An evaluation of the FeedSmart app for feed planning in a controlled nutrition study

JL Peers-Adams[a]* and P Smith[a]

[a]*AgResearch Invermay Agricultural Centre, Private Bag 50034 Mosgiel 9053, New Zealand*

**Corresponding author:* Email: jacqueline.peers-adams@agresearch.co.nz

Abstract

FeedSmart is an app designed for smartphones, tablets, and computers to help farmers make instant and accurate decisions around feed management. The accuracy of the FeedSmart app was assessed in an intensive controlled nutrition trial, over two consecutive years. The objective of the trial was to compare a maintenance (M) diet to a restricted diet, 0.6 of maintenance (R), over a 55-day period in sheep. In the first year, 48 animals were split between M and R groups. In the second year, 274 ewes were divided into light (L) and heavy (H) groups, then into M and R. The FeedSmart app was used to calculate the area required for both M and R groups. Based on previous data, restricted animals were expected to lose 7.1% of their body weight over the 55-day period. The changes in year 1 M and R groups and year 2 HM and HR groups were not significantly different from the expected changes. The weight changes in the year 2 LM and LR groups were significant, but were within the errors associated with the calculations underlying the FeedSmart app. In these trials, the FeedSmart app provided an accurate tool for feed management.

Keywords: FeedSmart; feed Planning; sheep; nutrition

Introduction

Feed planning is used to improve animals' health and productivity and pasture growth and quality to increase farm profitability (Densley et al. 2004). Having precise management of a farm's feed supply ensures good nutrition for livestock, while maintaining sufficient pasture quality and quantity.

Feed planning and prediction of feed demand increases farm profitability (Beukes et al. 2015) driving and influencing the amount of supplement or cropping required for optimal stock performance (Clark & Woodward 2007; Johns et al. 2016). However, it has also been demonstrated that matching animal performance with pasture performance and supply can also be more important for increasing farm profitability than improving animal performance *per se* (Thompson et al. 2016). Either scenario requires accurate feed planning.

During significant periods of an animal's lifespan, it is important to maintain an animal's health and increase productivity through feed. The requirements for feed supply can vary depending on gender and key activities (Beef and Lamb NZ 2008). In ewes, underfeeding animals during late stages of pregnancy and during lactation will result in poor milk production (Coop et al. 1972), higher ewe and lamb mortality (Everett-Hincks et al. 2004), poor udder development, and lower weaning weights (Litherland et al. 1999), while overfeeding may result in increased number of lambs with dystocia, both causing an economic effect on farmers (Stevens 1999; Wu et al. 2004)

The FeedSmart application (app) is designed to assist in feed management at all stages of the year. FeedSmart is a web app designed for smartphones, tablets, and computers to estimate energy and pasture intake of different classes of livestock in sheep and cattle throughout the year, including during pregnancy and lactation. Using equations from Nicol and Brookes (2007), the FeedSmart app considers different variables (weight, stock class and growth rate) to calculate an animal's nutritional energy requirement. These variables are the used to estimate either the number of days in a paddock, tally of animals, residual pasture cover, or size of paddock break, taking into consideration starting pasture cover, supplementary feed, feed utilisation and land type (flat, rolling, steep or high country). This paper utilised a set of experiments designed to examine the impacts of under-feeding in early gestation on foetal development and subsequent offspring performance. These experiments used the FeedSmart app to determine pasture allocation for maintenance diets. The objective of the current study was to use the data generated in these trials to assess the accuracy of the FeedSmart app. While an above-maintenance diet may have been useful for app validation, the main aim of these trials was related to foetal programming, so an above-maintenance diet was not required. Therefore, this paper reports the outcomes of using the FeedSmart app when feeding at maintenance and 60% of maintenance over two consecutive years.

