TOWARDS A DATA SET TO INVESTIGATE FEED EFFICIENCY IN NEW ZEALAND MATERNAL SHEEP

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SUMMARY

Residual Feed Intake (RFI) as a measure of feed efficiency has not been reported for New Zealand maternal sheep breeds. This study reports on a pilot study that generated RFI data on 37 16-month old maternal composite ewes. Records on ten were obtained utilising a prototype automated feeder, with the remainder fed in individual pens. The animals were introduced to lucerne pellets before daily feed measurements were taken over 42 days with animals weighed twice weekly. The RFI model fitted, to determine the relationship between the liveweight and average daily weight gain and the animal intake, had an R^2 of 0.79, with the partial R^2 for liveweight the most significant at 0.70. The observed phenotypic standard deviation of RFI was 209 g of DM/d which is 8% of the average daily intake. The animals were ranked for RFI, with the 16% most efficient animals (low RFI) consuming on average 0.6kg/day less feed, or 20% less than the 16% least efficient animals (high RFI). Additional data, collected for the animals using the prototype automated feeder, included the number and size of feeding events per day which showed consistent variation. Further animals will be evaluated over the coming years with the aim to collect data on 1000 animals. The animals will be sourced from the Central Progeny Test and will represent NZ maternal sheep breeds which will be measured for a range of other production traits allowing the heritability of the trait and its genetic correlation with other traits to be estimated.

INTRODUCTION

The trait of Residual Feed Intake (RFI) proposed by Koch *et al.* (1963) as a measure of feed efficiency has been shown to be heritable in beef and dairy cattle. A meta-analysis of 39 published RFI papers by Berry and Crowley (2013) for cattle resulted in a pooled heritability estimate of 0.33 ± 0.01 (range of 0.07 to 0.62). There are very few published estimates for measures of feed intake and efficiency in sheep. Heritability estimates of 0.32 to 0.41 were reported by Forgarty *et al.* (2006) for feed intake at pasture and Cammack *et al.* (2005) reported heritability estimates of 0.11 to 0.33 for measures of feed efficiency in growing terminal sired lambs. There are currently no published genetic parameter estimates for New Zealand maternal sheep breeds.

Other important aspects of the genetics of RFI include the repeatability of the trait between growing and mature animals, and the genetic correlation with other economically important traits such as reproduction. The trait of RFI has been shown to be highly genetically correlated in cattle when measured in young growing animals and older mature animals (Herd *et al.* (2003)). Although relatively few significant genetic correlations have been observed in cattle, there is some evidence of a negative genetic correlation between RFI and puberty onset and post-partum anoestrus period intervals resulting in a delay for both (Crowley *et al.* 2011).

A study to generate RFI data over several years to estimate its heritability, repeatability and genetic correlation with other traits is due to commence in July 2015. Pilot studies have been conducted to gain insight in to the phenotypic variability of the trait, and the repeatability of the trait on a group of ewes fed different feeds (fresh cut grass versus lucerne pellets) at different times (9 and 16 months). This paper reports results based on 37 animals from the second study when the animals were 16 months old and were all fed lucerne pellets, with ten measured via the prototype automated feeder and the remainder fed in individual pens.

MATERIALS AND METHODS

Permission for this study was granted from the AgResearch Invermay Ethics Committee (Ethics Numbers 13257 and 13456). Thirty-seven 16 month old maternal composite ewes (ewes that were surplus to requirement from the Central Progeny Test and were therefore from a variety of breeds as described by McLean *et al.* 2009) previously used in a feed intake study (Study 1) as nine month olds were used. The ewes were introduced to Lucerne pellets (sourced from Dunstan Feeds, Hamilton New Zealand; Dry Matter Content 85%; Metabolisable Energy (ME) content 10.1 MJ ME) over a two-week period before the study with *ad libitum* Lucerne pellets available. A random sub-set of ten of the ewes were placed in a pen with the prototype automated feeder, with the remainder placed in neighbouring individual pens in a raised-floor shed. The feeder was designed by AgResearch and utilized a feed trough on load cells with an automated feed delivery through an auger For the ewes utilising the prototype automated feeder approximately 2.5kg of feed was always available, allowing *ad libitum* access to feed, with the weight of feed consumed recorded in real time against the animal through the use of electronic identification. The resulting data was summed across a day for an animal to provide the total feed consumed, but the number of feeding events and the average weight of feed consumed at each feeding event was also calculated. The animals in the individual pens were offered 4-5kg of feed per day at approximately 9am each morning, with the residual feed weighed 24 hours later, at least 10% residual was targeted to ensure that the animal had *ad libitum* access to feed.

