Impact of the proximity of the water source on survival and growth of triplet lambs – a case study

S McCoard[a]*, J Wing[b], T Smith[b] and S-Y Hea[a]

[a]*AgResearch Limited, Grasslands Research Centre, Tennent Drive, 4442 Palmerston North, New Zealand;* [b]*Freestone Farm, Te Anau, Southland, New Zealand*

**Corresponding author:* Email: sue.mccoard@agresearch.co.nz

Abstract

The objective of this study was to evaluate whether the provision of greater access to watering sites two weeks prior to lambing and at least one week after lambing impacts lamb survival and growth to weaning, using triplets as a model. Triplet-bearing ewes (n=206, 116-131 days gestation) were randomly allocated to either the control (one water trough/paddock) or treatment group (2-3 water troughs/paddock) balanced for ewe live weight, body condition score and stage of gestation, at a stocking density of 8.6-9.1 ewes/ha with three replicated paddocks/treatment. Lamb survival was determined via DNA parentage and lamb growth recorded at docking, weaning and at six months of age. Lamb survival (60 vs 62%, P=0.690) and lamb growth (P=0.452) did not differ between the treatment and control groups. The key finding of this study was that increasing the availability of a water supply to triplet-bearing ewes in late pregnancy and early lactation did not influence lamb survival or growth.

Keywords: sheep; triplets; water; lamb survival

Introduction

Lamb survival is a major animal health and production issue, with the majority of deaths occurring within the first three days of life (McCoard et al. 2017). Water is an important nutrient for maintenance and productivity of livestock and contributes to all vital bodily functions (digestion, absorption, metabolism, nutrient transport, waste elimination and thermoregulation), and is particularly important for lactation. Water consumption varies greatly depending on the type and size of the animal, level of activity, climatic conditions and the animal's physiological state (Beed 1994). Water availability around lambing may be potentially limiting because large paddocks used for lambing often have a single water source (water trough or creek). Further, as ewes select lambing sites up to 24 hours before lambing and can remain at those sites for up to 12-24 hours after lambing, there is the potential for the ewes to not consume water for 1-2 days, potentially resulting in dehydration. Water deprivation can alter the endocrine and metabolic balance of the animal (Jaber et al. 2004; Li et al. 2000). In sheep and goats, water deprivation for 72 hours negatively affects milk production (50% reduction) by reducing feed intake and causes an increase in the viscosity of milk (Agana 1992). Because triplet-bearing ewes spend more time giving birth and establishing the ewe-lamb bond immediately after birth, there is potential for triplet-bearing ewes to be more at risk of dehydration than ewes bearing one or two lambs. Therefore, triplet-bearing ewes were selected as the model for this study.

A recent study by Corner-Thomas et al. (2019) reported no effect of increased access to water on ewe live weight or birth weight of their lambs with the water content of the pasture meeting the requirements of ewes in late pregnancy. However, the potential for improving access to a water source on lamb survival in NZ sheep farming systems has not been evaluated. The objective of this study was to evaluate whether the provision of greater access to water two weeks prior to lambing and at least one week after lambing in triplet-bearing ewes increases lamb survival and growth in a commercial farming system. We hypothesised that increasing water availability in lambing paddocks through provision of a greater number of water troughs around the paddocks would increase survival and growth of triplet-born lambs.

Materials and methods

The study was conducted in the 2018 lambing season at Freestone Farm near Te Anau (a high fecundity flock) in the South Island of New Zealand. This study did not require additional manipulation of animals beyond current standard farm practice and, thus, no ethics approval was required (notification #115, AgResearch Grasslands Animal Ethics Committee). This was because the only change in farm management beyond current practice was the provision of additional water troughs in some of the lambing paddocks. The animal performance data selected for reporting was based on records already collected on this farm as part of standard farm recording for this flock.

