Five-year old, diversified pasture supports greater lamb liveweight gain than a standard perennial ryegrass-white clover pasture

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Abstract

This study investigated liveweight gain of lambs grazing five-year-old pasture of either Italian ryegrass, red clover and plantain (Diversified) or perennial ryegrass and white clover (Standard). Coopworth lambs were born to either diversified or standard pasture and reared there until weaning in December (early summer). Liveweight gain (LWG) from tailing to weaning was 23% higher in lambs on diversified pasture (0.335 kg LWG/lamb/day) compared to those on standard pasture (0.272 kg LWG/lamb/day). From summer to autumn (December to May), liveweight, pasture mass, botanical composition and nutritive quality was measured as weaned lambs progressed through rotationally grazed paddocks of either diversified or standard pasture. Similar lamb liveweight gain between pasture types was observed over summer and autumn, with both groups averaging 0.187 kg LWG/lamb/day. From December to May, dry matter intakes (DMI) and feed conversion efficiencies (FCE) were similar between lambs grazing on either diversified or standard pasture. Average final lamb liveweight off diversified pasture was 4.2 kg higher than off standard pasture. The higher pre-weaning liveweight gain and subsequent greater weaning liveweight off diversified pasture was maintained throughout the summer and autumn.

Keywords: pasture quality, *Plantago lanceolata*, *Lolium perenne*, *Lolium multiflorum*, *Trifolium repens*, *Trifolium pratense*

Introduction

New Zealand pastoral agriculture developed successful grazing systems based on perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.) for most of the country's climatic zones, over the majority of their growing season (White and Hodgson 1999). In recent years, the standard perennial ryegrass-white clover pasture's agronomic and nutritional utility has come under critical review due to poorer performance through increasingly drier summer periods carrying over into autumn (Mercer 2011; Glassey et al. 2021). With observed and projected climate change altering conditions of pasture growth (Keller et al. 2021), studies focused on alternative pasture species are increasing nationally. Adding to the diversity of available sward options that provide greater liveweight gains and greater feeding value through dry summers and autumns will therefore improve the resilience of pastoral-based farming systems.

The idea of diverse pastures is typically where three or more species are sown to provide 'better' feeding value; extended herbage growth into summer and autumn for example, and/or higher nutritive value over that seasonal period. Diverse mixtures commonly contain herbs such as chicory (*Cichorium intybus*) or plantain (*Plantago lanceolata*), legumes such as red clover (*Trifolium pratense*) or white clover, and grasses such as Italian (*Lolium multiflorum*) or perennial (*Lolium perenne*) ryegrasses. These species individually, and collectively, generally have higher metabolisable energy, crude protein, water soluble carbohydrates and lower neutral detergent fibre and acid detergent fibre than primarily perennial ryegrass-based pasture over summer and autumn (Kenyon et al. 2010; Goulding et al. 2008; 2011; Cranston 2014). These pastures can provide lambs with better liveweight gains, especially under dryland systems where performance of perennial ryegrass-white clover pasture is limited by low moisture (Al-Marashdeh et al, 2020). However, diverse pastures are commonly made up of short-lived perennial species. The use of herb/clover mixes has been widely reported throughout New Zealand (Al-Marashdeh et al, 2020; Kenyon et al, 2010; Minneé et al, 2017; Moorhead and Piggot, 2009). These studies have shown better animal performance compared with perennial ryegrass-white clover pastures for up to three years. However, fewer studies have looked at the animal liveweight performance of these pastures past three years.

This study compares the liveweight gains of lambs

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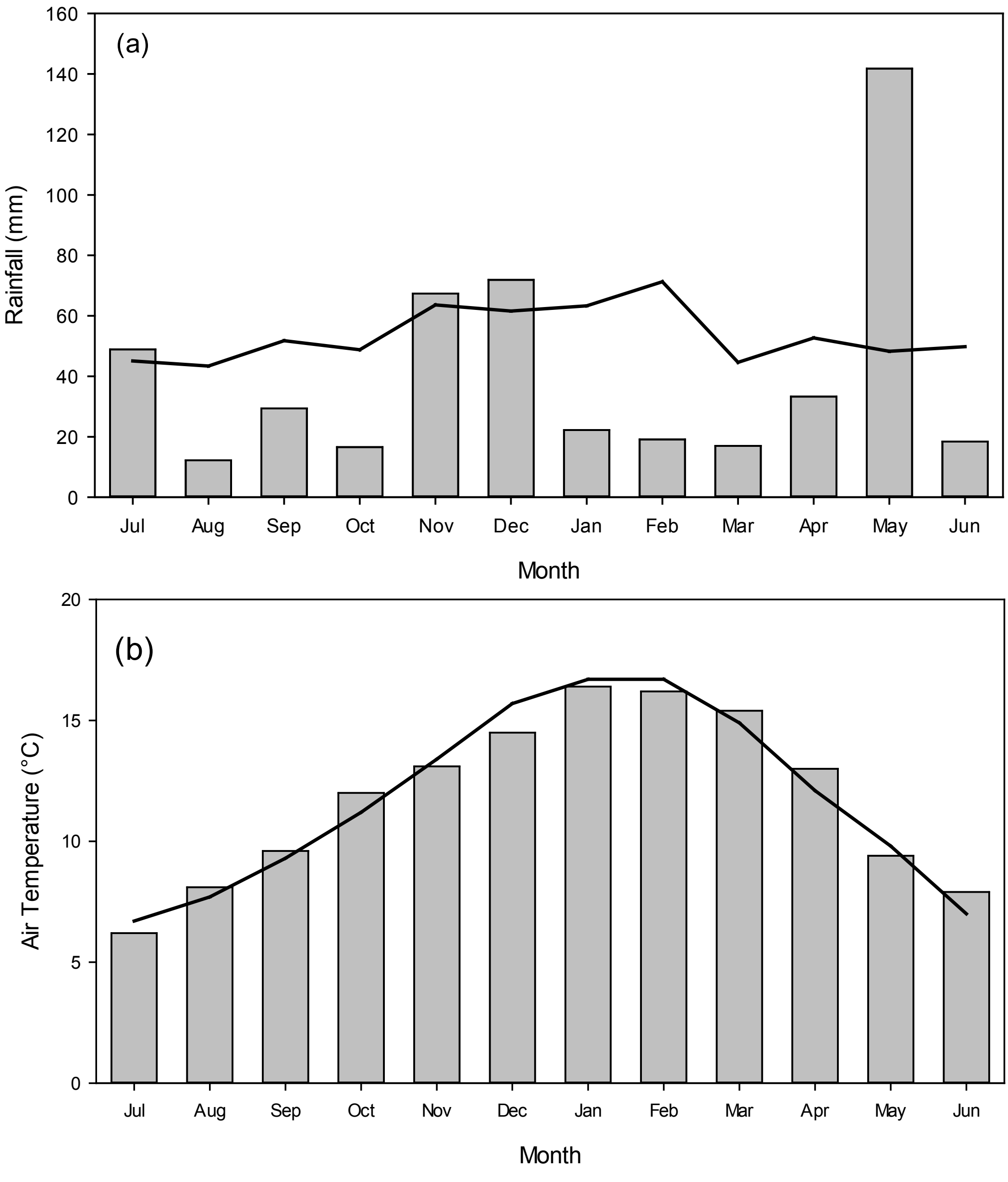

