Impact of pasture allowance during the transition period in ewes carrying singles, twins and triplets on lamb survival, growth and ewe efficiency to weaning with and without human intervention

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Abstract

Ewe and lamb mortality increases with fecundity, but practical on-farm solutions remain limited. This study evaluated the effects of pasture allowance during the transition period, from 100 days of gestation to 4 weeks of lactation, and its interaction with litter size on ewe and lamb performance with and without human intervention. The design was a 2 × 3 factorial, with two pasture allowances — High and Std, (achieved through pasture allocation regimes of 3000/2000 kg DM/ha and 2000/1400 kg DM/ha pre-/post-grazing for High and Standard respectively) — and three litter-size classes: single, twin, and triplet. Allowances were calculated for twin-bearing ewes and applied to all ewes regardless of litter size. Ewe body condition score was similar between all groups until late gestation, decreased from late gestation to 4 weeks of lactation as litter size increased, but were stable thereafter. These results highlight the mismatch between feed consumed and the energetic demands of late pregnancy and early lactation as litter size increases. Increasing pasture allowance reduced ewe mortality and morbidity and improved ewe efficiency by increasing survival of triplet-born lambs with intervention and twin- and triplet-born lambs without intervention. First-year data suggest current New Zealand pasture allowance recommendations may limit performance of highly fecund ewes, although further research is needed to confirm mechanisms, practicality, and economics.

Keywords: intervention, pasture, productivity, welfare

Introduction

Fecundity of ewe flocks in New Zealand and Australian extensive production systems has increased 10-20% in the last 20 years (Kubeil 2017; Flay et al. 2022) resulting in an increased number of triplet-bearing ewes within a flock (Amer et al. 1999; Thompson et al. 2023). Despite application of current genetic selection and management practices, pre-weaning mortality remains high in both ewes (2-16%; Doyle 2018; Flay et al. 2022; Haslin et al. 2023) and lambs (5-60%; Haslin et al. 2023; Thompson et al. 2023) in both New Zealand and Australian extensive production systems. Mortality of both ewes and lambs increases with increased fecundity (Kenyon et al. 2019). While causes of ewe and lamb mortality vary (Flay et al. 2022; Everett-Hincks et al. 2005), practical on-farm interventions to reduce mortality remain elusive.

The last six weeks of pregnancy and first four weeks of lactation (transition period) coincide with the period of greatest energetic requirement for the ewe to support exponential fetal growth and lactation (Nicol and Brookes 2007). This period is also a key time for physiological development of the progeny to set the potential for future productivity. The ability to meet the nutritional demands of pregnant ewes, especially those carrying multiple fetuses, is an important factor influencing lamb survival and growth, and thus ewe production efficiency (McCoard et al. 2017; Kenyon et al. 2019). The most common chronic stressor during this period in extensive pastoral production systems is undernutrition through inadequate feed availability over winter, exacerbated by higher nutrient demands of increased litter size.

Factors such as rumen capacity have been proposed as placing restrictions on feed intake when multiple lambs are being carried in late pregnancy (Kenyon et al. 2019). Research in the early 2000's cited ewe live weights of 50-60 kg with average condition scores of 2.2 (Kenyon and Morris 2014), while more recent research highlights the increase in both live weight to 70-75 kg and body condition to 3-3.5 (McCoard et al. 2020). The potential for mismatch between feed intake capacity and dam size may be slowly resolving itself as ewes are becoming heavier with a larger frame size. The potential to increase the amount of pasture offered to modern high fecundity ewes needs to be re-evaluated.

Prior studies have indicated that optimum pre- and post-grazing pasture covers for a ryegrass white clover sward in New Zealand are 1100 and 800 kg DM/ha to approximately 1 week prior to lambing and then not below 1200 kg DM/ha post-grazing covers for very late pregnancy and lactation (Morris and Kenyon 2014).

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While these targets were developed for single- and twin-bearing ewes, targets for triplet-bearing ewes remain unknown (Thompson et al. 2023). Increasing body condition score (BCS) of triplet-bearing ewes during pregnancy can improve lamb survival (Kenyon et al. 2014; McCoard et al. 2020; Haslin et al. 2023) suggesting improved nutrition during pregnancy may improve lamb survival in triplets. This has not been evaluated directly, nor has the potential benefit of increasing feed on offer in the first month of lactation when lamb nutrition is dependent on ewe milk supply. A recent study reporting that increasing average pasture covers from ~1400 to 1900 kg DM/ha in the month prior to weaning benefited both ewe live weight and lamb weaning weight supports this suggestion (Mackay et al. 2024). Collectively, these results indicate that current industry recommendations for feed on offer for multiple-bearing ewes under New Zealand pastoral farming conditions during late pregnancy and early lactation may be inadequate.

Our long-term objective is to evaluate the impact of altering pasture allocation during the transition period, and the interaction with litter size, on ewe and lamb production performance with and without human intervention. Herein, we present the results of the first year of the study examining performance of the ewes and lambs during late pregnancy through to weaning.