This study used triplet-bearing ewes (n=206). The ewes were randomly allocated to one of two treatment groups at set stocking (28th August 2018) at approximately 116-131 days of gestation (mean 121 days). The treatments were applied at the paddock level, with three paddocks (replicates) allocated to each treatment group. Paddock sizes are presented in Table 1. The control group (n=103) was provided with access to one water trough per paddock. The treatment group (n=103) was provided with access to two or three troughs per paddock. The maximum walking distance to a drinking water source in the control paddocks was 233±33m compared to 107±3m in the treatment paddocks.

Table 1 Paddock size, number of triplet lambs scanned, weaned, hand reared and fostered in the control (single drinking-water source) and treatment (2-3 drinking-water sources) groups in each replicate (paddock).

Paddock	Group	Paddock size (ha)	No. lambs at scanning	No. lambs weaning	Lamb survival to weaning (%)	No. lambs hand reared	No. lambs fostered
A32	Control	3.7	90	53	59%	4	2
A34	Treatment	3.7	87	42	48%	8	1
A35	Control	4.5	114	62	54%	6	1
A36	Treatment	4.1	112	68	61%	4	2
A40	Control	4.2	105	64	61%	1	2
A42	Treatment	4.4	114	65	57%	5	0

All ewes were fetal-aged at pregnancy scanning (transabdominal ultrasonography using a commercial operator) within an estimated five-day range (e.g., 65, 70, 75 days gestation). Ewes were set stocked in groups with a 10-day range in expected lambing date on 28th August 2018 according to their expected lambing dates at 8.8-9.1 ewes per hectare (standard farm practice).

Scanning data were used as a proxy for the number of lambs born, and survival of lambs determined through DNA parentage to establish the number of live lambs per ewe at docking and weaning. Fetal loss between mid-pregnancy scanning and lambing is typically low (~5%; Edwards et al., 2016; Juengel et al., 2015). Therefore, the number of lambs scanned is a relatively accurate reflection of the number of lambs born. All data used in this study were downloaded from Sheep Improvement Limited (SIL). Any lambs removed from the ewes and reared artificially, or lambs fostered onto ewes were recorded.

The ewes were offered a ryegrass/white clover mixed pasture. Pasture covers at set stocking were 2300-2700 kg/DM/ha and were 2100-3100 kg/DM/ha on 21st September 2018. Only sheep were set stocked in the trial paddocks. Cows and calves were introduced into the paddocks to manage pasture covers after all ewes had lambed. Feed budgets were calculated using the FeedPlus program (in-house Pāmu software developed by AgResearch). Dry matter allowances were calculated based on ewes mated on the 20th April 2018 at an average live weight of 80 kg, expected lambing date of 17th September 2018, a potential 300% lambing (i.e., three lambs/ewe) and 270% at docking (i.e., 2.7 lambs/ewe) with an average lamb birth weight of 3.9 kg. The calculations were based on an estimated pasture energy content of 11.5 MJ ME/kgDM from April to the end of August 2018, and 12.0 MJ ME/kgDM from September to weaning in early January 2019 at an average lamb live weight of 33 kg.

Pasture samples were collected from each of the paddocks at set stocking (30 August 2018) and were analysed for chemical composition by Hill Laboratories (Hamilton, New Zealand). Pasture samples were oven dried at 62°C and ground to pass through a 1.0-mm screen. Dry matter was measured by weight loss on drying at 105°C for a minimum of 24 hours. Nitrogen was estimated by NIR, calibration based on nitrogen by Dumas combustion. Crude protein was calculated by multiplying nitrogen by 6.25. Digestibility of organic matter in dry matter (DOMD) was calculated from organic matter digestibility (OMD) using the Australian Fodder Industry Association (AFIA) Standard Equation. OMD was estimated by NIR, calibration based on AFIA pepsin-cellulase procedure. Metabolisable energy was calculated from DOMD using AFRC and Lincoln University standard formulae.