Figure 1 Average monthly rainfall (a) and air temperature (b) recorded at the cemetery block Ashley Dene, Canterbury, New Zealand. Recorded for the 2020–2021 experimental period; black line represents long term means (LTM). Rainfall LTM was record at Burnham from 1970–2012 and air temperature LTM was recorded at Broadfields (Lincoln) from 1975–2010.

grazing five-year-old pasture, established either with Italian ryegrass, plantain and red clover (diversified) or with perennial ryegrass and white clover (standard).

Materials and Methods

Site and preparation

This farmlet site was established in October of 2016 at the Ashley Dene Research and Development Station near Burnham, Selwyn District, Canterbury (43°38'34" S, 172°20'51" E; 37 m a.s.l) with approval of the Lincoln University Animal Ethics Committee (AEC application #2017-05). The study site was partially irrigated receiving 40 mm of irrigation every 10 days from November to March, with no irrigation during most of autumn. The soils mainly consist of shallow Balmoral and Lismore, free draining stony silt loams, with low water holding capacity of 80–85 mm plant available water. Soil pH was 6.0–6.2, Olsen P 30-33 ug/L, sulphate S 7–10 mg/kg and a base saturation of 67–58% (soil analysis conducted in autumn 2019). Monthly rainfall and air temperatures for the 2020-21 season are presented in Figure 1.

Experimental design and pasture establishment

The grazing farmlet experiment was set up on 3.6 ha of flat land that was split into two blocks (A and B) comprising six 0.3-ha paddocks per block. In each block, three paddocks consisted of Italian ryegrass, plantain and red clover-based pasture (Diversified) or perennial ryegrass and white clover-based pasture (Standard). Pre-existing pasture cover in all twelve paddocks was sprayed out with glyphosate-based herbicide and roto-cultivated early in October. In late October, paddocks were heavy rolled and seed mixtures were sown via broadcasting. The diversified pasture seed mixture consisted of 10 kg/ha Asset Italian ryegrass *Lolium multiflorum* L., 5 kg/ha Tonic plantain *Plantago lanceolata* L. and 6 kg/ha Relish red clover *Trifolium pratense* L. The standard pasture seed mixture consisted of 20 kg/ha Prospect perennial ryegrass *Lolium perenne* L. containing AR37 endophyte and 5 kg/ha Tribute white clover *Trifolium repens* L. Following seed broadcasting, paddocks were chain harrowed and heavy rolled.

Livestock and grazing management

Each spring period (starting first week of September) ewes and their lambs at foot were continuously stocked with 4–6 ewes per the 12 replicates (two blocks; 30 ewes per block; six paddocks per block, three paddocks per pasture type) until weaning on 3rd December 2020.

At weaning, ram lambs were allocated into four groups of 12–14 lambs per group based on previous exposure to herbage type. This allowed a pre-weaning effect to be calculated. Ram lambs born and reared on either diversified or standard pasture returned to that pasture type for the subsequent post weaning, summer to autumn (December to May) grazing experiment period. Post weaning, both grazing blocks (A and B) consisted of six paddocks which had two groups of lambs (n=24–28 lambs). Within each block, one lamb group rotationally grazed three diversified pasture paddocks and the other lamb group grazed three standard pasture paddocks. Both groups of weaned lambs were shifted every 10–15 days, varying depending on the residuals (ranging from 900–1200 kg DM/ha) left in the paddocks to allow the maximum liveweight gain and pasture recovery. This was at the discretion of the livestock manager. Lambs were weighed at every shift, and either side of shearing, which occurred at the beginning of February.

Measurements

Herbage analysis

From December to May, pre-graze samples were taken within 24 hours before lambs were shifted onto fresh pasture. Post-graze cuts occurred at the same time as pre-graze cuts, except they were taken from the paddocks the lambs had vacated. Subtracting the dry matter of post-graze cuts from earlier sampled pre-graze cuts from within the same paddock, allowed dry matter intake (DMI) to be calculated as an estimate of feed utilisation.