Material and methods

All experiments were approved by the Invermay Animal Ethics Committee (14000, 14374, 14647 and 14887) and were conducted in accordance with New Zealand Animal Welfare regulations. All experiments were conducted at the Invermay Agricultural Centre (45°51′ S, 170°23′ E) across two years (2017–2018). The animals (ewes and rams) used in the experiments were of composite breeds, comprised of Coopworth, Romney and Texel. All ewes were given a Campyvax4® booster, Ultravac®7in1 booster and Flexidine prior to mating, as per manufacturer recommendations.

The 2017-trial comprised 48 mixed-age ewes randomly allocated to either a maintenance group (M) or a restricted group fed at 60% of the maintenance diet (R). As there was a substantial weight range amongst the ewes in 2018, to ensure more accurate feed calculation, the ewes were initially divided into a light mob (n=130) and a heavy mob (n=144). Each mob was then randomly split into a maintenance and a restricted-nutrition group. Therefore, the trial comprised a light-maintenance group (LM), a light-restricted group (LR), a heavy-maintenance group (HM) and a heavy-restricted group (HR) (Table 1). Further, the 2018 ewes comprised a mixture of two-tooth ewes and mixed-age ewes, the proportion of which ranged from 15% in the HR group to 33% in the LR. Further details are presented in Table 1.

The experiments described here were part of a larger program of research examining the effects of altered nutrition during gestation on the fertility of the female offspring (Smith et al. 2019). The requirements of this program were for either maintenance or restricted (0.6 of maintenance) nutrition for the first 55 days of gestation. Irrespective of year, fertile rams harnessed with crayons were introduced to the ewes and visually assessed for oestrus daily. Once a ewe showed signs of oestrus, as indicated by crayon marking on rump, she was accepted into the trial and randomly assigned to a maintenance or restricted nutritional group. Harnessed fertile rams were then introduced into each group. Ewes showing signs of oestrus were assumed to be not pregnant from the initial mating and withdrawn from the trial.

Ewes were given a new pasture allocation every day for the first 55 days of gestation (ryegrass clover mix) derived on calculations from the Beef and Lamb FeedSmart app based solely on starting weights. To assess the impact of the diets, live weights of ewes were regularly monitored for the 55 days. Further, body condition scores (BCS) were recorded on day 0 and day 55 to help assess the overall impact of the restricted diet.

Calculation of daily feed area

Diets (allocated area) for the maintenance nutrition groups were calculated using the following Feedsmart app settings, pasture growth rate of 0, the default pasture/ crop-quality setting of 10.8 MJME, and flat land. Allocation for the restricted nutritional groups was calculated by first establishing maintenance allocation for those ewes and then multiplying the allocated area by 0.6.

Starting pasture and residual cover (kg DM/ha) were measured daily using a plate meter (tru-test EC-10). The plate meter provides a relative reading which is based on pasture height and density.

The daily area allocated was calculated using the average weight of the mob, tally of animals in each group, average mating date, starting cover of each area, and the residual left the following day. Residual cover was estimated based on farm-management advice and confirmed with daily residual cover readings.

Results from a tightly controlled indoor experiment, in which animals lost 7.1% of live weight when fed at 0.6 of maintenance (Smith 2017), were used as a baseline to assess the accuracy of the FeedSmart app in calculating the restricted diet.