All ewes were vaccinated with Covexin 10 (MSD Animal Health, Wellington, New Zealand) four weeks prior to lambing and all ewes received a Flexidine injection (Bayer Animal Health, Auckland, New Zealand) on the 12th of July. The two-year-old ewes were also given a booster Campy Vax vaccination (Campyvax4®, MSD Animal Health) prior to mating. Prior to and during lambing, ewes were monitored three times a day and birthing assistance was provided if required. Water meters (Arad M Water Meters, ADM25-EV, WaterForce Winton, New Zealand) were installed in two paddocks (A40 - control and A42 - treatment) and paddock water intake was monitored from 1st September to 9th October 2018. Water use in these paddocks is presented as average intake per ewe in each group.

A generalised linear mixed model with a logit link function and random intercept for paddock was used to estimate the effect of paddock treatment on the proportion of lambs surviving from birth to weaning. The experimental unit was the paddock, as the treatments were applied at the paddock level, and the observational unit was the ewe. Variables included in the model were the paddock treatment at set stocking, ewe age (2, 3, 4, 5, 6+), body condition score (BCS; 1-5 scale, Jefferies 1961) and live weight before lambing, and the estimated age of the fetus at set stocking.

For the analysis of lamb live weights from docking to six months of age, a linear mixed model with weights nested within lambs, within ewe, within paddock was used. Variables included in the model were the ewe paddock treatment at set stocking, ewe age (2, 3, 4, 5, 6+), ewe BCS and live weight before lambing, the estimated fetal age at set stocking (as a proxy for lamb age), lamb sex, lamb rearing rank at docking, and the weighing time (docking, weaning and six months). The ewe BCS and live weights, and the estimated fetal age at set stocking variables were centred by subtracting each recorded value by their respective sample means. All statistical analyses were undertaken using the statistical software R (R Core Team, 2018).

No statistical analysis was undertaken for the ewe live weight or BCS data. Live weight and BCS records were taken prior to set stocking and, thus, prior to treatment. This raw data is included for the purposes of describing the populations.

Analysis of lamb survival was based on the number of lambs weaned (including fostered lambs) relative to the number of lambs scanned. Lambs that were hand reared were considered "dead" for this analysis.

Results and discussion

Pasture quality and water use

The chemical composition (as a % DM) of the pasture in the control versus treatment groups at the time of set stocking was: DM 23% for both groups, crude protein 22 *vs.* 21% DM, 12.6 *vs.*12.5MJ/ME kgDM, and 85 *vs.*84 digestibility of organic matter in dry matter. The chemical composition of the pastures indicates that good-quality pasture was offered to all groups at set stocking.

Ewe survival, assisted births, live weight and body condition score (BCS)

Based on the number of ewes present at scanning versus the number of ewes present at weaning, ewe deaths ranged from 3 to 12% among the paddocks (average of 6.5%). Lamb losses from these ewes were not included in the analysis of lamb survival but highlights another significant area of lost opportunity.

The live weight of the control *vs.* treatment ewes at mating was 75±0.1 *vs.* 74±0.1 kg, at pregnancy scanning was 82±1.3 *vs.* 85±1.1 kg and two weeks prior to set stocking was 90±1.1 *vs.* 90±1.1. The BCS of the control and treatment ewes at mating was 3.7±0.05 *vs.* 3.7±0.05, at pregnancy scanning was 3.6±0.04 *vs.* 3.7±0.05 and two weeks prior to set stocking was 3.6±0.04 *vs.* 3.6±0.04. On average, ewes in both groups had similar live weights and BCS (mean and variation) throughout gestation. The increase in live weight over time is expected because of advancing gestation.

Lamb survival

On average 48-61% of lambs survived from scanning to weaning (Table 1) and the number of lambs hand reared or fostered onto ewes was low and was similar across all replicates. There was no difference in lamb survival between the treatment and control group (60 *vs.* 62%, P=0.690). Furthermore, ewe age (P=0.460), BCS (P=0.450), ewe live weight (P=0.350) and fetal age at set stocking (P=0.250) had no effect on lamb survival in this population. It is important to note, that except for age, which was variable (2-6+ years) the ewes were of similar BCS, live weight and gestational age, therefore, it is not surprising that these traits did not influence lamb survival in this population. In this population, only three ewes (1.5%) lost 1 BCS unit from pregnancy scanning to lambing, and all other ewes either lost 0.5 BCS units (27%), maintained BCS (60%) or gained 0.5 BCS units (12%). This reflects the careful attention to detail of feeding management of the ewes.

