Effects of lamb live weight, sex and forage type (grass or plantain-clover mix) on lamb growth during summer

LM Cranston*, NM Schreurs, RA Corner-Thomas, PR Kenyon and ST Morris

Sheep Research Centre, School of Agriculture and Environment, Private Bag 11-222, Massey University, Palmerston North, 4442, New Zealand

**Corresponding author.* Email: l.cranston@massey.ac.nz

Abstract

Two studies were carried out, over consecutive summers, to examine the effect of lamb sex and initial live weight on liveweight gain when grazing a grass-based sward (undeveloped hill country pasture) or a plantain-clover mix (plantain, red clover and white clover sown on cultivatable hill country). There were no interactions (P>0.05) between the sex of the lamb, initial live weight or forage type on lamb liveweight gain. In year 1, ewe lambs grew at a slower rate than wethers (169 vs 181 g/day; P<0.01), but there was no difference between the two sexes in year 2 (P>0.05). In both years lambs with a lighter initial liveweight profile were also lighter (P<0.001) at the end of the study, but there was no difference (P>0.05) in the liveweight gains of the light and heavy lambs. In both years lambs grazing the plantain-clover mix grew 47-141 g/day faster than did lambs grazing the grass-based sward (P<0.001). This indicates that the plantain-clover mix can be utilised for a range of lamb classes, with similar positive results.

Keywords: *Plantago lanceolata*; herb; liveweight gain; liveweight profile

Introduction

New Zealand sheep-farming systems are predominantly based on temperate grasses (*Lolium perenne/Festuca arundinacea/Agrostis capillaries*) with a varying legume component (*Trifolium repens/Trifolium pratense/Trifolium subterraneum*) (Kemp et al. 2002). During summer and autumn seasons, these grass-based swards can display suboptimal growth and quality (Kemp et al. 2002). This can result in lamb growth rates of 80-150 g/day, which may not allow for the attainment of slaughter weight in a timely manner (Fraser & Rowarth 1996; Kerr 2000).

Many farmers sow summer active perennial herb and clover mixes to combat the above issues and improve animal performance and growth efficiency. Plantain (*Plantago lanceolata*) and clover (*T. repens/T. pratense*) mixes have been shown to increase lamb growth rates during summer and autumn compared to grass-based swards (Golding et al. 2011; Somasiri et al. 2015a,b). Farmers often only sow a small proportion of their farm in a plantain-clover mix, primarily due to poor winter growth. Consequently, the area of sown plantain-clover mix is not usually large enough to allow all lambs to graze on this forage type. Thus farmers, have to choose which class of lamb is best to finish on the plantain-clover mix. It is known that male lambs have faster growth rates than female lambs (Craigie et al. 2012; Holst et al. 1998; Rodríguez et al. 2008). It is unknown if this relationship holds on a plantain-clover mix, or if heavier lambs have the potential to grow faster than lighter lambs. Understanding the performance of different lamb types on a plantain-clover mix, combined with knowledge of schedule prices will enable farmers to manage plantain mixes to maximise the value of lambs sold for slaughter. The aim of the present study was to determine the impact of lamb sex, initial live weight and forage type during summer grazing on lamb liveweight gain and slaughter characteristics.

Materials and methods

Study design and animals

The study was conducted at Massey University's Tuapaka Hill Country Farm, 15 km east of Palmerston North, New Zealand (40°21'S, 175°45'E). The study ran over two consecutive summers (2016 and 2017) with approval from the Massey University Animal Ethics Committee (application number 15/109).

Several days prior to the start of the study, in both years, the lambs (~5 months of age) were weighed and the sex of the lambs was recorded. All lambs were orally administered Ancare 'Matrix' triple combination drench (active ingredients 1 g/L Abamectin; 40 g/L Levamisole HCI; 22.7 g/L Oxfendazole) at a rate of 1 ml per 5 kg body weight to control internal parasites. In addition they were given zinc capsules (active ingredient 43g Zinc Oxide, released over six weeks) as a preventative measure against facial eczema (Munday et al. 1997).