Using hand shears, two representative areas within each pre- and post-graze paddock were chosen for a 0.2 m^2 quadrat herbage sample taken down to ground level. These samples were processed by mixing and then splitting the sample using the quarterly method. From this bulk sample, a representative subsample was taken for botanical composition, which was then separated into herbage species groups, bagging into individual paper bags and dried in a forced air over at 60 °C for 3 days. Dried bulk and subsamples were weighted to quantify pre-graze dry matter per hectare and botanical composition of pre-graze herbage. Herbage species recorded were sown grass (Italian and perennial ryegrass), sown clover (red and white clover), plantain, unsown and dead. Unsown component was defined as volunteer species, which included annual grasses (*Poa annua*, *Bromus mollis*), white clover, dandelion (*Taraxacum officinale*), viper's bugloss (*Echium vulgare*), shepherd's purse (*Capsella bursa-pastoris*), speedwell (*Veronica arvensis*) and Californian Thistle (*Cirsium arvense*).

Nutritional composition snip cuts were taken from pre-graze plots at the same time as the quadrat cuts. Electric shears were used to collect 12 snips per paddock (cut to grazing horizon). The samples were processed the same as quadrat cuts, except the bulk sample was not kept and a larger subsample was used for chemical analysis. This involved grinding oven-dried samples (65°C for a minimum of 3 days) to 1 mm and analysing using near-infrared reflectance spectrophotometry (NIRS; Foss NIRSystems 5000, FOSS NIRSystemsInc, USA) to estimate the ME (Equation 1).

Equation 1

$$ME = digestable\ OM\ content\ \times 0.016\ (\frac{g}{kg} of\ DM)$$

Lamb liveweight analysis

Lambs were weighed prior to shifting onto their next paddock in each rotation. For weighing, lambs were moved to the portable yards and individually weighed using a Prattley scale crate and a Tru-test ID3000 scale head and matching Bluetooth wand. Lamb weights were accumulated, and stocking rate was able to be tracked using these methods, tracking number and weight of animals per time point. Lamb dry matter intake (DMI) was calculated using collated herbage quadrat cuts and Equation 2. Feed conversion efficiency (FCE) was also calculated using the DMI and liveweight gains (LWG) per day. Pre-weaning LWG was calculated from tailing through to weaning as tailing was the first recorded lamb weights. This gave a comparison of a pre-weaning effect.

Equation 2

$$DMI(\frac{kg}{day}) = \frac{[(Pre\ graze\ mass - Post\ graze\ mass) + Growth\ during\ grazing]}{number\ grazing\ days}$$

Statistical analysis

Genstat 20th edition was used to analyse the results. One-way and two-way ANOVA were used to analyse the pasture yield, utilisation, botanical composition, pasture nutritive value parameters, liveweight gains, feed conversion efficiency and dry matter intake data. Two-sample T-tests were used to analyse the animal LW gain data.

The liveweight gains, dry matter intakes and feed conversion efficiencies were all compared to determine differences in pasture type and performance between diversified and standard pasture. Yield of DM, botanical composition, and nutritive value of diversified and standard pasture are used to explain lamb performance.

Results

Compared to standard pasture, diversified pasture increased the pre-weaning lamb live weight gain (LWG). This heavier weight of lambs was sustained post-weaning over summer and autumn when lambs were finished on either diversified or standard pasture.

At weaning (3/12/2020) ram lambs grazing diversified pasture had an initial weight of 28.5 kg/hd. This was 19% higher (P<0.001) than ram lambs grazing standard pasture (24 kg/hd; Table 1). Throughout the summer – autumn period (3/12/2020 – 7/05/2021) lambs on diversified pasture were 6 kg/hd heavier on average (P<0.05) than lambs on standard pasture (Figure 2). However, post weaning onwards, the liveweight gain of ram lambs grazing diversified pasture averaged 0.196 kg LWG/lamb/day which was similar to lambs grazing standard pasture at 0.179 kg LWG/lamb/day. Liveweight gain per ha of lambs grazing either diversified or standard pasture was similar at 105 kg/ha and 91.1 kg/ha, respectively. Dry matter intakes over summer – autumn were not statistically different at 2.89 kg DM/lamb/day and 2.6 kg DM/lamb/day from diversified and standard pasture, respectively. Feed conversion efficiency was also not statistically different over the whole summer to autumn period between lambs on diversified pasture (70.1 g LWG/kg DMI) and standard pasture (72.5 g LWG/kg DMI; Table 1). The average final liveweight (7/05/21) of lambs on diversified pasture was 9.1% higher (50.3 kg/hd; P<0.05) than lambs on standard pasture (46.1 kg/hd; Table 1, Figure 2).

Liveweight gain over summer and autumn

At tailing (20/10/2020) the average weight of lambs grazing diversified and standard pastures were not significantly different at 14.1 and 13.1 kg/lamb (Table 1). However, over the six-week period from tailing to weaning, lambs on diversified pasture grew 23% faster (P<0.001) than lambs on standard pasture at 0.335 and 0.272 kg LWG/lamb/day, respectively.

At weaning, liveweight of lambs grazing diversified pasture was 18% greater than lambs grazing standard pasture (Table 1; Figure 2). However, onwards over the summer period, liveweight gain of weaned lambs grazing either diversified or standard pasture was not statisically different in December, January or February (Table 1). In February, more liveweight gain on both pasture types occurred compared to previous months, at 0.357 and 0.266 kg/lamb/day on diversified and standard pasture, respectively, though not statistically different (Table 1).