Statistics

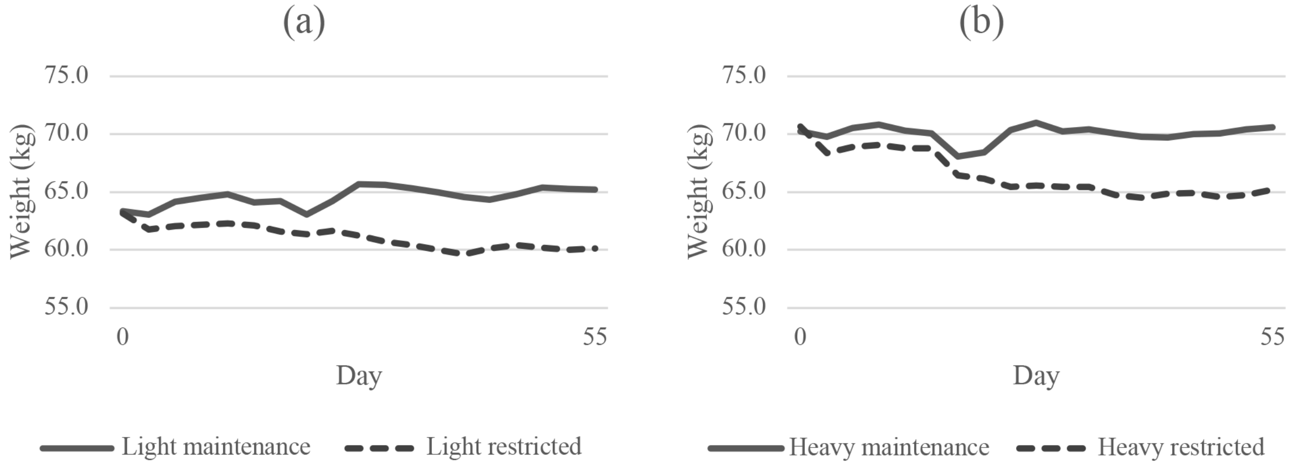
Statistical analyses were performed using the Genstat software package. (Genstat 18th edition, VSN International). Comparisons between expected and actual weight changes were analysed using a paired t test. For the maintenance group the hypothesis tested was initial weight (Day 0) – final weight (day 55) =0. For the restricted groups, allowing for the expected 7.1% loss in body weight, the hypothesis tested was 0.93 x initial weight (day 0) – final weight (day 55) = 0.

Table 1 Average starting weights (day 0), finishing weights (day 55), percentage of body weight change over the trial period and the percentage of two-tooth ewes in each group.

Group	Year of Trial	Number of animals	Day 0 weight (kg)	Day 55 weight (kg)	% of body-weight change	% of two-tooths
Maintenance	2017	24	70.7 ± 1.1	70.4 ± 1.2	-0.33 ± 0.07	
Restricted	2017	24	71.5 ± 0.9	67.0 ± 1.1	-6.3 ± 0.17	
Light maintenance	2018	67	63.4 ± 0.3	65.2 ± 0.4	2.90 ± 0.47	22.4
Mixed-age		52	63.8 ± 0.4	66.2 ± 0.4	3.4 ± 0.4	
Two-tooth		15	62.1 ± 0.9	61.7 ± 0.7	-0.5 ± 1.0	
Light restricted	2018	63	63.2 ± 0.3	60.1 ± 0.5	-4.9 ± 0.07	33.3
Mixed-age		42	63.7 ± 0.5	62.0 ± 0.5	-2.8 ± 0.4	
Two-tooth		21	62.0 ± 0.6	56.4 ± 0.7	-9.0 ± 0.8	
Heavy maintenance	2018	71	70.2 ± 0.4	70.6 ± 0.5	0.50 ± 0.06	18.3
Mixed-age		58	70.8 ± 0.4	71.7 ± 0.5	1.3 ± 0.5	
Two-tooth		13	67.9 ±0.5	65.7 ± 1.1	-3.2 ± 1.2	
Heavy restricted	2018	73	70.6 ± 0.4	65.2 ± 0.4	-7.7 ± 0.04	15.1
Mixed-age		62	70.9 ± 0.4	65.6 ± 0.4	-7.4 ± 0.4	
Two-tooth		11	69.4 ± 1.0	62.9 ± 0.9	-9.3 ± 0.9	

Maintenance groups received a maintenance diet based on metabolizable energy requirements for the first 55 days of gestation while restricted groups received of diet equivalent to 0.6 of maintenance. 2018 groups were subdivided into light and heavy based on starting weights. Data are means and standard error of the means.