At the beginning of the study (D1; 12 January 2016 and 18 January 2017, respectively), ewe lambs and wether lambs were each allocated to a light or heavy liveweight profile treatment based on their live weight at the previous recording date. The exact age and birth rank of the lambs was unknown. The weight range for light and heavy liveweight profile treatments differed marginally between years (Light; 23-29 kg in 2016 and 22-30 kg in 2017 and Heavy; 32-40 kg in 2016 and 33-40 kg in 2017) based on the availability of lambs, but in each year there remained a 3 kg gap between the weight range groups. Each liveweight profile treatment was then allocated to one of two forage treatments. The two forage treatments were: (i) established hill country pasture (hereafter termed grass) which contained browntop (*Agrostis capillaries*), yorkshire fog (*Holcus lanatus*) perennial ryegrass (*Lolium perenne*), other grasses and white clover (*T. repens*); (ii) a plantain-clover mix which was sown in autumn 2015 and contained

plantain (*Plantago lanceolata*), red clover (*T. pratense*) and white clover. Initial lamb live weights were balanced for forage treatment and sex of the lamb within each of the liveweight profile treatments.

In each year all lambs within each forage treatment were managed as one mob. All lambs were rotationally grazed to allow for *ad libitum* intakes. Therefore, those grazing the grass treatment were shifted into a new grazing area when the herbage mass reached a minimum of 1500 kg DM/ha and those grazing the plantain-clover mix were shifted when the sward height reached a minimum of 7 cm. The study ran for between six and seven weeks in each year based on herbage availability. The total area utilised in this study was 11.25 ha grass and 8.9 ha plantain-clover mix in each year.

Animal measurements

Lamb live weights were recorded within one hour of removal from herbage on D1, D17, D30, D50 in 2016 and D1, D15, D30, D42 in 2017. The relative growth rate (RGR) of the lambs was calculated as ($In W_2 - In W_1$)/time, where: W_1 = live weight at start of study; W_2 = live weight at end of study; Time = length of study (days). All lambs that weighed at least 36 kg (target slaughter weight) at the end of the study in both years were sent for slaughter following weighing. In 2016, lambs were slaughtered at Silverfern Farms Meat Works, Waitotara, New Zealand and individual lamb carcass weights were obtained. Dressing out % was calculated as (carcass weight/final liveweight) × 100. In 2017, lambs were slaughtered at Alliance Meat Works, Dannevirke, New Zealand and no slaughter data was collected.

Herbage measurements

Herbage mass, sward height, botanical composition were measured and grab herbage samples were collected for nutritive analysis on D1, D17, D30, D47 in 2016 and D1, D22, D34 in 2017. Herbage mass was measured by taking four 0.1 m^2 quadrat cuts (Frame 1993) per forage treatment at ground level. The samples were then washed before drying in a draught oven for at least 24 h at 70°C. Sward height was measured by taking two measures of 50 measurements in each forage treatment using a sward stick (Jenquip) (Hutchings 1991). Botanical composition samples were collected by cutting four strips 0.5 m × 0.1 m wide per forage treatment. A subsample of these (~30 g) was then separated into species and dried at 70°C for at least 24 h before botanical composition was established. Grab herbage samples were freeze dried and ground to pass a 1-mm sieve. The samples were analysed for *in vitro* digestibility (with metabolisable energy (ME) calculated as digestible organic matter digestibility × 0.163) according to the method of Roughan & Holland (1977). Neutral detergent fibre (NDF) was analysed using a Tecator Fibretec System and crude protein (CP) was determined using a total combustion method (Robertson & Van Soest 1981).

Statistical Analysis

All statistical analyses were performed using SAS (Statistical Analysis System, version 9.3; SAS Institute Inc., Cary, NC, US). Each year was analysed separately due to different ranges in the lamb liveweight profile treatment between years and different measurement dates.