The liveweight of lambs grazing diversified pasture was 21% higher (P<0.001) at the beginning of the autumn period at 44.6 kg/lamb compared with 36.9 kg/lamb (Table 1). During March, lamb liveweight gain on divesified and standard pasture was similar (Table 1). Lambs on both pastures lost weight through April (Table 1; Figure 2). Lamb liveweight gain from both diversified and standard pasture was high in May, compensating for April's liveweight reduction, but was not different between pastures at 0.435 and 0.423 kg/lamb/day, respectively (Table 1). Apparent dry matter intake and feed conversion efficiency of lambs on diversified and standard pasture over autumn were similar (Table 1).

Table 1 Liveweight (LW) at tailing, weaning (start of summer), start of autumn and season's end (Final LW), and liveweight gain (LWG), apparent dry matter (DMI) and feed conversion efficiency (FCE) of lambs grazing diversified or standard pasture over September 2020 to May 2021.

	Diversified	Standard	SEM	P value
Tailing LW (kg/lamb)	14.1	13.1	0.588	0.235
LWG to weaning (kg/lamb/day)	0.335	0.272	0.011	<0.001
Weaning LW (kg/lamb)	28.5	24	0.700	<0.001
LWG by Month (kg/lamb/day)				
December	0.212	0.174	0.025	0.349
January	0.225	0.148	0.557	0.369
February	0.357	0.266	0.083	0.473
DMI (kg DM/lamb/day)	3.14	2.85	0.195	0.41
FCE (g LW/kg DMI)	95.6	73.5	40.1	0.252
FCE by Month (g LWG/kg DMI)				
December	71.7	50.3	9.98	0.19
January	119	66.9	27.1	0.427
February	104	103	20.2	0.992
Autumn start Liveweight (kg/lamb)	44.6	36.9	0.882	<0.001
LWG by Month (kg/lamb/day)				
March	0.178	0.212	0.105	0.829
April	-0.109	-0.025	0.078	0.474
May	0.435	0.423	0.680	0.924
DMI (kg DM/lamb/day)	2.45	2.27	0.216	0.802
FCE (g LW/kg DMI)	33.7	71	46.9	0.692
FCE by Month (g LWG/kg DMI)				
March	33.1	64.8	25.4	0.627
April	-12.5	5.9	20.8	0.732
May	177.4	177.9	4.7	0.962
Final LW (kg/lamb)	50.3	46.1	0.747	0.005
LWG (kg/lamb/day)	0.196	0.179	0.041	0.773
LWG (kg/ha)	105	91.1	21.3	0.660
DMI (kg DM/lamb/day)	2.89	2.6	0.164	0.884
FCE (g live weight/kg DM intake)	70.1	72.5	20.9	0.790

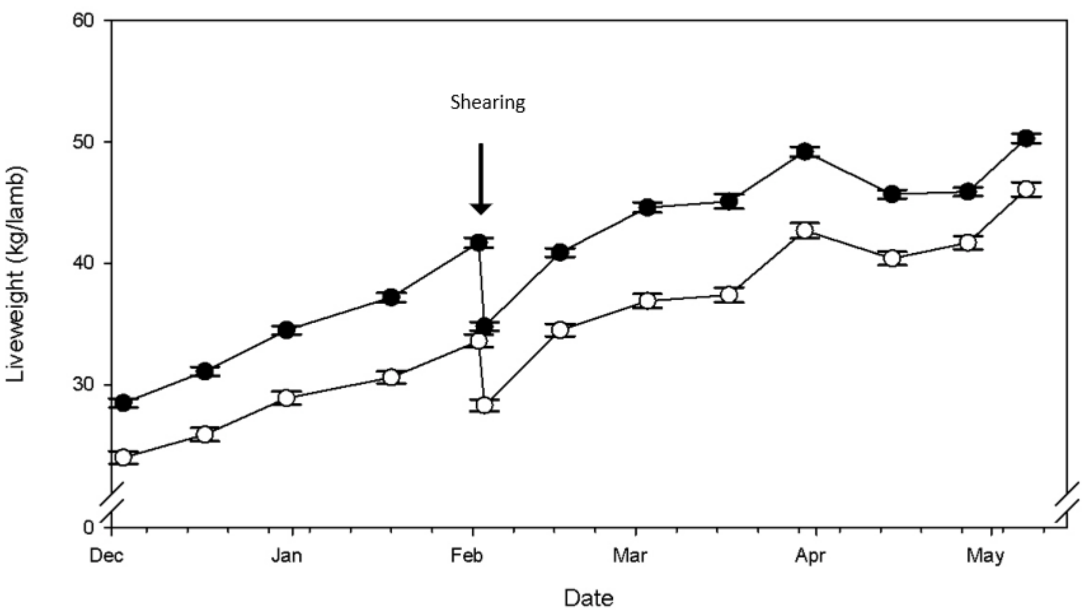

Figure 2 Average liveweight change of lambs (kg/lamb) grazing Diversified (●) and Standard (○) pasture from weaning (December) through to beginning of winter (end of May) at Ashley Dene Research and Development Station, Canterbury, New Zealand. Bars indicate SEM.

