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BRIEF COMMUNICATION: Relationship between measures of residual energy intake made on growing animals and adults

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Introduction

In New Zealand pasture-based sheep systems, young replacement ewe lambs and those lambs to be finished for slaughter, are often preferentially fed through summer, with ewes which have just weaned their lambs given secondary priority through until their pre-mating period. This is particularly the case in hill-country environments, in which an increasing proportion of the New Zealand ewe flock is farmed. Feed efficiency, defined as residual energy intake (REI), is a measure of whether or not an animal is eating more or less than expected for its live weight and growth rate. Of interest is whether or not animals described as efficient, or inefficient during their young growth phase, when on high-quality diets, continue to be so as an adult grazing sub-optimal feed during summer periods. There is limited comparable literature in sheep. The general finding of the beef cattle work is that the young and adult measures of REI are moderately phenotypically correlated and very highly genetically correlated, although in the most comprehensive study both the young and adults were fed the same medium-quality feed (Archer et al. 2002). In dairy cattle work, they have also found that calves divergent for REI during growth are also divergent for REI when lactating, although the size of the divergence was reduced (McDonald et al. 2014).

The purpose of this study was to generate repeat REI measurements on a small cohort of ewes at 28 months of age that had previously been measured at 6 and 18 months to determine the correlation between the measurements made at different ages. The cohort are being used in pilot studies in advance of a larger-scale genetics programme.

Materials and methods

Permission for this study was granted from the AgResearch Invermay Ethics Committee (Ethics Numbers 13257, 13270 and 13456). The ewes used in this study have previously been described in detail by Johnson et al. (2015a), and were New Zealand maternal composite sheep. Of the 37 used in the original studies, only 23 remained available for this study due to farm management decisions. Data to calculate the trait of REI was first collected on the animals when they were eight months old, with a subsequent measure at 16 months, with this study reporting on the final measurement made at 28 months of age after they have successfully reared their first cohort of lambs. When the animals were measured as six-month-old lambs they were fed freshly cut and carried ryegrass as described by Johnson et al. (2015a). As 16 months olds they were fed a lucerne pellet feed, both feed types used to mimic good quality feeding levels as is routinely offered to growing animals. In this study, to mimic the feed that ewes are fed post-weaning over the summer period, the ewes were fed ad libitum meadow hay pellet (sourced from Dunstan Feeds, Hamilton, New Zealand). The ME content of the hay pellets estimated, using NIR technology (AFIA 2006), to be 7.5 MJ ME, with crude protein 9.1%, a similar composition to that described by Wilkes et al. (2012). The animals were adjusted to the feed over a two week period, after which time daily feed intake was recorded for 42 days using an automated feed intake system with data summarised as described by Johnson et al. (2016a), with live weight recorded twice weekly. The animals were ultrasound scanned at the start of the trial as described by Young & Deaker (1994), and computed tomography (CT) scanned at the end of the trial as described by Johnson et al. (2016a). For both the ultrasound and CT techniques, images of the Longissimus thoracis were isolated in the location between the 12th and 13th rib with fat depth over the Longissimus thoracis estimated (C). The change in fatness was calculated as the difference between the end C and start C values.

A model based on Koch et al. (1963) was used to calculate Residual Feed Intake (REI) using the General Linear Model (GLM) procedure in SAS: $y = \beta_0 + \beta_1 MMWT + \beta_2 ADG + \varepsilon$; 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, 2004) using the bi-weekly live weight measurements and the day of measurement (with the first measurement made on day 0) and ε = the residual which is the trait of REI.

The correlation procedure was used in SAS (SAS, 2004) to determine the relationship between the measures of REI made at the three different time points, together with live weight and fatness data collected on the ewes when they were 28 months old.

Results and discussion

In the studies published to date from the greater REI research programme, the lambs fed good quality feed *ad libitum* have gained in excess of 300 g live weight per day and the goodness of fit (R^2) of the REI model (Koch et al. 1963) has been greater than 0.70 (Johnson et al. 2015b; Johnson

Table 1 Pearson correlation coefficients for measures of residual energy intake measured on ewes at six, 18 and 28 months, and feed intake, live weight and body fatness traits measured at 28 months. The correlation coefficient is below the diagonal, and the p-value of the correlation above the diagonal.

	Residual Energy Intake			28 Month			
	6 months	18 months	28 months	Feed Intake	Mid LWT	LWG	Change Fat
REI - 6 months		p<0.001	0.83	0.75	0.89	0.81	0.04
REI – 18 months	0.64		0.81	0.50	0.31	0.05	0.02
REI – 28 months	0.05	0.16		p<0.001	1.00	1.00	0.52
28 month feed intake	0.07	-0.17	0.68		0.002	0.003	0.28
28 month mid-trial liveweight	0.03	-0.20	0.00	0.60		0.17	0.89
28 month liveweight gain	0.05	-0.42	0.00	0.58	0.29		0.18
28 month change in fatness	-0.44	-0.48	0.14	0.24	0.03	0.29	

et al. 2016b). Based on modelling using the calculations of Nicol & Brookes (2007), it was estimated that although the pellets had a low ME content, the total ME intake of the animals should be sufficient to support maintenance and a minimum of 50 g/day growth rate. Although the average liveweight gain observed was 55 g/day it ranged from -48 g/day through to +190 g/day, indicating that some of the ewes actually lost a small amount of weight over the course of the 42 days. That sheep can lose weight even when fed *ad libitum* if the energy content of the feed is low, has previously been shown by Wilkes et al. (2012). The fit of the Koch et al. (1963) model only resulted in an R^2 of 0.54 which is lower than the value obtained in the studies in the growing lambs (Johnson et al. 2016b). The correlations between the REI values and the production measurements are provided in Table 1. There was a significant correlation between the REI estimates made at six and 18 months, however, there was a non-significant relationship when either time point was contrasted to the REI measurement made when the animals were 28 months old. Significant relationships were, however, observed between the REI estimates at the two younger ages and the changes in fatness observed when they were measured as older animals, and additionally between the REI estimate made at 18 months and the change in live weight when the animals were older.

Animals inefficient as growing animals on *ad libitum* high-quality feed had reduced ability to handle an *ad libitum* low-quality diet as adults and mobilised adipose reserves. Such results have not previously been reported, and if validated on larger numbers, it will highlight the importance of breeding for improved REI to maximise ewe production in hill country environments where feed quality is potentially limiting.

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