Materials and Methods

Experimental design and treatments

The animal trial was conducted in the Manawatu region of New Zealand (latitude 40º19/s, longitude 175º29", 13 m above sea level) in winter to early summer (August to September lambing and December weaning) of 2025. All animal manipulations were conducted in compliance with the institutional Code of Ethical Conduct for the Use of Animals in Research, Testing, and Teaching, as prescribed in the Animal Welfare Act of 1999 and its amendments (New Zealand). The AgResearch Animal Ethics Committee (Ref: 2025-2553-AE-11341) approved the manipulations.

Four hundred and fifty-six mixed age Highlander ewes, who had previously reared at least 1 lamb as a hogget, were selected from a single commercial flock. Pregnancy status of the ewes had been determined by a commercial provider at approximately 75 days after the start of the mating period using transabdominal ultrasonography. Equal numbers of ewes estimated to be carrying 1, 2 or 3 lambs, with a body condition score >3 (BCS; Jefferies 1961), were transported to the research farm ~3 weeks prior to the start of treatments to acclimatize.

The experimental design was a 2 x 3 factorial with two levels of pasture allowance during the transition period (Table 1), and three litter sizes determined by pregnancy scanning data (singles, twins and triplets). The ewes were stratified according to ewe age (2-6 years), body condition score (BCS), and live weight (LWT) and randomly allocated to one of 4 blocks within each pasture allowance treatment. Pasture allocations of 3000/2000 kg DM/ha pre-/post-grazing and 2000/1400 kg DM/ha pre-/post-grazing were provided to the High and Standard (Std) treatments respectively to achieve the stated pasture allowances. Treatments were applied from ~100 days gestation until 4 weeks of lactation with similar numbers of ewes bearing singles, twins and triplets managed together within treatment to achieve the target pasture allowance (Table 1). Ewe numbers and initial LWT and BCS of the ewes in each treatment group and replicate are presented in Table 2. During the treatment period, average paddock size for High and Std groups was ~2 ha, and total block area was 6.4 and 3.9 ha respectively. Thereafter, High and Std groups, within a block, were managed as a single mob on the Std pasture allowance until weaning. The Std pasture allowance was consistent with current industry recommendations for multiple-bearing ewes (Beef + Lamb New Zealand 2018). Preparation of pasture covers and appropriate feed budgeting enabled similar stocking density over the lambing and early lactation period.

Pre- and post-grazing herbage mass in each paddock was measured using a rising plate meter and default equation (FarmWorks F400, Ag Hub, Tauranga, New Zealand) every 1-2 days to determine pasture allowance for each grazing treatment. Ewes in both grazing treatments were provided with fresh drinking water in troughs *ad libitum*.

Animal management

All ewes were quarantine drenched for internal parasites (Startect®, Zoetis) on arrival at the research

Table 1 Pasture allowance provided to ewes on a High or standard feed regime during late pregnancy and early lactation, above a residual pasture cover of 2000 and 1400 for High and Standard treatments respectively.

	Allowance (kg DM/head/day)[1]	
Period[2]	High	Standard
-40	1.5	1.3
-26	1.8	1.4
-12	2.2	1.85
0	2.7	1.9
+14	3.4	2.8
+28	3.9	3.2

[1] Allowance calculated to meet the requirements of a twin-bearing ewe and offered to all ewes within the replicate.
[2] Days before or after lambing

Table 2 Number [1], live weight (LWT) and body condition score (BCS) of the ewes in the High and Standard (Std) pasture allowance groups within each of the replicated blocks at the start of treatment.

	Block 1		Block 2		Block 3		Block 4		Overall	
	High	Std	High	Std	High	Std	High	Std	High	Std
Single-bearing ewes										
N	20	18	18	16	15	19	18	15	71	68
LWT	63.4±8.07	64.0±5.41	65.2±5.83	66.8±7.33	62.8±5.56	64.7±7.84	63.0±7.25	67.9±8.44	63.6±6.68	65.8±7.26
BCS	3.9±0.34	3.7±0.3	3.7±0.35	3.6±0.33	3.8±0.42	3.7±0.25	3.7±0.35	3.8±0.37	3.8±0.36	3.7±0.31
Twin-bearing ewes										
N	16	23	25	24	28	17	22	25	91	89
LWT	68.8±6.74	70.3±5.38	71.8±9.33	73.7±11.07	68.4±7.24	67.4±6.22	69.0±5.67	67.9±7.98	69.5±7.24	69.8±7.67
BCS	3.9±0.25	3.9±0.37	3.8±0.37	3.8±0.36	3.9±0.36	3.8±0.35	3.9±0.26	3.9±0.34	3.9±0.31	3.9±0.35
Triplet-bearing ewes										
N	18	15	12	16	13	16	17	13	60	60
LWT	73.0±5.28	73.6±8.9	77.7±7.5	74.2±9.1	71.9±7.06	73.5±7.72	72.1±5.77	71.3±6.11	73.7±6.40	73.1±7.96
BCS	3.8±0.30	3.9±0.31	3.9±0.23	3.7±0.36	3.9±0.32	3.9±0.34	3.8±0.31	3.7±0.32	3.8±0.28	3.8±0.33

[1] The number of ewes presented reflects the actual number of lambs born per ewe and excludes ewes bearing quadruplets (n=16) and quintuplets (n=1)

farm and injected with a slow-release source of iodine the following day (Flexidine™ iodised oil injection for sheep and cattle, Elanco) due to prior history of iodine deficiency on the farm. All ewes were vaccinated against Toxoplasmosis (Toxovax®, MDS Animal Health), Salmonella (Salvexin + B, MSD Animal health) and Campylobacter (Camy Vax 4, MSD Animal Health) prior to selection, and Clostridia and Leptospirosis (Ultravac® 7in1, Zoetis) at ~130 days of gestation. All animal health treatments were administered according to the manufacturer's recommendations.