Lamb survival was lowest for two-year-old ewes (52%, CI 44–59%) and while on average it was the greatest in six-year-old ewes, there was a much-higher population variation (72.5%, CI 49-88%; Figure 1). These results are consistent with previous studies (McCoard et al., 2018; Juengel, McCoard, Johnstone unpublished data). The level of mortality observed in this study (39-52% across the different paddocks) is similar to values observed in previous

Figure 1 The effect of ewe age (two to six years) on the proportion of lambs surviving from pregnancy scanning to weaning ~12 weeks post-partum in triplet-bearing ewes with increased access to a water supply (treatment; 2-3 drinking-water sources per paddock) compared to standard farm practice (control; 1 drinking-water source per paddock). Data presented as predicted mean and 95% confidence intervals.

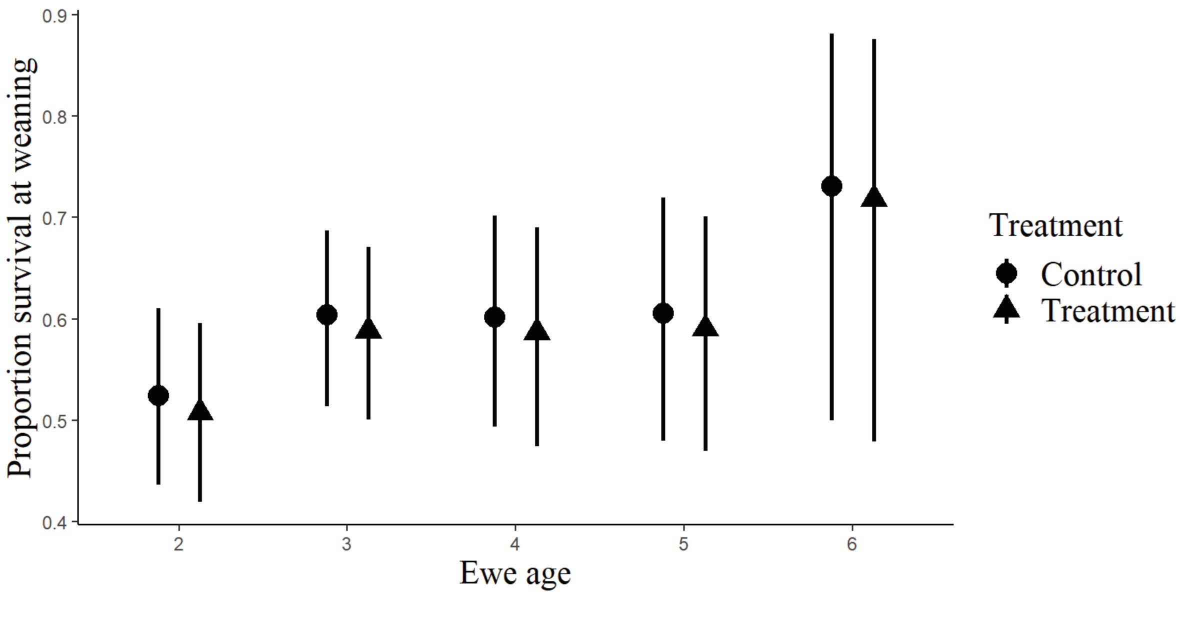


Figure 2 Live weight of female (solid lines) and male lambs (dashed lines) at docking, weaning and ~ six months of age. Sex × time interaction (P =0.003). Data are presented as means ± SEM.