The animals were weighed twice weekly, at approximately 9am. The animals were fed for forty-two days. The importance of using multiple measures of liveweight across the duration of the study to accurately estimate average daily live weight gain (ADG) was demonstrated by Johnson *et al.* (2015) using data from the first study using the same animals. The animals were Computed Tomography (CT) scanned at the beginning and conclusion of the study, but the images are not yet analysed.

A model based on Koch *et al.* (1963) was used to calculate Residual Feed Intake (RFI) using the General Linear Model (GLM) procedure in SAS: $y = \beta_0 + \beta_1 MMWT + \beta_2 ADG +$ Previous Feed + Feeder (Previous Feed) + ε; where y is measured feed intake calculated using the MIXED procedure in SAS fitting day as a repeated measure, β_0 = intercept, MMWT = metabolic mid-weight (mid-weight$^{0.75}$), ADG = the slope of model estimated by REG procedure in SAS (SAS Inst. Inc., Cary, NC) using the bi-weekly liveweight measurements and the day of measurement (with the first measurement made on day 0), Previous Feed=Lucerne pellet or grass in study one, Feeder=Individual pen or auto-feeder and ε = the residual which is the trait of RFI.

The animals were ranked based on their RFI values and the bottom and top 16% (n=6) assigned as being Low or High RFI respectively, with the remainder being assigned as medium. The significance of differences between the groups was assessed using the GLM procedure in SAS fitting RFI group as a fixed effect.

RESULTS AND DISCUSSION

The model fitted which included liveweight, ADG, previous feed and feeder in current trial and the intake of the animals had an R^2 of 0.79, of which the partial R^2 for liveweight was the most significant at 0.70. This value is higher than those reported in growing sheep by Redden *et al.* (2013) and Cockrum *et al.* (2013) whom reported R^2 values of between 0.45 and 0.65 using the same model. Computed Tomography images have also been collected on the animals which will be used to estimate the relative proportions of fat and lean in the animals. The addition of fat to the RFI model has been shown to improve the description of feed intake over and above liveweight and liveweight gain in cattle (Basarab *et al.* 2011), but not in sheep (Redden *et al.* (2013) and Cockrum *et al.* (2013)). The observed phenotypic standard deviation of RFI was 209g of DM/d for RFI which is 8% of the average daily intake, a value consistent with values summarised for beef and dairy cattle by Williams *et al.* (2011).

The results from the grouping of the animals in to Low, Medium and High RFI groups is in Table 1. Liveweights and growth rates were not significantly different between the RFI groups as expected. Both RFI and daily dry matter intake were significantly different between the RFI groups, with the most efficient animals (low RFI) consuming on average 0.6kg/day less feed, or 20% less than the least efficient animals (high RFI). This level of difference is consistent with the results of the sheep studies of Redden *et al.* (2013) and Cockrum *et al.* (2013) and a dairy heifer study of Williams *et al.* (2011) whom observed differences of 17%, 30% and 20% respectively.

This study also involved the testing of a prototype automated feeder. In addition to providing data on the total weight of feed consumed in a day, the automated feeder provides information on the number of feeding events per day, and the weight consumed at each feeding event. A basic summary of the average number and average weight of individual feeding events per animal per day for the ten animals that utilised the automated feeder is provided in Figure 1. From Figure 1, there are consistent trends observed between animals, at the extremes one ewe (7018) had an average of 26 feeding events per day consuming an average of 128 grams of feed per feeding event, whereas another ewe (58) had an average of 14 feeding events per day but is consuming on average 288 grams of feed per feeding event. In the longer term study it will be interesting to determine whether these are heritable traits, and whether or not they are correlated to either RFI or other traits including methane emissions.