For the duration of treatment, the ewes were rotationally grazed and moved on average every 3-5 days to maintain the target pasture allowances. All animals were monitored at least twice daily from 140 days gestation and throughout the lambing period between 0730 to 1730 hrs. Within the first 1-3 days post-lambing, ewes and lambs at foot were shed into adjacent paddocks with pasture allowances maintained according to the treatment regime. Once lambs reached ~4 weeks of age (±4 days), ewes and lambs from each treatment group (High/Std) within each block were combined and managed under the Std feeding management regime until weaning. This process was repeated until all ewes had lambed.

All lambs were tail docked and male lambs castrated at ~four weeks of age (end of grazing treatments). All lambs were vaccinated against scabby mouth (Phenax® Classic, Virbac) and clostridial disease (Ultravac 5in1, Zoetis) at tail docking as per the manufacturer's recommendations. Faecal egg counts of lambs were monitored from 8 weeks of age, but no antiparasitic treatments were required pre-weaning.

Ewe and lamb performance

Ewe LWT was measured using a walk over weigh crate and BCS (0-5 scale including half scores) were determined at 100 (start of pasture grazing treatment), 130 and 140 days of gestation, and at 4 (end of pasture grazing treatment), 8 and 12 weeks (weaning) of lactation, and were used to calculate the change in LWT and BCS between each time point.

Within the first 16 hours of life, lamb birth weight, BCS (same scoring system as used for ewes), sex and birth rank (single, twin, triplet) was recorded, and each lamb was EID ear tagged and matched to their dam. Lamb LWT and BCS were also determined at 2, 4, 8 and 12 weeks of age and used to calculate average daily gain and change in body condition score between time points. Lamb performance data presented includes data from all lambs that were reared by the ewes enrolled in the study independent of the level of maternal intervention required at lambing.

Lamb mortality was measured as the number of dead or orphaned lambs collected from birth to weaning. Lamb mortality was calculated at the level of the ewe based on the percentage of lambs that died or were orphaned within a litter. For this study, an orphan lamb was considered "commercially dead". A lamb was removed and reared as an orphan based on the following criteria: rejected by the ewe, poor vigour, low rectal temperature indicating hypothermia or risk of hypothermia (<38ºC) or very hungry and at risk of starvation at any time point post-birth. All ewe deaths and health interventions were recorded (e.g. dystocia, cast, mastitis treatment in ewes, navel infection in lambs). The level of human intervention to support the

ewes during the lambing period was categorised as 0 (none), 1 (minor intervention, e.g. righting a cast ewe and minor correction required to assist with lambing), and 2 (major intervention, e.g. veterinary medicine treatments and significant assistance required with lambing and righting a cast ewe more than two times). Ewe efficiency was calculated as the kg of lamb weaned per ewe.

Statistical analysis

A power analysis was used to determine the sample size required for the study to detect a 10% difference in lamb growth and 5% difference in lamb survival at 90% power. An initial analysis of ewe and lamb survival and ewe efficiency, BCS and LWT, herein labelled "with intervention", used data as collected from all ewes and lambs that survived to weaning, including maternal intervention at lambing (i.e. standing up if cast and assistance with lambing). Ewe post-lambing BCS data included all ewes rearing a lamb to weaning. The data was also analysed "without intervention". Lambs from ewes requiring any level of assistance (e.g. cast, dystocia, veterinary treatment) were considered "dead". Ewes which were classified as having major intervention (2) were assigned as "dead". Sixteen ewes gave birth to quadruplets and one ewe gave birth to quintuplets, and due to insufficient statistical power for comparison these ewes and their lambs were excluded from the analysis.

All analyses were conducted using R version 4.4.1 (R Core Team, 2024). The ewe data was analysed using the "anova" function in base R with the main effects evaluated were litter size, grazing treatment and their interaction. Fixed effects included in the model were ewe age, days from grazing treatment initiation to lambing, lamb sex, lamb rearing rank, and replicate. The lamb data was analysed using the "lmer" function of the lme4 version 1.1-35.5 (Bates et al. 2015) to fit random effect models. The fixed effects included in the model were the same as the ewe analysis with the ewe identifier included as a random effect. Analysis of variance for the linear models were carried out using the anova function in base R, while the analysis for the mixed effect models was carried out using the "anova" function of the lmerTest R package version 3.1-3 (Kuznetsova et al. 2017). Post-hoc tests for all models were performed using the "predictmeans" function of the predictmeans R package version 1.1.1 (Luo et al. 2014). Fishers exact test was used to evaluate the difference in proportion of ewe deaths, veterinary medicine treatments and dystocia between grazing treatments (Fisher 1922).