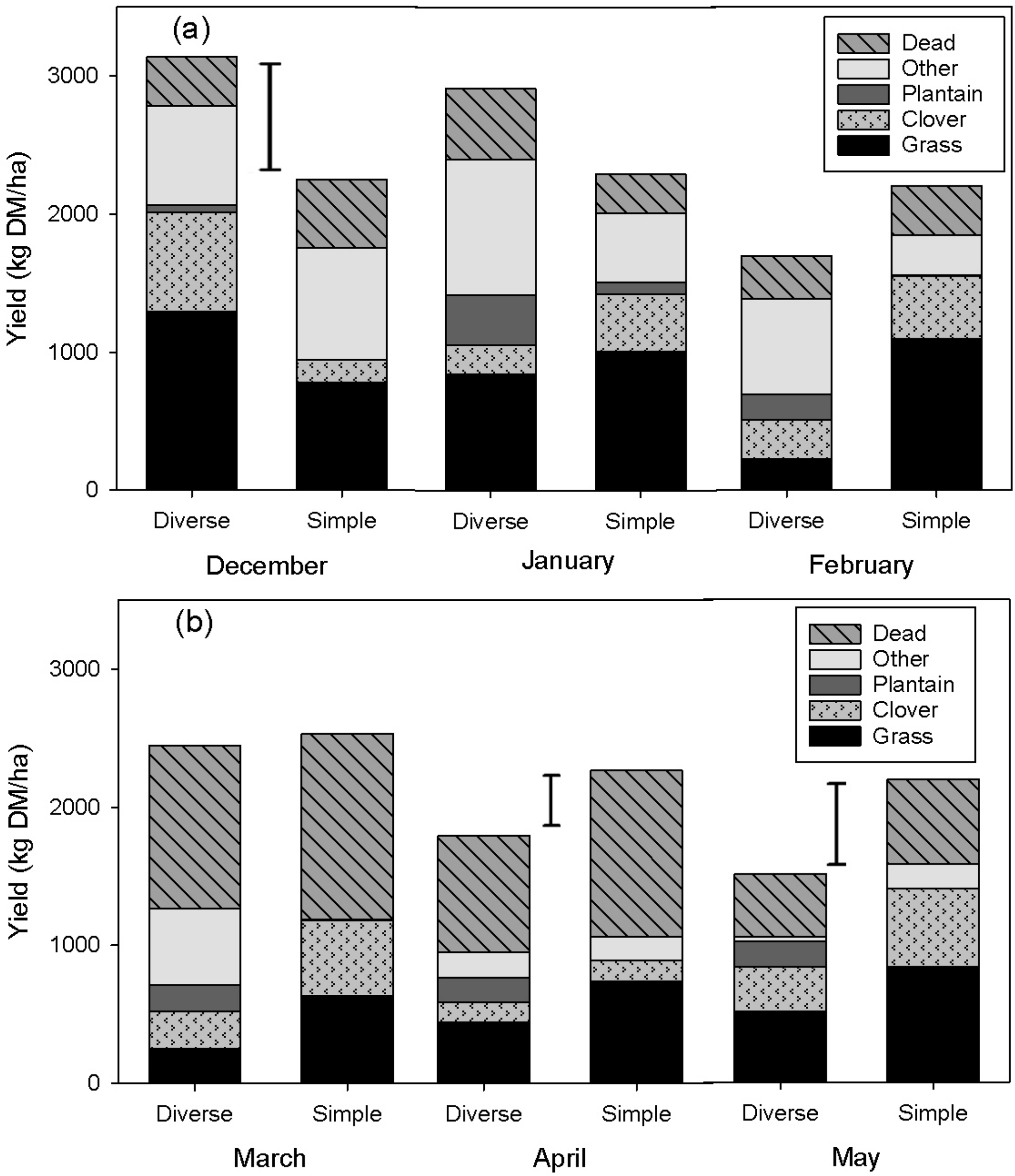

Figure 3 Botanical composition of pre-graze herbage yield (kg DM/ha) of a diversified (Diverse) and standard (Simple) pasture offered to ram lambs in (a) summer and (b) autumn at Ashley Dene Research Development Station, Canterbury, New Zealand, December 2020 – May 2021. Grass represents Italian ryegrass for diversified pasture and perennial ryegrass for standard pasture. Clover represents red clover for diversified pasture and white clover for standard pasture. Bars indicate LSD $_{(P<0.05)}$ of yield differences between pasture type for that month.

Pasture Mass

Averaged over the whole summer – autumn grazing period, pre-graze mass between standard and diversfied pasture was not significantly different, averaging 2,280 and 2,090 kg DM/ha for standard and diversified pasture, respectively. One exception occurred in mid-autumn (27/4/21) when standard pasture was 45% higher (P=0.032) than diversified pasture at 2,190 and 1,510 kg DM/ha, respectively. Post graze pasture masses did not differ over the summer – autumn grazing period, averaging 1,020 kg DM/ha for diversified pasture and 1,160 kg DM/ha for standard pasture.

In December, diversified pasture pre-graze herbage mass was 3,140 kg DM/ha, 40% higher (P=0.036) than standard pasture at 2,250 kg DM/ha (Figure 3a). In April, standard pasture pre-graze herabge mass of 2,270 kg DM/ha was 26% higher than diversified pasture (1,800 kg DM/ha; Figure 3b). In May, standard pasture had 45% more feed available (2,190 kg DM/ha) than diversified pasture (1,510 kg DM/ha; Figure 3b). Pre-graze herbage mass of diversified and standard pasture for January, February and March were not statistically different.

Botanical composition

Over December, pre-graze clover content in diversified pasture was 3.2 times greater (722 kg DM/ha) than standard pasture (170 kg DM/ha), while all other botanical components (grass, plantain, unsown or dead matter) between pasture types were statistically not different (Figure 3a). Botanical composition in January was statistically indifferent between the two pasture types (Figure 3a). In February, the proportion of grass available for lambs grazing standard pasture (1,100 kg DM/ha) was 3.8 times more (P<0.05) than diversified pasture (228 kg DM/ha; Figure 3a). Clover and dead proportions between standard and diversified pasture were not different in February, while the amount of plantain on offer to lambs grazing diversified pasture was 187 kg DM/ha (12%). The five-year old, diversified pasture had 1.4 times greater abundance of unsown species herbage (volunteer annual grasses, clover, herb/broadleaf weed species) than standard pasture (Figure 3a) in February.