Lamb live weight was analysed using the MIXED procedure allowing for repeated measures with a model including the fixed effects of measurement date, sex of the lamb, lamb liveweight profile, forage treatment and all two-way, three-way and four-way interactions between the fixed effects. Lamb liveweight gain was analysed using the MIXED procedure with a model including the fixed effects of sex of the lamb, lamb liveweight profile, forage treatment and all two-way and three-way interactions.

Pasture masses and nutritive value characteristics were analysed using the MIXED procedure with a model including the fixed effects of forage treatment and measurement date.

Results

Herbage mass, composition and quality

In 2016, throughout the study period the average herbage masses of the grass did not differ (P>0.05) from the plantain-clover mix (3881±260 and 4261±260, respectively; mean ± sem). The average composition of the plantain-clover mix was 46.6±2.1% plantain, 39.9±2.1% clover with the remainder made up of grasses, dead material and weeds. The grass treatment was made up of 24.6±2.2% brown top, 9.9±2.2% ryegrass, 18.0±2.2% Yorkshire fog, 5.9±2.2% clover, with the remainder coming from other grass species, dead material and weeds.

In 2017, throughout the study period the average herbage masses of the grass did not differ (P>0.05) from the plantain-clover mix (2871±195 and 3004±195, respectively). The average composition of the plantain-clover mix was 34.5±5.6% plantain, 41.2±5.6% clover with the remainder made up of grasses, dead material and weeds. The grass treatment was made up of 13.0±2.3%

Table 1 Effect of forage treatment (hill country pasture (grass) vs plantain-clover mix) on herbage crude protein (CP %), neutral detergent fibre (NDF), metabolisable energy content (ME). All data are presented as least-squares mean ± standard error of the mean.

	CP%	NDF%	ME
2016			
Grass	14.5 ± 0.27	54.5 ± 0.91	9.0 ± 0.09
Plantain-clover	16.3 ± 0.27	39.9 ± 0.91	10.2 ± 0.09
P value	<0.001	<0.001	<0.001
2017			
Grass	15.5 ± 0.70	55.4 ± 0.72	8.9 ± 0.08
Plantain-clover	20.9 ± 0.70	37.1 ± 0.72	10.5 ± 0.08
P value	<0.001	<0.001	<0.001

brown top, 11.7±2.3% ryegrass, 21.6±2.3% Yorkshire fog, 4.0±2.3% clover, with the remainder coming from other grass species, dead material and weeds.

In both years, the grass treatment had a 1.8-5.4 lower CP % (1.8-5.4%; P<0.001), higher NDF % (14.4-18.3%; P<0.001) and a lower ME content (0.8-1.6 MJME/kg DM; P<0.001) than did the plantain-clover mix treatment (Table 1).

Animal measurements

In 2016 wether lambs grew faster (P<0.01) than did ewe lambs, so that they were 0.5 kg heavier (P<0.05) at the end of the study (Table 2; Table 3). In 2017, although wether lambs were statistically heavier (P<0.001) than ewe lambs at the end of the study, the liveweight gain of the ewe and wether lambs did not differ (P>0.05). In both years, wether lambs had a greater (P<0.01) RGR than ewe lambs. There was no effect (P>0.05) of sex of the lamb on the proportion of lambs which reached the target slaughter weight, in either 2016 or 2017. Furthermore, in 2016, there was no effect of sex of the lamb on the carcass weight (16.4±0.15 vs 16.5±0.16 kg, for ewe and wether lambs, respectively) or dressing out percentage (41.2±0.31 vs 40.9±0.33 %, for ewe and wether lambs, respectively) of lambs which were slaughtered.