The data on lamb survival, mortality and ewe efficiency are presented as the main effects of pasture allowance and litter size and their interaction for all lambs that survived to weaning when human intervention was applied (with intervention). In addition, to illustrate the effect of human intervention, the data is also presented where lambs born to ewes that required human intervention were counted as "dead" (without intervention).

Results

Ewe mortality and morbidity

With Intervention: Ewe mortality did not differ between High and Std pasture allowance (0.9% vs. 2.8%; P=0.171). Reasons for ewe losses included Pasteurellosis pre-lambing, post-lambing clostridial infection, cast and failure to respond to treatment for uterine infection or mastitis. The percentage of ewes requiring veterinary medicine treatments was low and was not different between High and Std pasture allowance (0.5% vs. 2.3%; P=0.119). Interventions included treatment for ketosis, retained placenta and mastitis. Overall, 7.6% of ewes required assistance for dystocia. Dystocia incidence was lower in High than Std pasture allowance (4.4% vs. 9.5%; P=0.030). Overall, 5.3% of ewes were found cast prior to lambing and required intervention but there was no difference between grazing treatments or litter size groups. No cases of bearings were observed.

Without intervention: Ewe mortality was lower in the High than Std pasture allowance treatment (5.9% vs. 14.7%; P=0.003). Without intervention ewe mortality increased from 0.9% to 5.9% in High and from 2.8% to 14.7% in Std pasture allowance.

Ability to rear a lamb to weaning

The summary statistics for the ewes and lambs reared in the study with or without intervention are provided in Table 3.

With intervention: Overall, ewes on High pasture allowance reared 10% more of their potential lambs compared to ewes on Std pasture allowance (85% vs. 75%, P<0.0003). Triplet-bearing ewes on High pasture allowance reared more of their potential lambs (81% vs. 64%, P=0.0006) compared to ewes on Std pasture allowance, while twin- (86% vs. 81%, P=0.200) and single-bearing ewes (92% vs. 88%, P=0.582) reared a similar percentage of their potential lambs, translating into a greater percentage of lambs weaned per ewe lambed (165% vs. 147%). The percentage of ewes not rearing a lamb to weaning did not differ between High and Std grazing treatments (6% vs. 10%, P=0.154).

Without intervention: Overall, ewes on High pasture allowance reared 15% more of their potential lambs compared to ewes on Std pasture allowance (79% vs. 64%, P<0.0001). Triplet-bearing ewes on High pasture allowance reared more of their potential lambs (74% vs. 51%, P=0.0001) compared to ewes on Std pasture allowance, while twin- (81% vs. 68%, P=0.006) and single-bearing ewes (87% vs. 88%, P=1.0) reared a

Table 3 Summary of rearing success of ewes managed on High (2000 – 3000 kg DM/ha) or Standard (1400-2000 kg DM/ha) pasture allowance during the transition period (~100 days gestation to week 4 of lactation). Any lamb removed from the dam and reared as an orphan was considered "dead". Data are presented to reflect the population with and without human intervention

With intervention										
	Standard pasture allowance					High pasture allowance				
	Total ewes	Reared single	Reared Twins	Reared triplets	Reared none	Total ewes	Reared single	Reared Twins	Reared triplets	Reared none
Single-bearing	68	88%			12%	71	92%			8%
Twin-bearing	89	25%	69%		7%	91	19%	77%		4%
Triplet-bearing	60	18%	37%	33%	12%	60	5%	33%	57%	5%
Total	217	43%	38%	9%	10%	222	38%	41%	15%	6%

Without intervention										
	Standard allowance					High allowance				
	Total ewes	Reared single	Reared Twins	Reared triplets	Reared none	Total ewes	Reared single	Reared Twins	Reared triplets	Reared none
Single-bearing	68	88%			12%	71	87%			13%
Twin-bearing	89	19%	58%		22%	91	16%	73%		11%
Triplet-bearing	60	8%	30%	28%	33%	60	3%	27%	55%	15%
Total	217	38%	32%	8%	22%	222	36%	37%	15%	13%

similar percentage of their potential lambs. The number of lambs weaned per ewe lambed was greater in the High compared to Std grazing treatment (154% vs. 126%). The percentage of ewes not rearing a lamb to weaning was lower in the High compared to Std grazing treatment (13% vs. 22%, P=0.011).

Percentage lamb mortality

With intervention: Percentage lamb mortality was affected by litter size (P<0.0001) and pasture allowance (P=0.013) with lower mortality in triplet-born lambs from ewes managed on High compared to Std allowance, while no difference in mortality of twin- and single-born lambs between grazing treatments was evident (Figure 1). Overall, 19% of the lambs in the High grazing treatment were considered dead compared to 32% in the Std grazing treatment (P=0.013). Most lamb "deaths" (~70%) occurred on the day of birth.

Without intervention: Percentage lamb mortality was affected by litter size (P<0.0001) and pasture allowance (P=0.008) with lower mortality in twin- and triplet-born lambs from ewes managed on High compared to Std pasture allowance while single-born lamb mortality did not differ (Figure 1).