Throughout March, dead material made up 50% of total herbage mass on offer for both pasture types, and there were no statistical differences for clover and dead material between the pastures (Figure 3b). Standard pasture grass propotion (635 kg DM/ha) over March was 159% higher (P=0.003) than diversified pasture at 252 kg DM/ha (Figure 5b). Diversified pasture had a higher proportion of plantain (190 kg DM/ha; P<0.001) and unsown species (553 kg DM/ha; P=0.025) in March (Figure 3b). In April, proportions of clover and unsown species for the two pasture types were not different, though the grass component was 26% greater (P=0.033) in standard compared to diversified pasture, while plantain made up 10% (183 kg DM/ha) of diversified pasture (Figure 3b). There was more dead material (1,210 kg DM/ha) present in standard pasture in April (P<0.05) than diversified pasture (847 kg DM/ha). In May, there was no statistical difference between pasture types for botanical components of clover, plantain and dead matter. Grass proportion however was 45% higher (P<0.01) in standard pasture compared with diversified (Figure 3b). The unsown species component available to the lambs grazing standard pasture in May was 1.4 times higher (P<0.05) at 176 kg DM/ha than the diverse pasture at 39.1 kg DM/ha (Figure 3b).

Nutritive value

Metabolisable energy content averaged over summer – autumn did not differ between the standard and diversified pasture (Table 2). Metabolisable energy of diversified pasture did change across months (P=0.002), with December having the highest at 10.3 MJME/kg DM and March having the lowest at 9.5 MJME/kg DM (Table 2). Diversified pasture ME value in December was 6% higher (P=0.025) than standard pasture, while from January through to May, ME value of herbage was not different between pasture types (P>0.089).

Water-soluble carbohydrate content (WSC % DM) averaged over summer – autumn was 13.2% DM for standard pasture, which was 14% higher (P<0.001) than WSC of diversified pasture (11.6% DM). The WSC content of standard pasture was highest in December (14.3% DM) and varied across months with March being the lowest at 11.5% DM (Table 2). The WSC content of diversified pasture was different (P<0.001) across months with January being the highest at 14.8 % DM and March the lowest at 9.4 % DM (Table 2).

Dry matter digestibility (DMD %) of diversified pasture over summer – autumn was 63.7% which was not different from standard pasture at 63.6%. Diversified pasture DMD% changed across months (P<0.001) and was highest in December at 67.1% and lowest in March at 60.1% (Table 2). There was no difference (P=0.311) in DMD% between the months for standard pasture. The DMD% of diversified pasture in December was 6% higher (P=0.04) than standard pasture (Table 2). There was no difference in DMD% between pasture types across all other months (Table 2).

Acid detergent fibre (ADF %) of diversified and standard pasture over summer – autumn was not different at 31.6% and 32.5% respectively (Table 2). The ADF% changed across months for diversified pasture (P<0.001) being highest in March at 34.2% and lowest in December at 29.7%, while standard pasture

Table 2 Nutritive value (NIRS) analysis of diversified (D) and standard (S) pasture grazed from December (weaning) through to May (autumn) at Ashley Dene Research and Development Station, Canterbury, New Zealand.

	Month	December	January	February	2/2/21[1]	15/2/21[1]	March	April	14/4/21[1]	27/4/21[1]	May	Mean	P value
ME (MJ ME/kg DM)	**D**	10.3c	9.9abc	9.9bc	10.1a	9.6b	9.5a	10.1bc	9.9	10.2	9.6ab	**9.9**	0.002
	S	9.7	9.8	9.9	10.3a	9.5b	9.8	10.1	10	10.2	10.2	**9.8**	0.547
	Significance	*	-	-	-	-	-	-	-	-	-	-	
WSC (% DM)	**D**	13.7cd	14.8d	12.1bc	13.7a	10.5b	9.4a	11ab	9.5a	12.5b	11.4ab	**11.6**	<0.001
	S	14.3b	13.4ab	13.5b	15a	12b	11.5a	13.8b	13.2a	14.4b	14b	**13.2**	0.028
	Significance	-	-	-	-	-	*	**	*	-	-	***	
Digestibility (DMD %)	**D**	67.1c	64.1bc	64.1bc	65.8a	62.4b	60.1a	65.1bc	63.8	66.4	62.8ab	**63.7**	<0.001
	S	63.1	63.4	63.4	66.4a	60.4b	61.6	64.6	63.8	65.4	66.3	**63.6**	0.311
	Significance	*	-	-	-	-	-	-	-	-	-	-	
ADF (%)	**D**	29.7a	32ab	31.1a	30a	32.2b	34.2b	30.4a	31.1	29.6	30.5a	**31.6**	<0.001
	S	33.1	32.9	32.3	30.4a	34.15b	33.8	31.5	31.6	31.4	29.8	**32.5**	0.74
	Significance	**	-	-	-	-	-	-	-	-	-	-	
NDF (%)	**D**	46.8	50.9	46.6	42.8a	50.3b	50.6	49.7	51	48.4	50.1	**49**	0.155
	S	57.4	54.4	52.9	49a	56.8b	55.4	55.2	55	55.3	52.6	**54.9**	0.155
	Significance	***	-	*	-	-	***	***	-	**	-	***	
Crude protein (%)	**D**	16.6b	13.5a	13.3a	13.7	12.9	14.1a	17.2b	17.2	17.3	16.7b	**15.2**	<0.001
	S	12.5	13.1	12.3	13.0	11.5	12.9	14.4	14.6	13.9	15	**13.1**	0.063
	Significance	**	-	-	-	-	*	***	*	**	-	***	