Figure 1 Average weights of the 2018 ewes on either a maintenance or restricted diet over the first 55 days of gestation for the light group (a) and heavy group (b).



Results

In both 2017 and 2018, all groups were grazed on either adjacent paddocks or, in some cases, in the same paddock. There were no differences in either initial pasture cover, residual pasture cover, or change from initial to residual between years or between nutritional groups. The energy requirements calculated by the app for a 2017 M ewe was 11.37 MJME/day, 2018 LM ewe 10.47 MJME/day and 2018 HM ewe 11.31 MJME/day. The values for the corresponding R ewes were, for a 2017 R ewe 6.8/MJME/day, 2018 LR ewe 6.27 MJME/day and 2018 HR ewe 6.81 MJME/day. Starting pasture cover averaged 3853 (4005± 59 for M, 3696±30 for R groups respectively) while residual cover averaged 1511 (1608±65 for M groups and 1396±31 for R groups respectively). The 2018 heavy ewes, each maintenance ewe was, on average was allocated 3.2 m^2, while the corresponding restricted ewes were allocated 1.9 m^2. For the light ewes in 2018 the allocations were 3.4 m^2 per ewe for the maintenance group and 1.9 m^2 per ewe for the restricted group.

In both years, M animals showed a relatively consistent trend in live weight over the 55-day period with minimal change from their starting weight. R animals followed a pattern consist with the initial indoor-trial ewes to establish the baseline sub-maintenance weights. These animals showed an initial drop in weight, flattening out to a more consistent weight after approximately 25 days (fig. 1)

In the 2017 trial, ewes on the maintenance diet lost 0.3% (0.3 kg) of their starting body weight. Those animals on the restricted diet, expected to lose 7.1% of their body weight, lost 6.3% of their starting body weight (4.5 kg) (Table 1). Neither of these changes in weight were significantly different from the expected change (Table 2).

In the 2018 trial, both the LM and LR groups completed the trial significantly heavier than expected (Table 2). The LM animals gained 0.5% of their starting body weight, an increase of 1.8 kg. The LR group lost only 4.9% of their body weight, a loss of 3.1 kg when the expected loss was 4.4 kg (Table 1). Most of the two-tooth ewes (36/60) were within the light groups and their performance over the course of the trial differed from that of the mixed-age ewes. Whereas overall the LM group gained 2.9% of their initial body weight, the two-tooth ewes lost 0.5% of their body weight. In the LR group, while the overall loss was 4.9% of body weight, the two-tooth ewes lost 9%.

The HM group gained 0.5% of their body weight, a gain of 0.4 kg; within this group the two-tooth ewes lost 3.2% of body weight. The HR group lost 7.7% of their body

Table 2 Analysis of recorded weight changes vs expected weight changes of ewes fed maintenance or restricted diets during pregnancy.

Year/Group	Diet	Mean Difference expected change (kg)	Significantly different from 0 change	95% CI
2017	Maintenance	-0.2	no	(0.62, -1.09)
	Restricted	0.49	no	(1.72, -0.73)
2018 Light	Maintenance	1.83	yes	(2.42, 1.24)
	Restricted	1.37	yes	(2.04, 0.70)
2018 Heavy	Maintenance	-0.37	no	(1.05, -0.31)
	Restricted	-0.52	no	(-0.03, -1.00)

Maintenance animals expected change = 0 kg. Restricted animals expected change was equivalent to 7.3% of body weight lost. Results of paired t-tests testing the hypotheses that for M groups day 55 weight- day 0 weight= 0 and for R groups day 55 weight - 0.93 x day 0 weight = 0. $P<0.01$ represent significance.

weight, a loss of 5.5 kg: within this group the two-tooth ewes lost 9.3% of body weight (Table 1). These overall losses were not significantly different from the expected changes (Table 2).

Irrespective of year and weight group, those animals on the restricted diet lost on average 0.5 of a BCS, while the animals on a maintenance diet lost an average of 0.1 BCS.