Overall, human intervention resulted in a total of 8% more lambs alive to weaning of which 38% were in the High and 62% were in the Std grazing treatment group.

Ewe efficiency

With intervention: The total weight of lambs born

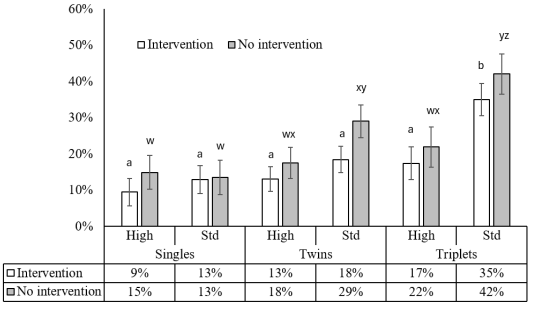
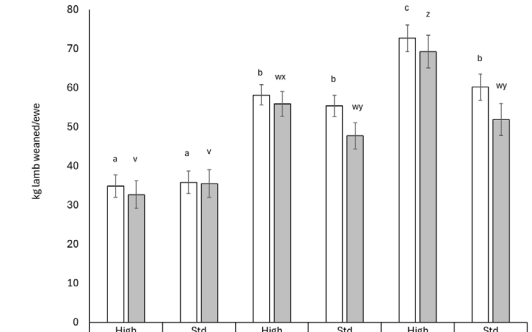


Figure 1 Percentage lamb mortality at weaning in single-, twin- and triplet-born lambs from ewes managed on High (2000 – 3000 kg DM/ha) or Standard (1400-2000 kg DM/ha) pasture allowance during the transition period (~100 days gestation to week 4 of lactation) with (open bars) or without (grey bars) human intervention Data are presented as mean ± SEM. Different letters indicate statistically significant differences between litter size and grazing treatment groups with (ab) or without (wxyz) human intervention.

per ewe lambed increased with litter size (P<0.0001, singles ~6kg, twins ~9.5kg, triplets ~12kg) and was not affected by grazing treatment (P=0.852). There was an interaction between grazing treatment and litter size for the weight of lambs weaned per ewe (P=0.009) with a 22% increase in total weight of lambs weaned in triplet bearing ewes managed on High compared to Std pasture allowance, but not in single- and twin-bearing ewes (Figure 2). The kg of lamb weaned per



	High	Std	High	Std	High	Std
□ Intervention	35	36	58	55	73	60
▨ No intervention	33	36	56	48	69	52

Figure 2 Total weight of lambs weaned per ewe lambed in single-, twin- and triplet-bearing ewes managed on High (2000–3000 kgDM/Ha) or Standard (1400-2000 kgDM/Ha) pasture allowance during the transition period (~100 days gestation to week 4 of lactation) with (open bars) or without (grey bars) human intervention. Data are presented as mean ± SEM. There was a significant grazing treatment by number of lambs born interaction with (P = 0.0009) and without (P=0.005) human intervention. Different letters indicate statistically significant differences between litter size and grazing treatment groups with (abc) or without (vwxy) human intervention.

ewe increased with litter size in ewes managed on the High (singles < twins < triplets) but at the Std pasture allowance multiple-born litters were not different (singles < twins/triplets). Similar results were observed of the total weight of lamb weaned per kg of ewe at weaning (data not shown).

Without intervention: There was an interaction between litter size and grazing treatment for the weight of lambs weaned per ewe (P=0.004) with a 33% increase in total weight of lambs weaned in triplet-bearing ewes managed on High compared to Std pasture allowance but not in single- and twin-bearing ewes (Figure 3). Similar results were observed of the total weight of lamb weaned per kg of ewe at weaning (data not shown).

Ewe LWT and BCS

Ewe live weight at each measurement time point did not differ with grazing treatment (P > 0.05) but was affected by litter size at all time points evaluated (P<0.001). Pre-lambing, single-bearing ewes were lighter than twin-bearing ewes, which in turn were lighter than triplet-bearing ewes (Figure 3). Post-lambing, single-bearing ewes were heavier than twin- and triplet-bearing ewes, which in turn did not differ. The change in ewe LWT from 100 to ~140 days of gestation was affected by grazing treatment (P<0.0001) with ewes on the High pasture allowance gaining more weight than ewes on the Std pasture allowance (17.0

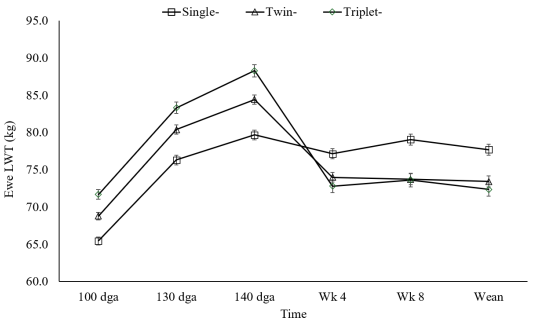


Figure 3 Live weight from 100 days gestation (dga) to weaning in single-, twin-, and triplet-bearing ewes that were managed on High (2000 – 3000 kgDM/ha) or Standard (1400-2000 kgDM/ha) pasture allowance during the transition period (~100 days gestation to week 4 of lactation). Data are presented as mean ± SEM.

vs. 14.8 kg; P<0.0001). During this period, ewe LWT change increased with increasing litter size (P<0.0001) with greater weight gain in triplet- (16.7 kg, compared to twin- (15.7 kg) and single-bearing ewes (14.4 kg) respectively. From ~140 days of gestation to 4 weeks of lactation, ewe LWT change did not differ between grazing treatments (P=0.594) but was affected by litter size (P<0.01) whereby LWT loss increased with litter size (-2.6 vs. -10.4 vs. -15.2 kg in single-, twin-, triplet-bearing ewes respectively). No grazing treatment by litter size interactions were observed.