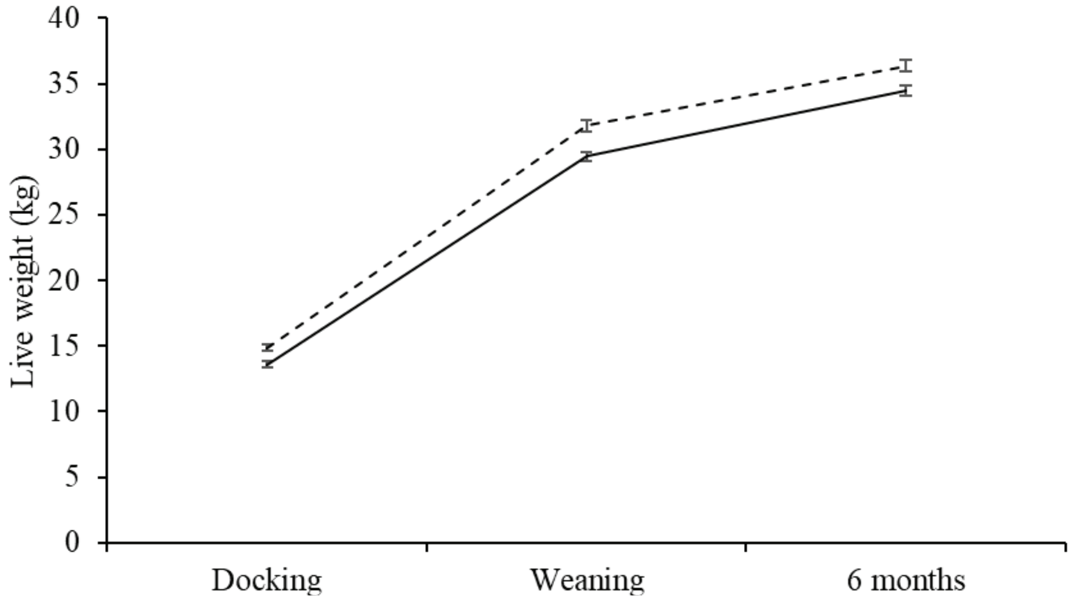
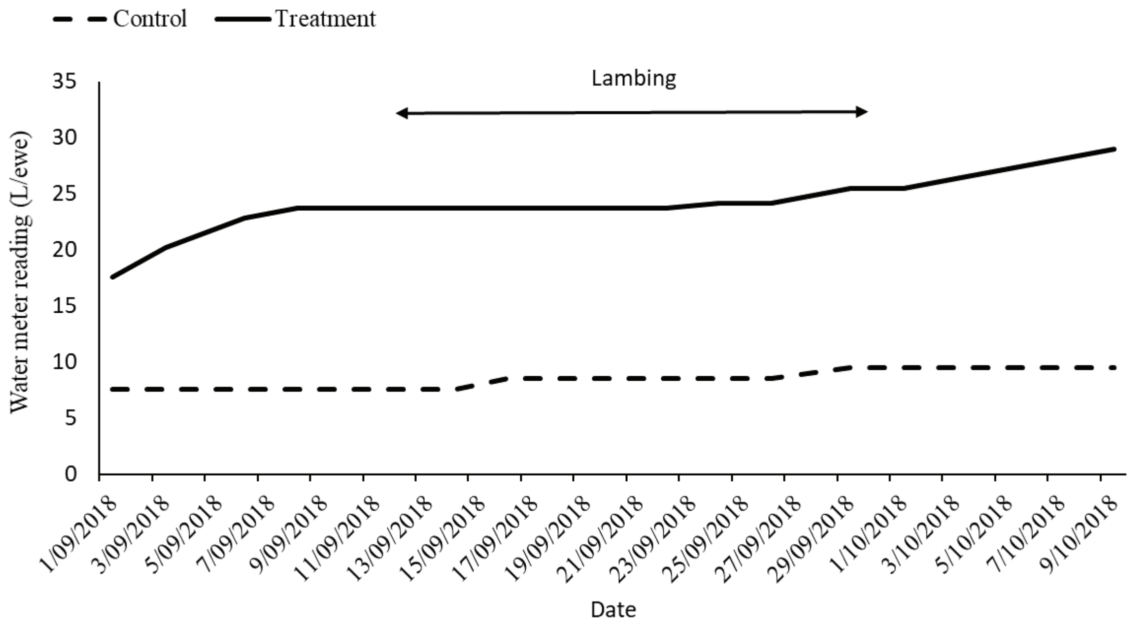