Discussion

FeedSmart app is a tool freely available for farmers to help with feed and nutrition management in sheep and cattle. To assess the accuracy of the FeedSmart app, we utilised data from trials primary designed to examine the effects of gestational under-nutrition. Therefore, we can, with confidence, discus the performance of the app in relation to maintenance and sub-maintenance diets only. The trial requirement for daily allocations, resulted in extraordinarily high stocking rates ranging from 1500 to 7000 stock units/ha. The calculations underlying the FeedSmart app provide an estimate of nutritional energy requirements (Nicol & Brookes 2007). It is suggested to include a safety margin of 10% to prevent underfeeding of some individuals. In the current trials, to assess the accuracy, no safety margins were included.

In 2017, the app provided an accurate estimate of feed allocation to achieve the desired energy requirements at a maintenance level. Weight changes in both M and R groups were not significantly different from expected (paired t-test, P= 0.49 for M, P=0.32 for R), though liveweight loss in the R group was predicted from previous experimentation, rather than derived from the FeedSmart app. Similarly, in 2018, weight changes in HM and HR groups were not significantly different from expected (paired t-test, P=0.31 for HM, P=0.25 for HR). However, in both the LM and LR groups, weight changes were significantly different from expected (paired t-test, P<0.01 for both groups). The LM group, predicted to maintain weight, gained 1.8 kg, while the LR group, predicted to lose 4.4 kg, lost only 3.1 kg.

In relation to the mix-aged ewes, the two-tooths did not perform as well, e.g., in the LM group the two-tooths lost 0.5%, whereas the mixed-age gained 3.9%. Similarly, in the LR group the two-tooths lost 9.0% whereas the mixed-age lost 2.8%. Interestingly the predicted feed requirements in the FeedSmart app for a two-tooth is less than that for a mixed-age ewe, yet the two-tooths performed poorly compared to the mixed-aged ewes. We would hypothesis that the two-tooths were unable to compete with the mixed-age ewes for feed in a high-stocking environment; this hypothesis is supported in the literature (NRC 1985). This may offer some explanation for the significant deviation from the expected weight changes in both the LM and LR groups. While the two-tooth ewes in the 2018 heavy mob also performed differently from the mixed-age ewes, this did not impact significantly on the overall result, likely due to the lower proportion of two-tooth ewes in the heavy mobs. Additionally, there is evidence to suggest that the nutritional requirements of two-tooth ewes differ from those of mixed-age ewes (Stevens & Young 2013; Corbett & Ball 2002).

When feeding animals diets for growth or maintenance, the larger the weight range in the mob the more variable the outcome (Treacher 1983). There are potentially several reasons which contribute to outliers, for example, individual variations in energy requirements (Nicol & Brookes 2007; Corbett & Ball 2002), the ability to compete for feed, and animal health status. Certainly, within these trials, in a high-stocking-rate environment we observed animals which were consistently first to populate new breaks and dominated the grazing resource in specific areas, while others were slow to the new breaks, subsequently struggling to compete for feed. Comparison of these animals with their live weights suggests that this was a major contributor to the outliers of these studies.

Feed requirements can be underestimated in the sheep and beef industry due to incorrectly accounting for pasture wastage (utilisation) (Johns et al. 2016). The FeedSmart app automatically accepts that 10% of the feed will be lost due to pasture wastage. This can be changed in the app dependant on conditions. In the current study, the pasture wastage was set to 0. This primarily was based on the extraordinarily high stocking rate (between 1.4 m^2 and 6.6 m^2 per ewe). Further evidence supporting this was recorded in times of heavy rainfall. As part of ethics requirements for these trials, animals were housed under cover overnight in times of heavy rainfall. In these instances, animals were on their allocated area between four to six hours. The residuals recorded in these instances did not differ from those recorded after 24 hours, suggesting that the available pasture was predominantly eaten within the first four to six hours each day. In a normal farm situation, having a high stocking rate and intense grazing, especially during high-rainfall periods, will decrease animal production, as the amount of feed utilised is reduced significantly (Valentine et al. 2009). Animals cause treading and pugging to the pasture, triggering slow regrowth and a loss of dry matter of pasture, reducing feed intake (Nie et al. 2001; Valentine et al. 2009). This can be accounted for in the app by altering the utilisation settings.