Ewe BCS did not differ between grazing treatments at the beginning of the study with an average BCS of 3.8. Ewe BCS was greater in High compared to Std grazing treatment at 140 days of gestation (3.9±0.02 vs. 3.8±0.02, P<0.0001) and week 4 (3.4±0.04 vs. 3.2±0.04, P<0.0001), but not at week 8 of lactation (3.5±0.04 vs. 3.4±0.04, P>0.10) or weaning (3.4±0.04 vs. 3.5±0.05, P>0.10). Ewe BCS change pre-lambing (100 to 140 days of gestation) did not differ between grazing treatments (P=0.110), but twin- and triplet-bearing ewes had lower BCS change (0.02 vs. 0.03 BCS units respectively) compared to single-bearing ewes which gained 0.2 BCS units (P=0.0003; Figure 4). From ~140 days of gestation to 4 weeks lactation BCS change did not differ between High and Std grazing treatments (-0.6±0.04 vs. -0.6±0.04, P>0.654). Single-bearing ewes in the High grazing treatment lost less BCS than their Std counterparts (-0.2±0.04 vs. -0.4±0.04, P=0.01), while BCS change did not differ between High and Std ewes bearing and rearing twins (-0.7±0.05 vs. -0.8±0.06, P=0.172) or triplets (-1.0± vs. -1.1, P=0.846). From week 4 of lactation (end of grazing treatment) to weaning, ewes in the High grazing treatment gained less BCS compared to the Std grazing treatment (0.1±0.04 vs. 0.3±0.04, P<0.0001). Single-bearing ewes in the High grazing

treatment lost BCS from week 4 to weaning while their Standard counterparts gained BCS (-0.1±0.06 vs. 0.3±0.06, P=0.001). BCS change did not differ between grazing treatments for ewes bearing and rearing twins (0.2±0.06 vs. 0.3±0.07, P=o.311) or triplets (0.2±0.08 vs. 0.2±0.11, P=0.922).

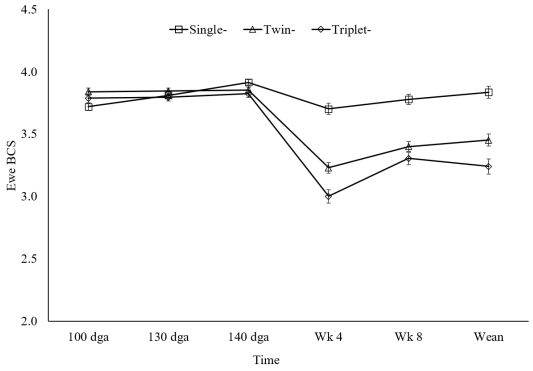


Figure 4 Body condition score (BCS) from 100 days gestation (dga) to weaning in single-, twin-, and triplet-bearing ewes that were managed on High (2000–3000 kg DM/ha) or Standard (1400-2000 kg DM/ha) pasture allowance during the transition period (~100 days gestation to week 4 of lactation). Data are presented as mean ±SEM.

Lamb LWT, growth and health

Lamb birth weight (kg) was affected by litter size (P<0.001, singles 5.7±0.07; twins 5.0±0.13; triplets 4.2±0.18) but not between High and Std grazing treatment (4.8±0.07 vs. 4.8±0.07, P=0.770). Live weight from birth to weaning was not affected by grazing treatment at any time point (P>0.10) but was influenced by litter size and rearing rank (P<0.0001; Figure 5). Average daily gain (ADG, g/d) from birth to weaning was affected by litter size and rearing rank (P<0.0001) with singles having higher ADG (360±3.8) than twins reared as singles (342±7.6), which in turn had higher ADG than twins reared as twins (308±2.8) and triplets reared as singles (310±11.6) or twins (302±6.1) with triplets reared as triplets having the lowest ADG (266±4.2). Male lambs had higher ADG than female lambs (326±3.2 vs. 303±3.3, P<0.0001). There was no effect of grazing treatment on pre-weaning ADG of the lambs (P=0.342).

Overall, 58 lambs were treated for entropion (6%), 53 were treated for scald (6%) and 8 (<1%) required veterinary drug treatment for significant health issues, i.e. navel infection, pneumonia or joint ill, with no differences evident between grazing treatments or litter size.