Notes: [1] shows where months are split into individual grazing dates, small italics letters indicate a significance between grazing points (p<0.05) within that month.
- Stars indicate significant differences between pasture types at that month. Where <0.001= ***, <0.01= **, <0.05= *
- **D** = Diverse pasture, **S** = Simple pasture
- **P** values <0.05 indicate significant differences between months for each pasture type individually. Letters allow comparisons of significantly different NIRS values of each month.
- Dash indicates no significance

ADF% did not change across months (Table 2). There was no difference in ADF % between pasture type for all the months apart from December. The ADF % of standard pasture in December was 33.1%, 11% higher (P=0.008) than diversified pasture at 29.7% (Table 2).

Neutral detergent fibre (NDF %) of standard pasture (54.9%) was 12% higher (P<0.001) than diversified pasture (49%) over summer – autumn. In December, standard pasture NDF% of 57.4% was 23% higher (P<0.001) than diversified pasture (46.8%). In February, NDF% of standard pasture was 52.9%, 14% higher (P=0.045) than diversified pasture (46.6%), while 9% higher (P<0.001) in March at 55.4% and 50.6%, respectively. In April, NDF% was 55.2% for standard pasture, 11% higher (P<0.001) than diversified pasture at 49.7% (Table 2).

Crude protein content over summer – autumn was 15.2% and 13.1% for diversified and standard pastures, respectively. Diversified pasture was 16% higher (P<0.001) than standard pasture for the experimental period. Crude protein content of diversified pasture varied across the months (P<0.001), being the highest in April at 17.2% and lowest in February at 13.3% (Table 2). Crude protein content between diversified and standard pasture differed in December, March, and April. In December, crude protein content of diversified pasture (16.6%) was 33% higher (P=0.004) than standard pasture (12.5%). In March, this difference was 9% (P=0.015) between diversified (14%) and standard pasture (12.9%), and in April, a 23% difference (P<0.001) between diversified (17.2%) and standard pasture (14%), (Table 2).

Discussion

This farmlet study investigated liveweight gain of lambs on 5-year-old diversified or standard pasture over the growing season of 2020–2021. At tailing, there was no difference in liveweight between lambs grazing diversified and standard pastures, however a subsequent 23% increase in liveweight gain for lambs reared on diversified pasture was observed from tailing to weaning (Table 1). This was similar to what Hutton et al. (2011) and Kenyon et al. (2010) observed, with both reporting increases in liveweight gain from birth through to weaning in multiple bearing ewes on herb/clover mixes compared with ryegrass dominant pastures. Hutton et al. (2011) found that daily liveweight gain of lambs grazing herb/clover mixture consisting of plantain, chicory, red and white was 33% more than lambs on a ryegrass-based sward. However, Kenyon et al. (2010) reported similar liveweight results between the ryegrass/plantain pasture and herb/clover mix, suggesting that plantain has a positive effect of lamb liveweights through lactation. Overall, the results and previous studies suggest there is a positive influence of the diverse components on early liveweight gain of lambs. Our study here showed that a pre-weaning effect appeared to be evident on lambs reared on diversified pasture. No herbage production or nutritive value data were able to be collected during the spring grazing period from September to early December, however. How much of the nutrient requirement of lambs was fulfilled by suckled milk from the diversified pasture-fed nursing ewe is a potential factor in explaining the greater pre-weaning lamb performance that was recorded for lambs reared on diversified pasture compared to standard pasture.

At the end of summer – autumn, lambs rotationally grazing diversified pasture had accumulated 4.2 kg/lamb more liveweight than lambs grazing standard pasture (50.3 vs 46.1 kg, respectively). This was similar to the liveweight difference of 4.5 kg/lamb at weaning. This difference in lamb liveweight between diversified and standard pasture was maintained throughout the summer – autumn post weaning grazing period (Figure 2) although notably, there was no significant difference in LWG/lamb/day, LWG/ha, apparent DM intake or feed conversion efficiency over the post-weaning period (Table 1). This indicated that the weaned lambs on both pasture types grew at the same rate and had the same ability to convert feed into liveweight. Liveweight gain did not differ between pasture types as the pre-graze mass of both pasture types were the same up until the 27/4/21, when standard pasture began to produce more biomass indicating the lambs in each grazing rotation throughout summer – autumn utilised the same amount of feed.

It was expected that after five years, a standard pasture would have greater production as perennial ryegrass and white clover pasture performance persists for 5−10 years (Brock and Hay 1995; Chapman et al. 2015). The species make-up of diversified pasture (red clover, plantain and Italian ryegrass) is regarded as short-lived perennials, tending to persist for only 2–4 years (Brown et al. 2005; Ford and Barrett 2011; Moorhead and Piggot 2009; Stewart 1996; Clements et al. 1991; Thom and Prestidge 1996).