In both years, plantain-clover-mix lambs grew faster (P<0.001) than did grass-fed lambs, so that at the end of the study they were 2.3 kg heavier in 2016 and 5.6 kg heavier in 2017 (P<0.001) (Table 2; Table 3). In both years, plantain-clover-mix lambs had a faster (P<0.001) RGR than did grass-fed lambs. More of the plantain-clover-mix lambs reached the target slaughter weight, compared to the grass-fed lambs (17% more in 2016 and 25% more in 2017;

Table 2 The effect of sex of lamb, forage treatment (grass vs plantain-clover mix) and initial lamb liveweight profile (light; 23-29 kg vs heavy; 32-40 kg) on the initial and final live weight (kg), liveweight gain (g/day), relative growth rate (%) and the proportion of lambs to reach target slaughter weight in 2016. All data are presented as least-squares mean ± standard error of the mean, except the proportion to reach target slaughter weight where it is presented as back-transformed logit mean (95% confidence interval).

	n	Initial live weight (kg)	Final live weight (kg)	Lamb liveweight gain (g/day)	Lamb relative growth rate (%/day)	Proportion to reach target slaughter weight
Sex of lamb						
Ewe	*207*	30.4 ± 0.18	38.7 ± 0.18	169 ± 2.6	0.50 ± 0.007	0.68 (0.62-0.74)
Wether	*201*	30.3 ± 0.18	39.2 ± 0.18	181 ± 2.7	0.53 ± 0.007	0.73 (0.66-0.79)
P value		>0.05	<0.05	<0.001	<0.001	>0.05
Forage treatment						
Grass	*205*	30.4 ± 0.18	37.8 ± 0.18	152 ± 2.6	0.45 ± 0.007	0.62 (0.55-0.68)
Plantain-clover	*203*	30.3 ± 0.18	40.1 ± 0.18	199 ± 2.6	0.57 ± 0.007	0.79 (0.73-0.84)
P value		>0.05	<0.001	<0.001	<0.001	<0.001
Liveweight profile						
Light	*208*	26.8 ± 0.18	35.3 ± 0.18	175 ± 2.6	0.56 ± 0.007	0.45 (0.38-0.52)
Heavy	*200*	33.9 ± 0.18	42.5 ± 0.18	175 ± 2.7	0.46 ± 0.007	0.98 (0.95-0.99)
P value		<0.001	<0.001	>0.05	<0.001	<0.001

Table 3 The effect of sex of lamb, forage treatment (grass vs plantain-clover mix) and initial lamb liveweight profile (light; 22-30.5 kg vs heavy; 33.5-40 kg) on the initial and final live weight (kg), liveweight gain (g/day), relative growth rate (%) and the proportion of lambs to reach target slaughter weight in 2017. All data are presented as least-squares mean ± standard error of the mean, except the proportion to reach target slaughter weight where it is presented as logit transformation with back-transformed proportion in parentheses).

	n	Initial live weight (kg)	Final live weight (kg)	Lamb liveweight gain (g/day)	Lamb relative growth rate (%/day)	Proportion to reach target slaughter weight
Sex of lamb						
Ewe	196	31.7 ± 0.17	40.0 ± 0.17	206 ± 4.6	0.56 ± 0.008	0.79 (0.73-0.85)
Wether	193	32.0 ± 0.17	40.8 ± 0.17	216 ± 4.6	0.59 ± 0.008	0.85 (0.80-0.90)
P value		>0.05	<0.001	>0.05	<0.01	>0.05
Forage treatment						
Grass	196	31.8 ± 0.17	37.6 ± 0.17	141 ± 4.6	0.41 ± 0.008	0.70 (0.63-0.76)
Plantain-clover	193	31.9 ± 0.17	43.2 ± 0.17	282 ± 4.6	0.75 ± 0.008	0.95 (0.91-0.97)
P value		>0.05	<0.001	<0.001	<0.001	<0.001
Liveweight profile						
Light	193	28.4 ± 0.17	36.8 ± 0.17	206 ± 4.6	0.62 ± 0.008	0.64 (0.57-0.71)
Heavy	196	35.3 ± 0.17	44.0 ± 0.17	217 ± 4.6	0.53 ± 0.008	1.0 (0.0-1.0)
P value		<0.001	<0.001	>0.05	<0.001	<0.001

P<0.001). In 2016, the plantain-clover-mix lambs produced a heavier carcass which provided a greater dressing-out percentage compared to grass-fed lambs (17.6±0.13 kg and 43.0±0.28 % vs 15.3±0.18 kg and 39.0±0.37 %, for plantain-clover-mix lambs and grass-fed lambs, respectively).