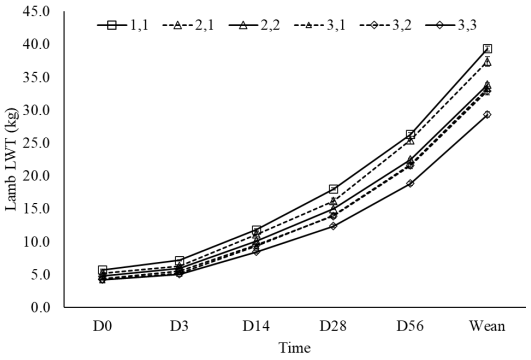


Figure 5 Lamb live weight (LWT) from birth (D0) to weaning at ~12 weeks in single-, twin-, or triplet-born lambs reared as either singles (1,1; 2,1; 3,1) twins (2,2; 3,2) or triplets (3,3) from birth to weaning. Data are presented as mean ±SEM. Live weight from birth to weaning was affected by litter size (P<0.001) at all time points with singles>twins and triplets reared as singles>twins and triplets reared as twins>triplets reared as triplets (all P<0.05).

Discussion

The objective of this study was to evaluate the impact of altering pasture allowance during the transition period (~100 days gestation to 4 weeks lactation) and the interaction with litter size on ewe and lamb performance to weaning. The key findings of this study were that managing ewes on High vs. Std pasture allowance (achieved by pasture allocations of 2000-3000 vs. 1400-2000 kg DM/ha) during the transition period decreased ewe morbidity (ability of the ewe to rear a lamb to weaning and dystocia incidence) and decreased lamb mortality from 27% to 18%, translating into a greater percentage of lambs weaned per ewe lambed (165% vs. 147%). The primary driver of production efficiency gains was reduced mortality and morbidity of the ewes, and reduced mortality in triplet-born (with intervention) and twin- and triplet-born lambs (no intervention) in the High compared to Std pasture allowance treatments. Additionally, the results of this study indicate that human intervention can reduce ewe mortality, particularly in ewes managed on the Std pasture allowance, or alternatively, ewes managed on the High pasture allowance group reduced the need for intervention. These results indicate that current industry recommendations for pasture allowance are insufficient to support survival of highly fecund ewes and their lambs in pasture grazing systems in New Zealand.

The lower survival of twin- and triplet-born lambs compared to single- counterparts in the Std group when feed allowance was restricted are consistent with observations of Everett-Hincks et al. (2005). In smaller

ewes (50-60kg) on pasture allocations of 2000 kg DM/ha pre-grazing and 1200 kg DM/ha residual, achieved by managing stocking density, Everett-Hincks et al. (2005) reported there was no difference in survival of twin- or triplet-born lambs. Combined with the results from the present study, this suggests that pasture allocation of up to 2000 kg DM/ha and grazing residuals of 1400 kg DM/ha are limiting the performance of triplet-bearing ewes when human intervention is applied, and both twin- and triplet-bearing ewes and their lambs without human intervention, and that higher pasture allocations are required for ewes of modern genetics. Further supporting this notion, lamb mortality did not differ between litter size groups in ewes managed on High pasture allowance in the present study highlighting that the High pasture allowance treatment was able to support similar lamb survival to weaning independent of litter size.

It is generally considered that as litter size increases, so does the nutritional stress on the dam resulting from increased nutrient demand not matched by an increase in feed intake (Kenyon et al. 2019), contributing to higher mortality of triplet-bearing ewes and their lambs compared to single- and twin-bearing ewes (Kleemann et al. 1993). It is well established that increasing ewe BCS through improved nutrition can improve lamb survival, especially in highly fecund ewes (Everett-Hincks et al. 2013; Kenyon et al. 2014; McCoard et al. 2020; Haslin et al. 2023). In the present study, BCS differences between grazing treatments at 140 days gestation and week 4 and 8 of lactation were small (<0.3 BCS units), suggesting pasture allowance in both the High and Std treatment groups were generally sufficient to meet the energetic requirements during this timeframe. However, the BCS loss exhibited in twin- and triplet-bearing ewes in both grazing treatments from late gestation to 4 weeks of lactation, indicates ewes consumed insufficient nutrients to maintain condition while meeting the high energetic requirements of late-pregnancy and early lactation. Interestingly, BCS in single-bearing ewes in both grazing treatments remained relatively constant throughout lactation indicating that even when pasture allowance is not restricted in the first month of lactation, gaining BCS during lactation is hard to achieve. The absence of a clear association between BCS loss in late pregnancy and early lactation and lamb survival, and the small effect of grazing treatment on BCS and BCS change in ewes independent of litter size, indicates that BCS loss during the transition period, may not be a good predictor of lamb survival outcome in well-fed ewes.

The impact of human intervention during the lambing period on ewe and lamb performance has been recently highlighted as an area where further research is required (Thompson et al. 2023). A recent survey of commercial farmers from the United Kingdom, Ireland and New Zealand highlighted that survival of triplet-born lambs increases when management intervention is applied at lambing, such as removal of one lamb from a litter to rear by another ewe or artificially (Erichsen et al. 2024). The present study supports that view. In the current study such management interventions included identifying cast ewes, providing assistance with dystocia and treatment of infections (e.g. retained placenta and mastitis). Assuming that interventions were necessary for survival of the dam, these interventions likely contributed to increased lamb survival and reduced the percentage of ewes not rearing a lamb to weaning in the High compared to Std pasture allowance treatment group. These results also highlight the potential benefits of increasing pasture allowance for highly fecund ewes in late pregnancy for reducing the need for intervention. A challenge for the industry is establishing if such interventions can be implemented practically and cost effectively on farm.