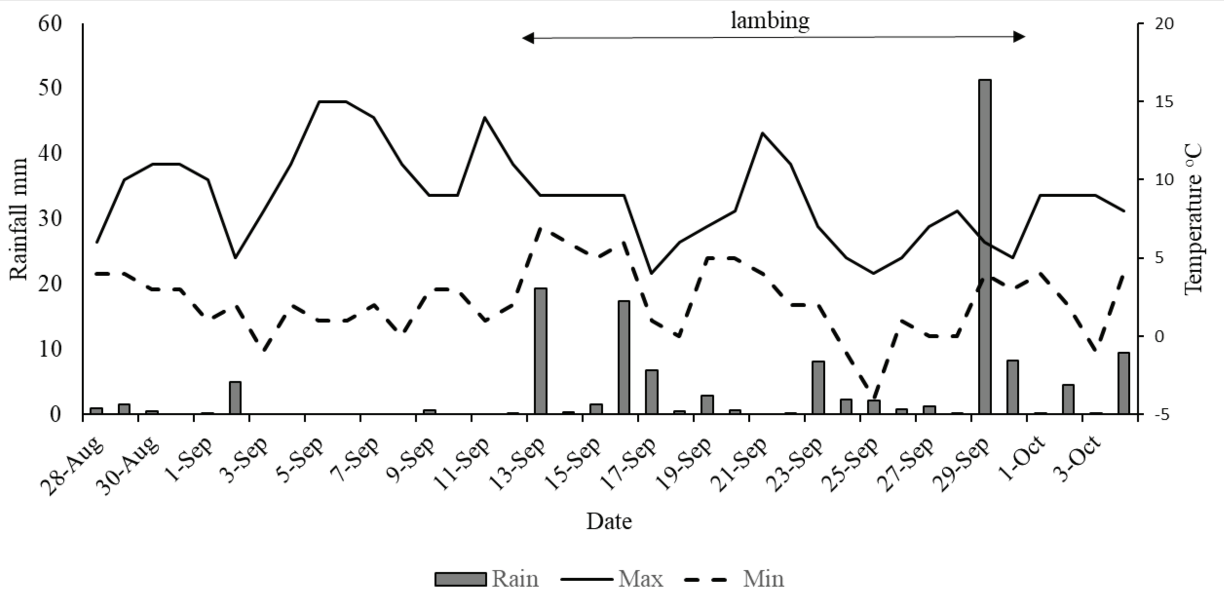
Figure 3 Water usage in one control (single-drinking water source) and one treatment (2-3 drinking-water sources) paddock during the trial from set stocking to one week after lambing.



studies in New Zealand (25-40%; West et al. 2008; Stafford 2013), Australia (Hinch & Brien, 2014) and other areas of the globe (Rowland et al. 1992; Dwyer et al. 2007).

The key finding from this study is that increasing availability of a water supply to triplet-bearing ewes in late pregnancy and early lactation, by reducing the walking distance to drinking water troughs, did not influence lamb survival or growth. The intake of water per ewe was estimated to be 2-3-fold higher in the treatment compared to control group (Figure 3), likely resulting from the shorter walking distance. While the water intakes remain to be verified in a larger study, these preliminary results illustrate that, when a nearby water source is provided, water intake increases even when pasture water content is high. Water deprivation for 72 hours negatively affected milk production (50% reduction) in sheep and goats by reducing feed intake and caused an increase in the viscosity of milk (Agana 1992) which can affect the ability of the lamb to extract colostrum/milk from the gland. However, Casamassima et al. (2008) reported that reducing water consumption by 20-40% daily had no effect on milk yield, composition or feed intake. In the present study, reducing the walking distance to a water source and/or increasing water intake did not appear to influence lactational performance of the ewes as

Figure 4 Estimated daily rainfall and minimum and maximum temperatures during the trial period from set stocking to one week after lambing. Data source: www.worldweather.com.



indicated by similar lamb survival and growth between the groups. Furthermore, there was no apparent effect on the formation of the ewe-lamb bond/mis-mothering which can occur when ewes leave their birth site.

