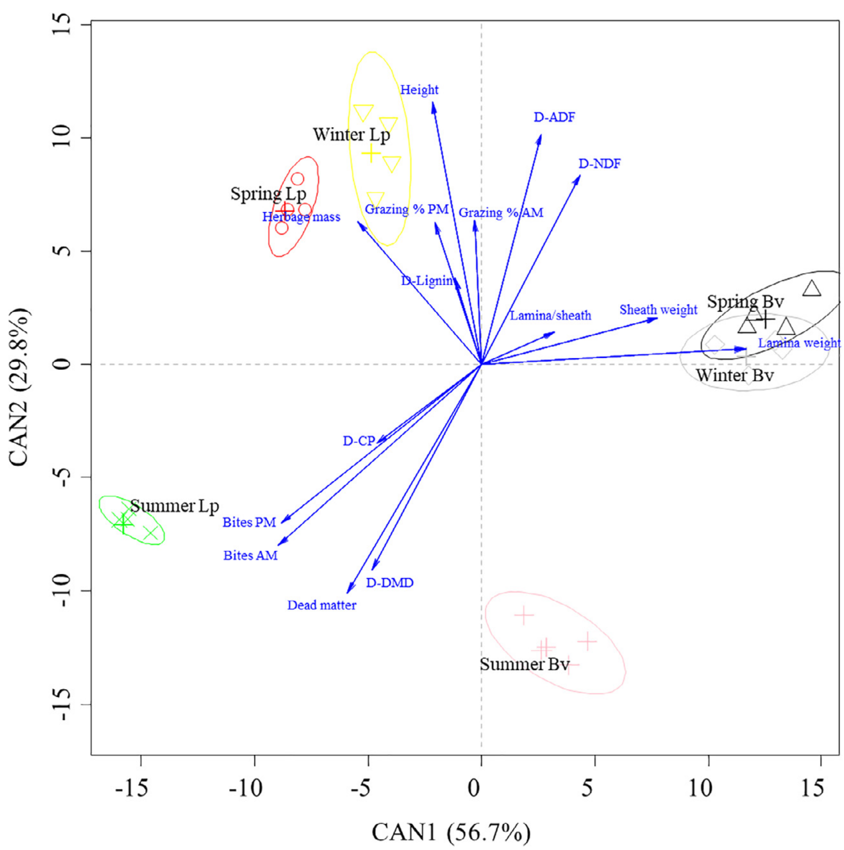

Fig. 2. Canonical variate analysis for relationship among pasture morphological variables, the difference (D) between the nutritive quality of the hand-plucking method and the above-ground herbage samples for DM digestibility (D-DMD), CP (D-CP), ADF (D-ADF), NDF (D-NDF), and lignin (D-lignin), and ewe lamb grazing behaviour parameters. Oval highlighted the 95% confidence interval around the means for interaction of pasture type and season. Abbreviations: Percentage of grazing in the morning (Grazing % AM), percentage of grazing in the afternoon (Grazing % PM), number of bites per minute in the morning (Bites AM), number of bites per minute in the afternoon (Bites PM), *Lolium perenne* pasture (Lp), *Bromus valdivianus* pasture (Bv).

species. Considering that pasture height and herbage mass ranged within the optimal, maximised intake rate for both species (Edwards et al., 1995), it can be interpreted that preference in spring was driven by pasture quantity, instead of nutritive value. Cave et al. (2014) also observed that in early spring when the nutritive value of all of the species in a pasture mix was high, ewe lambs chose a diet of species that were most readily available.

The similar nutritive value in the above-ground pasture mass (except for ADF) and pasture attributes (except for lamina weight per tiller and lamina/sheath ratio) could have explained the similar preference during summer at PM, and the reason the ewes did not attempt to select a diet of better nutritive value, as they exhibited in winter and spring. In addition, a shifting in preferential grazing behaviour from AM to PM was only detected in summer. This can be interpreted that Lp assured a more rapid intake of nutrients than Bv in the morning. However, in the afternoon, ewe lambs may have tried to fill their rumen to the maximum and favour nutrient release during the night (i.e., when ewes are not grazing), performing a less selective grazing (Gregorini, 2012).

It is well known that herbage mass and pasture height affect bite mass and rate, which determine intake rate (Tharmaraj et al., 2003). In the present study, the bite rate was always lower