In both years, at the start of the study, light lambs were approximately 7 kg lighter (P<0.001) than heavy lambs (Table 2; Table 3). There was no difference (P>0.05) in the liveweight gain of light and heavy lambs in either year, so that light lambs remained lighter (P<0.001) than heavy lambs at the end of the study. In both years, light lambs had a greater (P<0.001) RGR than did heavy lambs. A greater proportion (P<0.001) of heavy lambs reached the target slaughter weight than light lambs, in both 2016 and 2017. In 2016, heavy lambs had a greater carcass weight and dressing-out percentage than did light lambs (17.6±0.12 kg and 41.2±0.24 % vs 15.3±0.19 kg and 40.8±0.39 %, for heavy and light lambs, respectively).

Discussion

In the present study, lambs grazing plantain-clover mix grew faster than did lambs grazing grass, and this effect was not dependent on the sex or initial live weight of the lamb. This indicates that it is not more valuable to utilise the plantain-clover mix for one particular lamb class. Rather, farmers can choose to graze the plantain-clover mix with any lamb class and expect similar positive results. Previous studies have shown weaned lambs grow faster when grazing plantain-clover mixes during summer/autumn compared to those grazing grass-based swards (Golding et al. 2011; Somasiri et al. 2015a,b). These faster growth rates resulted in approximately 20% more plantain-clover-mix lambs reaching target slaughter weight by the end of the study, compared to lambs which grazed grass. In the present study the grass sward contained higher pasture covers than would be typically utilised for summer lamb finishing. This could have potentially resulted in reduced herbage quality than typical of a grass based sward and therefore potentially lower lamb liveweight gains. However, lambs grazing the grass swards grew at 140-150 g/day when offered unlimited allowances, aligning with suggested maximum lamb growth rates on grass during summer (Fraser & Rowarth 1996; Kerr 2000). The greater growth rates of lambs grazing the plantain-clover mix is not surprising given the lower NDF content and higher CP and ME content of the plantain-clover mix compared to the grass in the present study.

Previous studies have consistently shown that ram lambs grow faster than castrated lambs which in turn grow faster than ewe lambs on grass-based swards (Craigie et al. 2012; Kerslake et al. 2012; Schreurs 2013). In the present study, wether lambs grew faster than ewe lambs in 2016 and had greater RGRs than ewe lambs in both years, regardless of whether they grazed grass or plantain-clover mix. This suggests that farmers buying in lambs for finishing on plantain-clover mixes would be better to purchase male lambs, rather than female lambs. However, male lambs often receive a premium price over female lambs when purchased store. Therefore, the potential growth advantage needs to be sufficient to offset the initial cost or enable them to be sold sooner at a more optimum time in relation to the meat schedule. Alternatively, farmers could graze replacement ewe lambs on plantain-clover mixes, in order to increase the proportion reaching target breeding live weights at 8-9 months of age.

Lambs displayed similar growth rates, regardless of whether they were classified in the light or heavy liveweight profile. However, the light lambs had a greater RGR than the heavy lambs. This indicates that the light lambs were growing proportionally faster because the liveweight gain was a greater proportion of their live weight. Given, that the average live weight at the start of the study in 2016 was 26.8 and 33.9 for the Light and Heavy lambs, respectively, and both groups gained 175 g/day, predicted animal intake would have been 11.38 and 12.7 MJ ME/day, with 56% vs 53% of the total energy intake, being allocated to growth (Nicol & Brookes 2007). Similarly, in 2017, 60% and 58% of the total intake energy would have been utilised for growth for the Light and Heavy lambs, respectively. Combined, this suggests that the lighter lambs grew more efficiently than the heavier lambs, however, this effect may not be large enough to warrant farm system changes.

Conclusion

Lamb liveweight gains during summer can be improved by grazing a plantain-clover mix rather than grass. Regardless of initial lamb live weight, lambs displayed similar improvements and wether lambs had faster growth rates than ewe lambs in one of two years. Strategically, this means that a farmer could utilise their plantain-clover mix for any lamb class, thus offering greater flexibility.