An accurate nutrition program to feed animals throughout the year is imperative for the animal's health and production to be successful and can be achieved through feed management. Regular recording of live weights and BCS of animals is important to monitor the animals' requirements and the success of the farm's feed management. It is important to understand that BCS also plays a role in assessing an animal's response to nutrition (Freer et al. 1997) particularly over extended periods of restricted nutrition. For example, in the 2017 R group 7 of 24 animals had lost at least 0.5 of a BCS by day 25. It is interesting to note from day 25 to 55 when the weights stabilised an additional 15 animals lost at least 0.5 of a BCS. An additional value of BCS is apparent during mid to late pregnancy as live weights can be complicated to monitor effective feed budgeting. Arguably, one deficiency in the app is that it does not utilise BCS information. Users should be aware of the BCS of the animals when determining target weights in the app.

Research by Corner-Thomas and colleagues evaluated the use of specific tools by New Zealand sheep farmers (Corner-Thomas et al. 2019). The study showed 1220 respondents had used one or more tools for herbage measurement (rising-plate meter, pasture probe, sward stick or C-DAX pasture meter). On average 39.1% of farmers found them to be "not relevant", while 22.1% said there were "unwanted complications" and 13.8% found "benefits not apparent". Research also discloses widespread farmer use of visual pasture cover for herbage measurements. Therefore, the perception amongst farmers may be that cost, complexity, accuracy, and relevance can be discouraging factors to the uptake of apps such as FeedSmart. Tools for feed planning and management to farmers can improve prediction of pasture shortages and surplus throughout the year, and vital feeding assessments and decisions (Gray et al. 2003). The resistance to use the available tools can lead to poor feed planning, loss of profitability and productivity (Wall et al. 2012). In these trials we found the app to be versatile, easy to use, and accurate.

Conclusions

While intense stocking rates in these trials were not likely to be utilised in most farming situations, this approach provided a unique opportunity to assess the accuracy of the FeedSmart app. In these trials where maintenance and below-maintenance diets were used, we found the app to be accurate, quick, and easy to use in the field. In our trials, a high level of precision was required when determining pasture allocation and nutritional energy requirements, and we found the FeedSmart app provided us with the levels of accuracy required.

Acknowledgments

This research received funding from the AgResearch Strategic Science Investment Fund. The assistance of the farm staff at AgResearch Invermay was much appreciated.

References

Beef and Lamb NZ 2008. Feedsmart 2. 2 edition. Beef and Lamb.

Beukes PC, Mccarthy S, Wims CM, Romera AJ 2015. Regular estimates of paddock pasture mass can improve profitability on New Zealand dairy farms. Journal of New Zealand Grasslands Association 77: 29-34.

Clark DA, Woodward SL 2007. Supplementation of dairy cows, beef cattle and sheep grazing pasture. In: Rattray PV, Brookes IM & Nicol AM eds. Pasture and supplements for grazing animals, New Zealand Society of Animal Production. Hamilton New Zealand Occasional Publication 14. pp 117-131.

Coop IE, Clark VR, Claro D 1972. Nutrition of the ewe in early lactation. New Zealand Journal of Agricultural Research 15: 203-208.

Corbett J, Ball A 2002. Nutrition for maintenance. In: Sheep Nutrition M. Freer and H. Dove eds. CAB International, Wallingford, Oxon, UK. pp 143-163.

Corner-Thomas RA, Kenyon PR, Morris ST, Ridler AL, Hickson RE, Greer AW, Logan CM, Blair HT 2019. Farm-management tools: reasons for the decision not to use specific tools. Proceedings of the New Zealand Society of Animal Production 79: 125-130.

