BRIEF COMMUNICATION: Modelling liveweight change to inform residual feed intake models in growing lambs

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Introduction

A research programme to investigate the genetics of Residual Feed Intake (RFI), as a measure of feed efficiency, is being established for New Zealand maternal sheep. The basis of the RFI model is to estimate the dry matter intake that should be required by an individual to support its energy requirements for maintenance and production (e.g., growth, lactation), and compare it against its actual intake. Residual feed intake studies have been conducted for decades in beef cattle (Archer et al. 1997; Kearney et al. 2004), and terminal sheep breeds (Cockrum et al. 2013) and more recently in dairy cattle (Waghorn et al. 2012). A common feature of all studies is questions surrounding what duration the trial should be, and how often the animals should be weighed. Multiple weights over time are required to generate an accurate estimate of the growth rate of the animals. The energy required for growth differs depending on the growth rates achieved, and at moderate to high growth rates, accounts for more energy, than that required for maintenance, such that inaccurate estimates of growth rate will significantly impact on the RFI estimate of an individual. Indeed, as shown by Archer et al. (1997) in cattle, longer periods of recording are required to obtain an accurate liveweight profile than are required to get repeatable estimates of feed intake, with only 35 days of feed intake data required, compared to 70 days to accurately estimate weight gain. The frequency with which animals are weighed within any of these trials varies. One option is the integration of a weigh platform in to the feeding system for multiple weights generated per day (Kearney et al. 2004), however, more commonly the weigh platform is not integrated and animals are weighed in stand-alone scales three times per week (Waghorn et al. 2012) through to monthly (Cockrum et al. 2013).

Prior to the commencement of a long-term research programme for New Zealand maternal sheep, a pilot trial was conducted to generate data on between-animal variability and repeatability of RFI. This paper investigates the liveweight data collected as part of this pilot trial, determining the optimum number of weights required, and the best models to describe the data and their ability to accurately predict liveweight gain.

Materials and methods

Permission for this trial was granted from the AgResearch Invermay Ethics Committee (AE13270). Forty non-pregnant ewe lambs, approximately nine months of age, were individually penned undercover and fed for two periods (P1 & P2) of 42 days each. During P1 all animals were fed a ryegrass sward harvested the previous day. During P2, half remained on the ryegrass sward and the other half were fed pure lucerne pellets, following a transition period. The animals were weighed twice-weekly, in the morning prior to the new day's feed being offered. Only 38 animals completed P2 of the trial, with two dying due to misadventure. Regression models were fitted individually for each animal using the regression procedure in SAS (SAS, 2004). A series of combinations of different data sub-sets and models were used for liveweight data collected from P1 and P2 respectively: linear model fitted using the twice-weekly collected data for the first four (9 weights), five (11 weights) and all six weeks (13 weights) worth of data; a linear model fitted using the twice-weekly collected data for all six weeks, but excluding data from day 18 (12 weights); a linear model fitted using once-weekly data for all six weeks (7 weights); a quadratic model fitted using the twice-weekly collected data from all six weeks (13 weights); a quadratic model fitted using the twice-weekly collected data from all six weeks, but excluding data from day 18 (12 weights).

Figure 1. Raw liveweight profiles for ewe lambs (approximately 9 months of age at the start of Part 1) from a pilot trial investigating residual feed intake (Solid line and circles: n=40 lambs from Part 1 of trial when all were fed grass; Short dashed line and triangles: n=18 lambs from Part 2 of the trial fed grass; Long dashed line and squares: n=20 lambs from Part 2 of the trial fed lucerne pellets).