The longer term data collection, which will take place over the next 3-5 years, will aim to collect data on 800-1000 animals. The animals will be sourced from the Central Progeny Test which will represent NZ maternal sheep breeds. A range of other traits will also be measured on the animals some of which will be measured before entering the feed intake facility including weaning weight, onset of puberty and others will be measured post- time in the facility including mature weight and reproductive performance. The ram lamb brothers of the ewes will have been grown out and slaughtered as lambs, which will provide carcass breeding values for the sires. Repeated feed intake data will be collected on the same animals as mature ewes to investigate the genetic correlation between feed efficiency measured in a growing lamb and a mature ewe to consider whether the two measures should be considered as repeated measures of the same trait or different traits. There will also be the opportunity to investigate alternate predictor traits reviewed by Berry and Crowley (2013).

CONCLUSIONS

The results from this study suggest that the feed intake system established, is obtaining RFI phenotypic data with a co-efficient of variation of 8%, which is consistent with RFI data in other production species. The next stage is to collect sufficient data to estimate the heritability of RFI in NZ maternal sheep, and its genetic correlation with other economically important traits.

Table 1. **Characteristics (average ± SE) among residual feed intake (RFI) group traits**

	RFI Group			**Signif. of**
	Low (n=6)	**Medium (n=25)**	**High (n=6)**	**RFI Group**
Study Mid Weight (kg)	71.7 + 2.98	70.9 + 1.46	71.3 + 2.98	NS
Average Daily Gain (g/day)	231 + 24.1	248 + 11.8	247 + 24.1	NS
Dry Matter Intake/Day (kg)	2.7 + 0.18[a]	3.0 + 0.09[ab]	3.3 + 0.18[b]	P<0.001
Residual Feed Intake (g/day)	-309 + 43.0[a]	3 + 21.0[b]	323 + 43.0[c]	P<0.001

[1]Values within a row with different superscripts are significantly different (P<0.05)

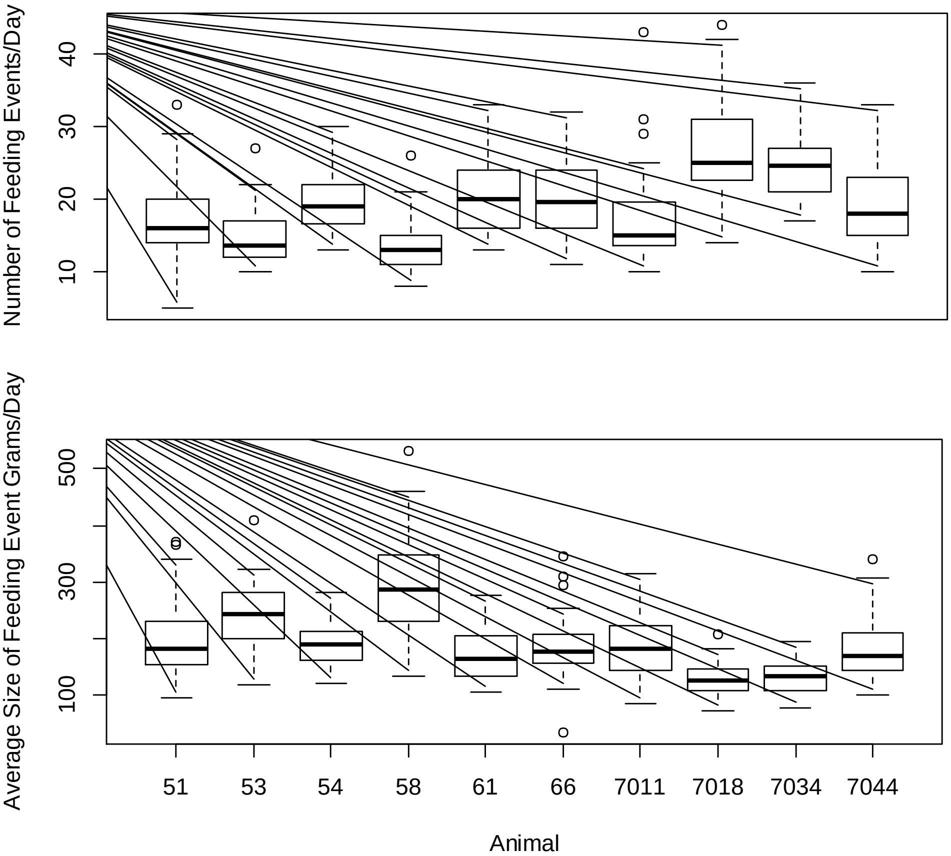

Figure 1. Boxplot summary of number of, and average size of feeding events per day for individual animal data collected over 42 days from a prototype automated feeder.

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