Densley RJ, Williams ID, Miller DB, Densley DW, Sapienza DA 2004. Advances in maize silage genetics and crop management and the impact on the NZ dairy industry. Proceedings of the New Zealand Society of Animal Production 64: 105-109.

Everett-Hincks JM, Blair HT, Stafford KJ, Lopez-Villalobos N 2004. The effect of ewe nutrition on maternal behaviour score and litter survival. Proceedings of the New Zealand Society of Animal Production 64: 188-191.

Freer M, Moore AD, Donnelly JR 1997. GRAZPLAN: Decision Support Systems for Australian Grazing Enterprises-II. The Animal Biology Model for Feed Intake, Production and Reproduction and the GrazFeed DSS. In Agricultural Systems 54. pp 77-126.

Gray DI, Parker WJ, Kemp EA, Kemp PD, Brookes IM, Horne D, Kenyon PR, Matthew C, Morris ST, Reid JI, Valentine I 2003. Feed planning- alternative approaches used by farmers. Proceeding of the New Zealand Grassland Association 65: 211-217.

Johns C, Johns J, Stevens DR 2016. Increasing lamb survival and lamb weaning weight through feeding high fecundity crossbred sheep. Hill Country-Grassland Research and Practice 16: 323-328.

Litherland A, Lambert M, Mclaren P 1999. Effects of herbage mass and ewe condition score at lambing on lamb survival and liveweight gain. Proceedings of the New Zealand Society of Animal Production 59: 104-107.

Nicol AM, Brookes IM 2007. The metabolisable energy requirements of grazing livestock. In: Rattray PV, Brookes IM & Nicol AM eds. Pasture and supplements for grazing animals, New Zealand Society of Animal Production. Hamilton New Zealand Occasional Publication 14. pp 151- 172.

Nie ZN, Ward GN, Michael AT 2001. Impact of pugging by dairy cows on pastures and indicators of pugging damage to pasture soil in south-western Victoria. Australian Journal of Agricultural Research 52: 37-43.

NRC 1985. Nutrient requirements of sheep. 6th Edition, National Academy of Sciences, National Research Council, Washington, D.C. pp 1-7.

Smith P 2017. Effects of gestational nutrition on post-natal fertility in sheep. Doctor of Philosophy thesis, University of Otago.

Smith P, Stanton J-A L, Quirke L & Juengel J L 2019 Gestational nutrition 1: alterations to gestational nutrition can increase indicators of fertility in sheep. Reproduction 157: 199-313.

Stevens DR 1999 Ewe nutrition: decisions to be made with scanning information. Proceedings of the New Zealand Society of Animal Production 59: 93-94.

Stevens DR, Young G 2013. Using data from large scale farming operations to understand the importance of feeding the ewe to improve whole farm performance. New Zealand Grassland Association Tauranga: 97-102.

Thompson BR, Stevens DR, Scobie DR, O'Connell D 2016. The impact of lamb growth rate pre- and post-weaning on farm profitability in three geo-climatic regions. Proceedings of the New Zealand Society of Animal Production 76: 132-136.

Treacher TT 1983. Nutrient requirements for lactation in the ewe. In: Haresign W ed. Sheep Production. Butterworths, London, pp. 133–153.

Valentine S, Lewis P, Cowan RT, DeFaveri J 2009. The effects of high stocking rates on milk production from dryland and irrigated Mediterranean pastures. Animal Production Science 49: 100-111.

Wall A J, Stevens D R, Thompson B R & Goulter C L 2012 Winter management practices to optimise early spring pasture production: a review. Proceeding of the New Zealand Grassland Association 74 85-90

Wu G, Bazer FW, Cudd TA, Meininger CJ, Spencer TE 2004. Maternal Nutrition and Foetal Development. American Society for Nutritional Sciences 134(9): 2169-2172.