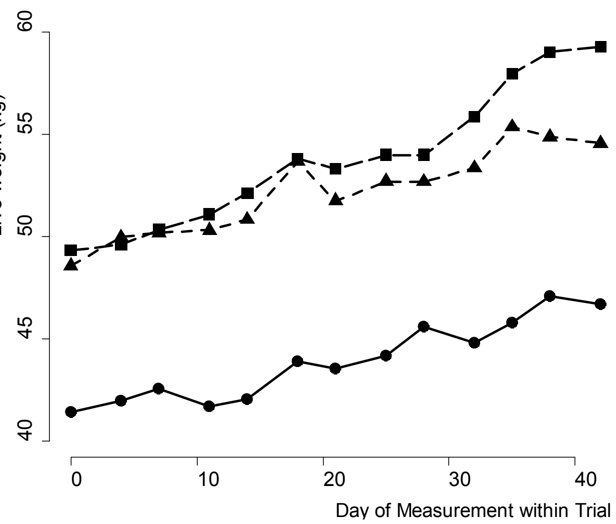
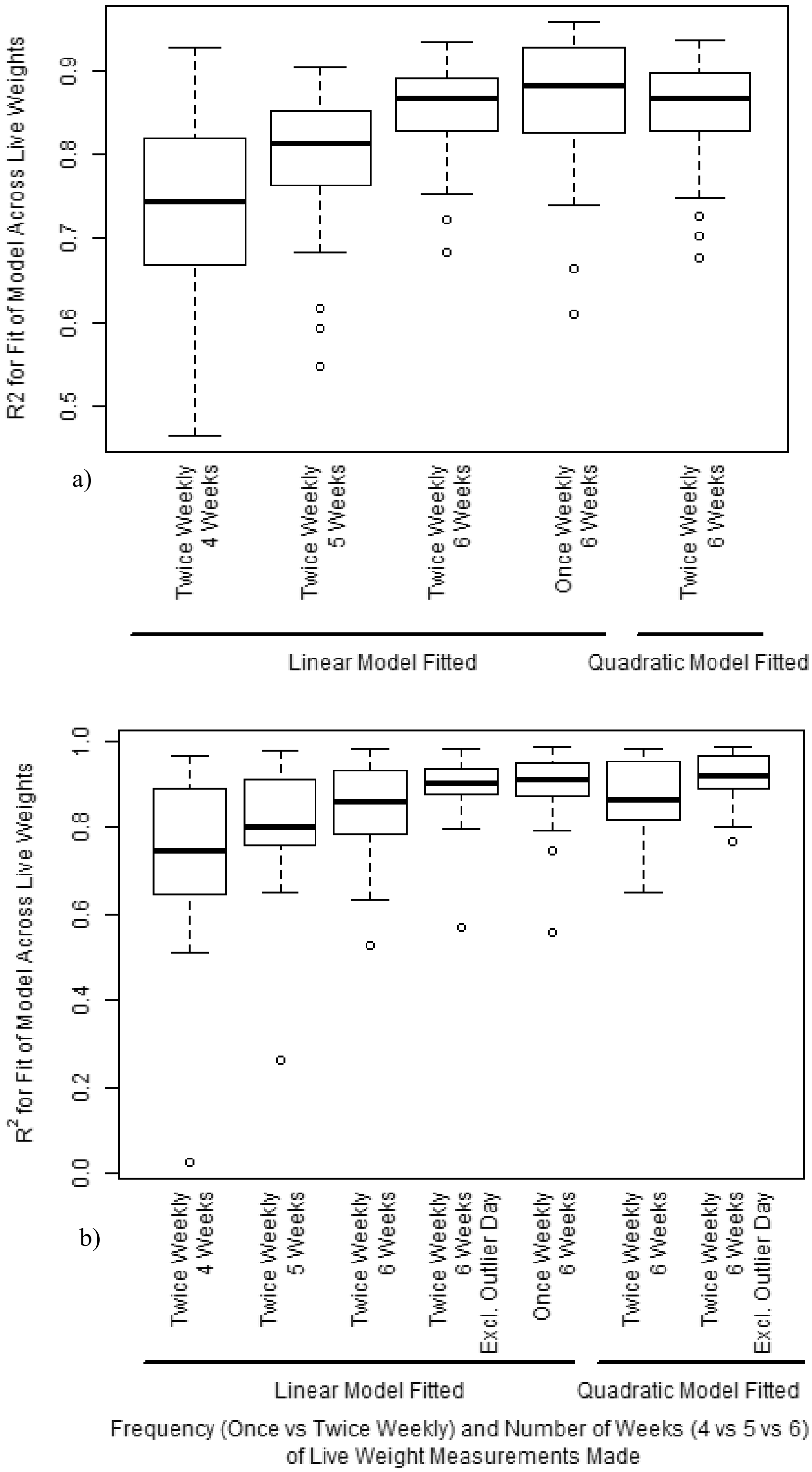


Figure 2. Summary of the proportion of variation (R^2) explained for 40 (Part 1) or 38 (Part 2) animals for a series of different models that included varying amounts of liveweight data derived from data collected from a pilot trial to investigate residual feed intake in ewe lambs approximately eight months old at the start of Part 1. a) results from Part 1 of the trial b) results from Part 2 of the trial.