Sheep can tolerate a water loss greater than 20% (Jaber et al. 2004) due to their forestomach which is able to accumulate water to use when water availability is low. It is likely that this adaptive capacity, coupled with the high-water content of the pasture (i.e., <25% DM) was able to mitigate against the risk of water deprivation during the parturition period, or that a single water source was able to provide sufficient water to cover their requirements. A limitation of this study was that due to the requirement to minimise contact with the ewes to avoid disruption of the birth process and to achieve commercial farming practice, no direct physiological measures on the ewes prior to or at lambing could be undertaken to determine their level of hydration. Such measures could be considered in future studies when animals are housed or under experimental conditions that enable individual animal handling. During the lambing period, a total of 138 mm of rainfall was recorded accompanied by relatively cool temperatures (Figure 4). Furthermore, there was only one day during lambing when no rainfall was recorded. Sun et al. (2017) reported that in cattle, the number of wet days rather than total rainfall significantly impacted daily water intake from troughs. Therefore, it is possible that the ewes were able to gain access to water from puddles in the paddocks, in addition to water in and on pasture, thereby reducing the need to visit the reticulated water supply.

Lamb growth

There was no effect of treatment on lamb growth (P=0.578). Sex (P<0.001, males > females), weighing time (P<0.001), ewe live weight at lambing (P=0.002), rearing rank at docking (P<0.001), fetal age at set stocking (P=0.001) and the interaction between sex and time (P=0.003; Figure 2) were significant predictors of lamb live weight. At docking the lambs were on average 14±0.4 kg live weight, 30±0.4 kg live weight at weaning and 35±0.4 kg live weight at six months of age. Ewe BCS and age were not significant predictors of lamb weight from docking to weaning.

The relatively high ewe losses (3-12) and lamb losses (39-58%) across the paddocks irrespective of treatment group, highlights the challenges associated with triplet-bearing ewes. The causes of the high losses were not investigated in this study but are within the range reported in the literature (Kenyon et al. 2019) and losses could be contributed to a variety of causes as previously described (McCoard et al. 2017; Kenyon et al. 2019) Increasing access to a fresh water supply by reducing the walking distance did not influence lamb survival or growth in this study. A recent study by Corner-Thomas et al. (2019) reported no effect of increased access to water on ewe live weight or birth weight of their lambs with the water content of the pasture meeting the requirements of ewes in late pregnancy. While it was not possible to determine the frequency of visits to the troughs by the ewes in the current study, the results suggest that the water content of the pasture and presence of one water trough was sufficient to meet the requirements of the ewes, or that they were able to visit the water sources frequently enough to not adversely affect lamb survival or growth. It is important to note that the paddock sizes used in this study (3.7-4.4 ha) may be considered small in comparison to some extensive production systems. Whether similar results would be observed in environments where paddock sizes are much larger or where feed quality and/or terrain differs, warrants further investigation.

Further research is required to identify practical intervention strategies to improve survival of triplet-bearing ewes and their progeny. There are substantial eco-efficiency gains to be realised through capitalising on increased fecundity (Mackay et al. 2011; 2019). However, novel strategies are yet to be discovered and implemented to realise this potential even on high-performing farms such as the Freestone Farm where best-practice feeding and animal-management strategies including increased shepherding around lambing time are implemented.