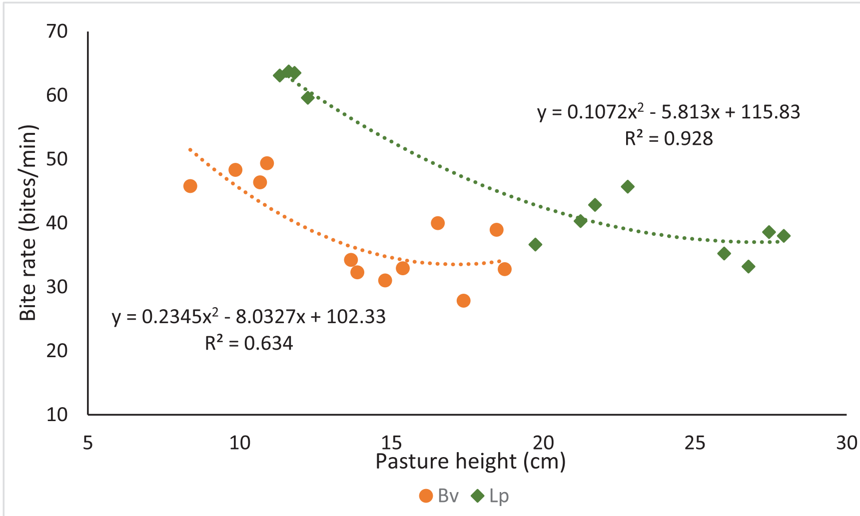

Fig. 3. Relationship between bite rate of ewe lambs and pasture height of *Lolium perenne* and *Bromus valdivianus* monocultures across winter, spring and summer. Abbreviations: *L. perenne* (Lp) and *B. valdivianus* (Bv).

in Bv than Lp, most likely due to a greater time of bite formation (Fonseca et al., 2013), related to a greater lamina and sheath mass in the former (Table 2), but not with pasture height and herbage mass as reported by Illius et al. (1992). Greater sheath mass and a low tiller density are intrinsic characteristics of Bv compared to Lp (López et al., 2013; Descalzi et al., 2018), which increased the distance of plant aerial organs in the pasture, known as divarication (Szymczak et al., 2020). This spatial arrangement increases the searching and handling time, constraining bite formation and bite rate (Prache, 1997; Fonseca et al., 2013). In addition, bite mass is mainly modified by bite depth (Edwards et al., 1995), which is depressed by high amount of high tensile resistance sheaths, negatively affecting bite formation (Benvenutti et al., 2006; Savian et al., 2020). This explains the ewe lambs' preference for pasture structures that allow a greater rate of ingestion (Black and Kenney, 1984) and the lesser preference (expressed in grazing time and bite rate) of Bv pasture, as ewe lambs perceive a diminishment of the energy obtained due to grazing, compared with Lp. The relationship between bite rate and pasture height displayed in Fig. 3 reflects the ewe lambs' bite rate adjustment to the Lp and Bv changes of components of the yield (Table 2) as a consequence of the seasonal growth of both species, highlighting the higher seasonal growth of Lp in relation to Bv (Fig. 3).

Interestingly, the results of the present study are like those reported by Boval and Sauvant (2021) for Lp (Fig. 3), where bite rate decreases to a minimum with 20–30 cm of herbage height. The curve plateau breakpoint between pasture height and bite rate concurs with the maximum bite mass, and it is an indication of the maximum intake rate by ruminants (Boval and Sauvant, 2021). However, it appears that this bite rate-pasture height relationship is applicable to C3 species with similar aerial structure to Lp. For divaricate species, such as Bv, the relationship between pasture height and bite rate was moderate above 15 cm height (Fig. 3). Similar results were reported for *F. arundinacea* Schreb. (Szymczak et al., 2020), a species that has more morphological and ecological similarities with Bv than Lp (Grime et al., 2014). There is a greater range of pasture heights for Lp than Bv, and the greatest heights for Bv have the most variation in bite rate.

The canonical variate analysis identified D-ADF as the main driver of ewe lamb preference in the morning, as indicated by AM grazing time (Table 1). Ewe lambs were selected against ADF content in a greater extend when grazing Bv than Lp (Table 3). This behaviour has been also observed for sheep grazing a range of legume species, which selected against legumes with greater ADF content (Thomas et al., 2010). In addition, the canonical variate analysis showed that ewes actively selected towards a higher DMD in the pasture diet during summer, and in a greater extent compared to winter and spring. The positive association between D-DMD and bite number (CAN 2, Fig. 2), can be interpreted as a compensatory mechanism, where ewe lambs increased searching and walking in summer to maximise diet DMD ingested, rather than reducing the intake rate (Garcia et al., 2003).

All the differences detected between pasture types do not make them mutually exclusive, but rather complementary. For example, a binary mixture of Lp and Bv could alleviate the divarication of Bv monocultures, as Lp could occupy empty spaces between Bv tillers, which may increase the intake rate (Savian et al., 2020; Szymczak et al., 2020). Moreover, adding a species with greater non-digestible fibre may have been an effective way to maintain a healthy and functional rumen (Newman et al., 1995; Rutter, 2006; Edwards et al., 2008). However, these assertions need to be tested.

Conclusion

The present study provided evidence that ewe lambs show partial preference for Lp over Bv in winter and in the morning during summer. This was associated with the higher fibre contents of the Bv in that period. Sheath and lamina weight per tiller and, thus, tiller size are important pasture structures that also affected the partial preference between Bv and Lp. The study also demonstrated that ewe lambs adjust their diet to changing pasture conditions, either due to nutritive value or quantity of pastures.

Ethics approval

Not applicable.

Data and model availability statement

None of the data were deposited in an official repository. The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Declaration of interest

None.

Acknowledgements

The content of this scientific article was published as part of a PhD thesis (García-Favre, 2023).

We thank Massey University Research Fund (MURF) and C. Alma Baker Trust for financial support. In addition, we thank Mark Osborne and Brian Smith for their support and assistance during the field trial. The senior author is thankful for the financial assistance of the Massey Doctoral Scholarship.

Financial support statement

This research received no specific grant from any funding agency, commercial or not-for-profit section.

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