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References

Craigie CR, Lambe NR, Richardson RI, Haresign W, Maltin CA, Rehfeldt C, Roehe R, Morris ST, Bunger L 2012. The effect of sex on some carcass and meat quality traits in Texel ewe and ram lambs. Animal Production Science 52: 601-607.

Frame, J 1993. Herbage Mass. In: Hodgson, J, Baker RD, Davies DA, Laidlaw AS, Leaver JD ed. Sward Measurement Handbook. United Kingdom, British Grassland Society, Pp. 39-69.

Fraser TJ, Rowarth JS 1996. Legumes, herbs or grass for lamb performance? Proceedings of the New Zealand Grassland Association 58: 49-52.

Golding K, Wilson E, Kemp P, Pain S, Kenyon P, Morris S 2011. Mixed herb and legume pasture improves the growth of lambs post-weaning. Animal Production Science 51: 717-723.

Holst PJ, Kemp DR, Goodacre M, Hall DG 1998. Summer lamb production from puna chicory (Cichorium intybus) and lucerne (Medicago sativa). Animal Production in Australia 22: 145-148.

Hutchings N 1991. Spatial heterogeneity and other sources of variance in sward height as measured by the sonic and HFRO sward sticks. Grass and Forage Science 46: 277-282.

Kemp PD, Matthew C, Lucas RJ 2002. Pasture species and cultivars. In: Hodgson J, White J ed. New Zealand pasture and crop science. Auckland, New Zealand, Oxford University Press. Pp. 83-99.

Kerr P 2000. A guide to Improved Lamb growth - 400 plus. Wellington, New Zealand, New Zealand Sheep Council.

Kerslake JI, Hely FS, Maclennan G, Lindsay S, Behrent MR, Campbell AW 2012. Does castration status have an effect on the quality of lamb meat? Proceeding of the New Zealand Society of Animal Production 72: 144-146.

Munday R, Thompson AM, Fowke EA, Wesselink C, Smith BL, Towers NR, O'Donnell K, McDonald RM, Stirnemann M, Ford AJ 1997. A zinc-containing intraruminal device for facial eczema control in lambs. New Zealand Veterinary Journal 45: 93-98.

Nicol AM, Brookes IM 2007. The metabolisable energy requirements of grazing livestock. In: Rattray PV, Brookes IM, Nicol AM ed. Pasture and supplements for grazing animals. Hamilton, New Zealand, New Zealand Society of Animal Production.

Robertson JB, Van Soest PJ 1981. The detergent system of analysis and its application to human foods. In: James WPT, Theander O ed. The analysis of dietary fibre in food, volume 3. New York, USA, Marcel Dekker Inc. Pp. 123-158.

Rodríguez AB, Bodas R, Prieto N, Landa R, Mantecón A, Giráldez FJ 2008. Effect of sex and feeding system on feed intake, growth, and meat and carcass characteristics of fattening Assaf lambs. Livestock Science 116: 118-125.

Roughan PG, Holland R 1977. Predicting in-vivo digestibilities of herbages by exhaustive enzymic hydrolysis of cell walls. Journal of the Science of Food and Agriculture 28: 1057-1064.

Schreurs NM 2013. Comparison of castrate and entire ram-lambs for meat quality and skatole in the fat. Proceedings of the New Zealand Society of Animal Production 73: 68-70.

Somasiri SC, Kenyon PR, Kemp PD, Morel PCH, Morris ST 2015a. Growth performance and carcass characteristics of lambs grazing forage mixes inclusive of plantain (*Plantago lanceolata* L.) and chicory (*Cichorium intybus* L.). Small Ruminant Research 127: 20-27.

Somasiri SC, Kenyon PR, Morel PCH, Kemp PD, Morris ST 2015b. Herb-clover mixes increase lamb live weight gain and carcass weight in the autumn period. New Zealand Journal of Agricultural Research 58: 384-396.