Acknowledgements

This work was funded by AgResearch's Strategic Science Investment Fund (SSIF) with on-farm trial, data collection and capture funded in-kind by Pāmu and Focus Genetics LP.

References

Agana AA 1992. Water utilization by sheep and goats in northern Nigeria. World Animal Review. FAO 73: 9-14.

Beed DK. 1994. Water: the most important nutrient for dairy cattle. Presented at the 31st Florida Dairy Production Conference; Gainesville, FL, USA: University of Florida.

Casamassima D, Pizzo R, Palazzo M, D'Alessandro AG, Martemucci G. 2008. Effect of water restriction on productive performance and blood parameters in comisana sheep reared under intensive condition. Small Ruminant Research 78: 169-175. Doi: 10.17221/144/2015-VETMED

Corner-Thomas RA, Winchester N, Draganova IG, Burkitt LLO, Kenyon PR. 2019. The impacts of reticulated water on sheep performance during winter in the Manawatu. New Zealand Journal of Animal Science and Production 79: 202 (abstract).

Dwyer CM. 2007. The welfare of the neonatal lamb. Small Ruminant Research 76: 31–41. Doi: 10.1016/j.smallrumres.2007.12.011.

Hinch GN, Brien F. 2014. Lamb survival in Australian flocks: a review. Animal Production Science 54: 656–666. https://doi.org/10.1071/AN13236

Jaber LS, Habre A, Rawda N, Abi Said M, Barbour EK, Hamadeh S. 2004. The effect of water restriction on certain physiological parameters in Awassi sheep. Small Ruminant Research. 54: 115-120. https://doi.org/10.17221/144/2015-VETMED

Jefferies BC. 1961. Body condition scoring and its use in management. Tasmanian Journal of Agriculture 32: 19-21.

Kenyon PR, Roca Fraga FJ, Blumer S, Thompson AN. 2019. Triplet lambs and their dams – a review of current knowledge and management systems. New Zealand Journal of Agricultural Research 62(4): 399-437. Doi/org/10.1080/00288233.2019.1616568

Mackay AD, Rhodes AP, Power I, Wedderburn ME. 2011. Has the eco-efficiency of sheep and beef farms changed in the last 20 years? Proceedings of the New Zealand Grassland Association 73: 119-124.

Mackay AD, Scobie DR, Rhodes TR, Devantier D. 2019 INVITED PAPER. Has progress been made in increasing the eco-efficiency of livestock systems? New Zealand Journal of Animal Science and Production 79: 43-55.

McCoard SA, Sales FA, Sciascia QL. 2017. Invited review: impact of a specific nutrient interventions during mid-late gestation on physiological traits important for survival of multiple-born lambs. Animal. Doi:10.1017/S1751731117000313.

Nowak R, Poindron P. 2006. From birth to colostrum: early steps leading to lamb survival. Reproduction Nutrition and Development 46(4): 431-446. doi: 10.1051/rnd:2006023.

R Core Team 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available online at https://www.R-project.org/.

Rowland JP, Salman MD, Kimberling CV, Schweitzer DJ, Keefe TJ. 1992. Epidemiologic factors involved in perinatal lamb mortality on four range sheep operations. American Journal of Veterinary Research 53: 262–267.

Stafford KJ. 2013. Welfare of sheep and goats. Animal welfare in New Zealand. Occasional publication no 16. New Zealand Society of Animal Production, Cambridge, New Zealand, pp. 56–71.

Steiger Burgos M, Senn M, Sutter F, Kreuzer M, Langhans W. 2001. Effect of water restriction on feeding and metabolism in dairy cows. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology 280: R418–27. doi: 10.1152/ajpregu.2001.280.2.R418

Sun LZ, Auerswald K, Wenzel R, Schnyder H. 2014. Drinking water intake of grazing steers: The role of environmental factors controlling canopy wetness. Journal of Animal Science 92: 282-291.

West DM, Bruere AN, Ridler AI. 2008. The sheep: health, disease and production, (3rd edition). Vet Learn Foundation, Wellington, New Zealand.