Diversified pasture showed high proportions of Italian ryegrass and red clover in early summer before dropping off in autumn. Plantain was low to begin with but maintained ~10% throughout the experimental period. This is in keeping with the literature, where after three years plantain was at ~15% when mixed with grasses (Stewart, 1996). Overall, the botanical proportions of sown species in the five-year-old, diversified pasture were higher than expected based on what previous literature suggests, which may partially explain the same LWG achieved as standard pasture. Based on previous literature, standard perennial ryegrass-white clover pasture should have outperformed diversified pasture of Italian ryegrass, red clover and plantain in the fifth year, however, producing similar LWG to standard pasture would suggest the components of the diversified pasture are persisting within the sward at a level that provides feeding value comparable to standard pasture. These results differ from Al-Marashdeh et al. (2020) who showed after three years on the same farmlet, LWG was 0.24 and 0.16 kg LWG/lamb/day for diversified and standard pasture, respectively. Al-Marashdeh et al. (2020) results are similar to Somasiri et al. (2015) who showed LWG of 0.23 and 0.12 kg LWG/hd/day for a herb/clover mix (plantain, white clover and red clover) and PR/WC pasture, respectively. Both these studies were completed over 2-3 years on newly established pastures and therefore, LWG is expected to be higher when compared here. So far there has been no further research into the long term (five years onwards) production and persistence of herb-clover mixes compared with standard perennial ryegrass-white clover pasture.

The nutritive value of the two pasture types were similar over the summer – autumn period which offers further explanation for the observed similar LWG on these two pasture types over this period. Reviewed literature suggests diverse pasture components show higher ME, and lower ADF than standard pasture (Kenyon et al. 2010; Goulding et al. 2008; 2011; Cranston 2014). The similar ME, DMD and ADF values observed here may be because of the age of the pasture and climatic conditions over the summer – autumn experimental period. Apart from December, the summer – autumn experimental period was drier than average (Figure 1). Drier conditions reduce the growth of young leaf material and increases the rate of maturity which are both detrimental to pasture quality (Caradus et al. 1995; Lambert and Litherland 2000). The crude protein of diversified pasture here was higher potentially because of the content of red clover and volunteer white clover (recorded in unsown component, Figure 3). Volunteer white clover represented 56% of the unsown portion in diversified pasture, so would have positively affected crude protein content of the pasture on offer.

Over summer there was no difference in pre and post grazing masses or utilisation (data not shown) between diversified and standard pastures. There were differences in botanical components between pasture types in December with more red clover in diversified pasture than white clover in standard pasture, indicating that earlier in the summer – autumn period, red clover made up a significant proportion of the yield compared with white clover in five-year-old pasture. This opposes most previous literature stating red clover persists for only 2–3 years.

Focusing further on individual components of diversified pasture, it showed a high proportion of Italian ryegrass in the sward in December, where it equated to 35% and hit a low of 10% in March (Figure 3). We postulate that significant Italian ryegrass seedling recruitment has occurred owning to successful seeding and thus contribution to a base seedbank in most years. Red clover content over the experimental period peaked at 23% in December and was lowest in January at 7%. The plantain peaked at 12% in January and May and was lowest in December at 1.6%. This shows the variability of Italian ryegrass, red clover and plantain throughout the season but also shows after five years in early summer they still contribute to a significant portion of the pasture. Plantain was able to maintain above 10% in the pasture which is similar to the 15% shown by Stewart (1996).

Overall differences in pasture quality across summer – autumn were evident for WSC, NDF and CP. Standard pasture had 13.8% higher WSC and 12% higher NDF compared with diversified pasture (Table 2). The observed higher NDF is in agreement with Jackson et al. (1996) where higher NDF was due to standard pasture having perennial ryegrass and white clover which both have been shown to increase in NDF by up to 43.8% over the dry summer period in Canterbury when compared with spring (Brown et al. 2005). The higher WSC reported from standard pasture, however, does not agree with the reviewed literature (King et al. 2012; Cranston 2014; Minneé et al. 2017) where studies showed that plantain and Italian ryegrass had higher WSC than perennial ryegrass and white clover alone or as a mix. In March and April there was more WSC in standard pasture compared with diversified pasture. In March, there were more volunteer species in diversified pasture, which contained 44% weeds such as shepherd's purse and dandelion which are less palatable than sown species (Burritt and Hart, 2014). The diversified pasture had an overall greater CP compared with the standard pasture (Table 2). This was because there was more CP in diversified pasture in December, March and April. This agrees with the reviewed literature where the high CP in red clover and plantain are able to maintain a higher pasture CP than standard pasture components (Burke 2006; Golding et al. 2011; Brown and Moot 2004; Whitacre 2001).

Conclusions

Pre-weaning liveweight gains were 23% higher on diversified pasture compared with standard pasture. The pre-weaning liveweight gains were maintained after weaning, where lambs on diversified pastures were able to maintain an average higher liveweight than lambs grazing standard pasture, although with the same rate of liveweight gain. The pre-and post-grazing covers between the pastures was similar for the majority of the experimental period, indicating the same yield production from both pasture types. Diversified pasture was able to maintain a functional proportion of Italian ryegrass, red clover and plantain after five years, notably in the early summer period.

This study has shown that weaned lamb liveweight production from a five-year-old, diversified pasture containing Italian ryegrass, red clover and plantain is no different to a five-year-old perennial ryegrass and white clover pasture. However, it has shown that the diverse pasture was able to provide better liveweight gains for suckling lambs (pre-weaning). The results show farmers that the diverse components are able to outperform the perennial ryegrass-white clover pasture after five years indicating that the benefits of earlier years' production are not simply lost after 3–4 years of production.

The pre weaning effect of increased liveweight gains should be further looked at for this pasture type. Further research into why the lambs grow faster pre-weaning would be beneficial to understanding the results. If rearing lambs is still more productive on diversified pasture, then the potential for early spring grazing and lambing on the pasture when it is in its 5th year may give farmers more options and flexibility with pasture management.

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