The proportion of variation explained (R^2) was generated for each animal-model combination, which was summarised for each combination using a boxplot.

Results and discussion

The raw average liveweight profiles for the three groups of animals (Part1:AllGrass; Part2:Grass; Part2:Lucerne) are in Figure 1. From Figure 1 it can be seen that, whilst within each group there was a trend for increasing live weight across the period of the trial, between any two consecutive measurements there was variability. The most anomalous weights were measured at day 18 for the animals on the ryegrass diet in Part2 of the trial, with an apparent spike in live weights.

The series of data-sets, that included different combinations of weight data, were analysed by fitting linear or quadratic models to the data, the proportion of variation explained by the model fitted was reported for each animal. The results are illustrated in Figure 2 using boxplots to represent the spread in the proportion of variation (R^2) explained for each animal by the different models fitted (i.e. each boxplot is the summary of the R^2 values for 40 animals in P1 and 38 in P2). From these boxplots, it can be seen that when a sub-set of only four weeks' worth of data was used, for both P1 and P2 the median proportion of variation explained was less than 0.75. For P1 the proportion of variation explained with the inclusion of weeks 5 and 6 data increased with each additional week's worth of data, and at the same time the range of R^2 values decreased. For P1, the sub-set of once-weekly weights for all six weeks resulted in similar R^2 values, compared with when the twice-weekly data was fitted, although there is a small increase in the range of values. There was no benefit through fitting a quadratic model to data from P1. For P2 the proportion of variation explained, similarly increased with each additional week's data, however a decline in the overall range was not observed. From Figure 1 it was clear that the data on Day 18 was not consistent with the data from the surrounding days, and so that day's data were removed and the models re-fitted. This both increased the proportion of variation explained, and decreased the range, with the exclusion of one animal that continued to be an extreme outlier. For P2, the sub-set of once-weekly data appeared to explain more of the variation than the model when all of the data was used, however, this was due to the Day 18 data not being included in this analysis. When the once-weekly model was compared to the all-data model where Day 18 was excluded, the same trend to that seen for the P1 data was observed, with similar proportions of variation explained to when the twice-weekly data was fitted, although there is a small increase in the range of values. Fitting a quadratic model did not change the outcome for the majority of animals, but for four individuals it did increase the proportion of variation explained by the model by over 0.10. For three of these individuals their weight plateaued towards the end of the trial; whether this indicates they were approaching maturity is not clear but is being monitored subsequently.

For this data set then, a linear model fitted to the liveweight data over the six-week period, consistently explains a high proportion of the variation for an individual animal. A linear model has been shown to be a suitable model for explaining weight gain in growing animals in a number of RFI studies from dairy and beef cattle and sheep (Archer et al. 1997; Williams et al. 2011; Redden et al. 2013). It is possible that an alternate model such as a quadratic model may be more appropriate for animals approaching their mature weight, as may be the case for some animals in this trial, however, for such animals any RFI calculations would need to consider these two periods (growing and approaching maturity) as their energy requirements will change. In all models fitted, the proportion of variation explained was influenced by the fact that, between any two weights, significant fluctuations across all animals occurred. This fluctuation could have been due to possible variation in gut fill (despite set weighing times that were prior to the introduction of the new-days' feed) or possible systematic errors in the scales. Although in P1 there were limited differences between the models fitted using twice- versus once-weekly data, the results from P2 illustrate the importance of having enough days' worth of data that, should an outlier set of weights occur, (e.g., Part2 Day 18), the data from that day can be excluded, but still leave sufficient other data to be fitted.

Conclusions

The results from this trial are consistent with existing literature in that obtaining an accurate liveweight profile to estimate weight gain for use in an RFI model is challenging and requires multiple days' worth of liveweight data. In this study, twice-weekly weights for six weeks consistently explained a high proportion of variation, and therefore, accurately predicted growth rate. This results of this trial are also consistent with the literature in that the liveweight gain profile of the animals was adequately explained by a linear model.

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