It is well established that lamb birth weight decreases as litter size increases (Kenyon et al. 2019; McCoard et al. 2017) which is consistent with the observations in the present study. In the present study, while lamb birth weight was affected by litter size, it was not affected by grazing treatment suggesting both grazing treatments were able to adequately support fetal growth and lamb birth weight. Experimental studies indicate that key risk factors for lamb mortality are low birth weight, particularly due to poor maternal nutrition during pregnancy, litter size and birth difficulty (Dwyer et al. 2016). In the present study, there was an interaction between litter size and grazing treatment for lamb mortality, highlighting the complex interactions between these risk factors. Work is currently underway to further understand the potential mechanisms that contributed to lamb mortality and survival outcomes in the present study, including changes in dam and offspring physiological status, dam behaviour, pasture quality and weather conditions.

Ewe lambing percentage is a key driver of ewe efficiency and farm profitability and eco-efficiency (Earle et al. 2017; Young et al. 2014; Mackay et al. 2019). Therefore, the greater weaning percentage in the High compared to Std grazing treatment, with intervention (165% vs. 147%) or without intervention (154% vs. 126%), highlights the value of increasing pasture allowance during the transition period. In the present study, similar numbers of single, twin and triplet-bearing ewes were selected for experimental purposes to measure the impact of grazing treatment on litter size and their interaction which is not the ratio observed in commercial flocks. Rather, in commercial flocks, as pregnancy scanning percentages increase, the proportion of triplet-bearing ewes increases and single-

and twin-bearing ewes decrease, e.g. a flock scanning 240% has approximately 45% triplet-, 45% twin- and 10% single-bearing ewes (Amer et al. 1999). It has been generally well accepted to date that triplets have reduced survival and lower weaning weights compared to single- and twin-born counterparts (Kenyon et al. 2019). However, the results of the present study suggest that similar levels of survival in triplets compared to their single- and twin counterparts can be achieved when the pre-grazing mass during the transition period is increased to between 2000-3000 kgDM/ha with a grazing residual of 2000 kg DM/ha. Prior studies evaluating the effect of increased pasture covers on survival of triplets have used pasture covers of up to 2000 kgDM/ha (Everett-Hincks et al. 2005), which has historically been considered as "overgenerous" (Rattray et al. 1987). The differences between these prior studies and the present study suggests that ewes of modern genetics may have greater feed requirement than ewes from over 2 decades ago and that feeding recommendations require review. Furthermore, the high proportion (70%) of lamb deaths or removals to be reared as an orphan (i.e. commercially dead) occurring at or on the day of birth, and lower proportion (39%) being in the High compared to Std ewes, indicates that the physiological requirements of the ewes and their fetuses are not being met during gestation to support parturition and neonatal survival. Further investigations are underway to explore environmental and physiological parameters that may be contributing to ewe and lamb mortality and morbidity.

Practical considerations and future directions

The results presented in this paper provide an insight to the potential value of providing pasture covers which result in higher pasture allowance and residuals, and the opportunity of this approach to reduce ewe and multiple-born lamb mortality and morbidity and reduce the requirements for intervention at lambing. An underlying mechanism to explain these effects is lacking from this analysis but research is continuing to define the metabolic and immunological responses of the ewes in this study. Further insight into the impacts of energy density and protein content of the diets is also underway. This may help explain potential changes in the responses of the ewe around lambing.

Applying these results in practice will be challenging. Farmers aspiring to replicate the outcomes will need to consider many aspects of their farm system to enable the provision of a high pasture allowance and residual pasture covers in the late winter/early spring. Options such as altering the priority of various livestock classes, creating extra feed through nitrogen fertiliser inputs, modifying winter feed supply, and lambing later are all methods of changing available feed supply to match supply with demand. Examples of achieving this type of change have been documented (e.g. Johns et al. 2016) and indicate that considerable effort is required to transition to improved ewe and lamb performance outcomes.

The economics and eco-efficiency of implementing a feeding management regime such as this are currently under evaluation using a modelling approach. However, some examples do exist to highlight the impacts of improving lamb survival on farm economics and eco-efficiency (e.g. Johns et al. 2016, Taylor et al. 2024; Stevens 2026) while using current feed resources. It will be important for practitioners to recognise that achieving these goals will require a transition from current practices to capture the potential benefits outlined in this study.

Conclusions

The data from the first year of this multi-year study indicate that current industry recommendations for pasture allowances during the transition period are insufficient to support survival of multiple-bearing ewes and their lambs in pasture grazing systems in New Zealand. The improved survival of multiple-bearing ewes and their lambs, but not lamb growth rate, was the primary driver of the higher ewe efficiency (kg lamb weaned per ewe) in ewes managed on higher pasture allowances during the transition period. Human intervention increased the overall percentage of ewes weaning a lamb, overall lamb and ewe survival and ewe efficiency. A challenge for the industry is establishing if such interventions can be implemented practically and economically on farm.

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