Proc. Assoc. Advmt. Anim. Breed. Genet. 22:325-328

INVESTIGATING VARIATION IN THE TEST LENGTH REQUIRED TO ESTIMATE THE TRAIT OF RESIDUAL ENERGY INTAKE IN GROWING MATERNAL LAMBS

P.L. Johnson, J. Wing, K. Knowler and P. Johnstone

AgResearch Invermay, Mosgiel, New Zealand

SUMMARY

Residual energy (or feed) intake (REI) is one measure of feed efficiency, and is an estimate of whether an animal is consuming more or less energy for its biological outcomes than predicted. To date, little research has been conducted in sheep, and a multi-year trial is underway to generate data for New Zealand maternal breeds, firstly targeting growing lambs. Data required to estimate REI includes daily feed intake and live weight information from which growth rate can be calculated. A key to data collection for the trait of REI is to determine the test length required to accurately estimate REI. A dataset was available on approximately 600 growing maternal breed lambs from 3 cohorts that were measured for daily feed intake of lucerne pellets for a period of 42 days (after 14 days adjustment), with live weight measured twice weekly during the test period. The full dataset was subsetted to simulate reduced test lengths and environmental variance was calculated for each cohort-data subset. Additionally the correlation between the REI estimates from the reduced length datasets and the full dataset was also estimated. The results suggested that the variance of all traits stabilised within 21 to 28 days, and a correlation of greater than 0.90 existed between the estimates made on the data collected in 21 days versus the complete 42 day dataset. These results suggest that the environmental variances stabilises quicker in lamb studies than in beef studies which require a minimum of 56 to 70 days' worth of data.

INTRODUCTION

Residual energy (or feed) intake (REI) is one measure of feed efficiency, and is an estimate of whether an animal is consuming more or less energy for its biological outcomes than predicted. Less research has been conducted on the trait of REI in sheep (compared with other production species), however, a series of studies are now being undertaken which are seeking to investigate the phenotypic and genetic variability of feed efficiency in sheep.

As has been the case in all other species, one of the keys to generating feed efficiency data is the development of an optimum test period in which feed intake, live weight and liveweight gain (the key variables in the REI model) are to be measured. This needs to be a balanced decision as the cost of data collection is high, but equally too short ~~of~~ a measurement period will result in poor parameter estimation. In cattle the traits of feed intake and liveweight gain have been shown to require different test periods to obtain accurate (minimised variance) estimates (Archer *et al.* 1997).

The paper investigates the optimum test period for young ewes, using a 42 day test period dataset collected on approximately 600 9-month old growing New Zealand maternal ewes.

MATERIALS AND METHODS

Animals and data. The animals used in this study are the first cohorts of a multi-year trial investigating the trait of REI in New Zealand maternal sheep breeds. Details of the animals and traits measured during the test period are in Johnson *et al.* (2016) with the addition of animals from Greenhouse Gas selection lines (Elmes *et al.* 2014). Briefly, 3 cohorts of 200 9-month old growing ewes of composite New Zealand maternal genetics were housed in an indoor feed intake facility in mobs of 40 and given *ad libitum* access to lucerne pellets via automated feeders which recorded individual feeding events per animal through the use of electronic identification tags. The adjustment period was 14 days and the test period was 42 days. The live weight (LWT) of the animals was measured twice weekly in the morning, un-fasted.

Analyses. Residual energy intake was estimated as described in detail by Johnson *et al.* (2016) using the model first described by Koch *et al.* (1963). Briefly, REI is the residual value of a regression model where energy intake is the dependent variable with mid-test metabolic live weight ($LWT^{0.75}$), and daily liveweight gain (average daily gain: ADG) fitted as independent variables.

In order to investigate the impact on environmental variance of reduced test lengths datasets based on cumulative days' worth of data were generated. For daily energy intake, 42 datasets were generated for each of the 3 cohorts including all data collected up to and including the day represented by the dataset. Specifically, dataset 1 only contained daily energy intake (DEI) data collected on day 1 of the trial, with Dataset 2 containing data collected on days 1 and 2 of the trial. Dataset 42, the final dataset, contained data from all of the days within the test period. Given LWT was only measured twice weekly only 13 of the datasets included additional live weight data. For the datasets that contained additional LWT data, ADG and mid-test metabolic live weight were re-calculated and REI re-estimated. A summary of the data for the full 42 day dataset is in Table 1. The traits of DEI, LWT, ADG and REI from each cohort-subset of data were individually analysed in GenStat Version 13 (Payne *et al.* 2009) using a REML model and the estimate of error (environmental) variance reported. All 42 datasets within a cohort were analysed for the trait of DEI, however, only datasets containing additional LWT data were analysed for the remainder of the traits. The environmental variances from each analysis were collated for each trait and plotted per cohort against day of trial to demonstrate the change in environmental variance within increasing amounts of data contributing to the trait estimation.

Correlation coefficients were estimated for each cohort for REI contrasting the full 42-day dataset with the sequential datasets. The correlation coefficients were plotted against day of trial to observe the change in correlation with increasing amounts of data contributing to the estimation of REI.

Table 1. Summary statistics (mean ± std (range)) for 3 cohorts of 9-month old ewe lambs measured to estimate residual energy intake, with data collected over the full 42 day test period

	Cohort 1	Cohort 2a	Cohort 2b
Mid-test period metabolic midweight ($LWT^{0.75}$)	19.2 ± 1.8 (14.1 – 25.7)	21.2 ± 1.6 (16.2 – 26.3)	22.2 ± 1.8 (17.0 – 27.6)
Daily energy intake (MJ ME/day)	21.6 ± 2.9 (12.7 – 29.3)	23.3 ± 3.0 (15.5 –31.38)	29.7 ± 3.2 (18.6 –36.8)
Average daily gain (g/day)	314 ± 50 (190 – 478)	317 ± 58 (178 – 503)	380 ± 64 (205 – 702)
Residual energy intake (MJ ME/day)	0.0 ± 1.0 1.0 (-2.8 – 3.4)	0.0 ± 1.0 (-2.5 – 2.8)	0.0 ± 1.0 (-4.1 – 2.5)

RESULTS AND DISCUSSION

Optimising the test length to estimate residual feed intake values is important in determining the potential throughput of animals tested, and also the cost of generating the trait data if it is to be implemented into breeding programmes. The changes in environmental variance estimates with increasing test length are presented in Figure 1 for 3 cohorts of growing maternal 9-month old ewes. For all traits the environmental trait variances stabilise with 21 to 28 days of measurements. The only trait to show a small consistent trend of an increase in variance is live weight, however, this reflects differences in growth rate between individuals which results in further divergence between animals across the time period.

The phenotypic correlation between REI estimated for the different test lengths with the estimate from the full 42 day test length are in Figure 2 for the 3 cohorts. The correlation between the full dataset was greater than 0.9 with just 21 days' data, and greater than 0.95 with 32 days' data.

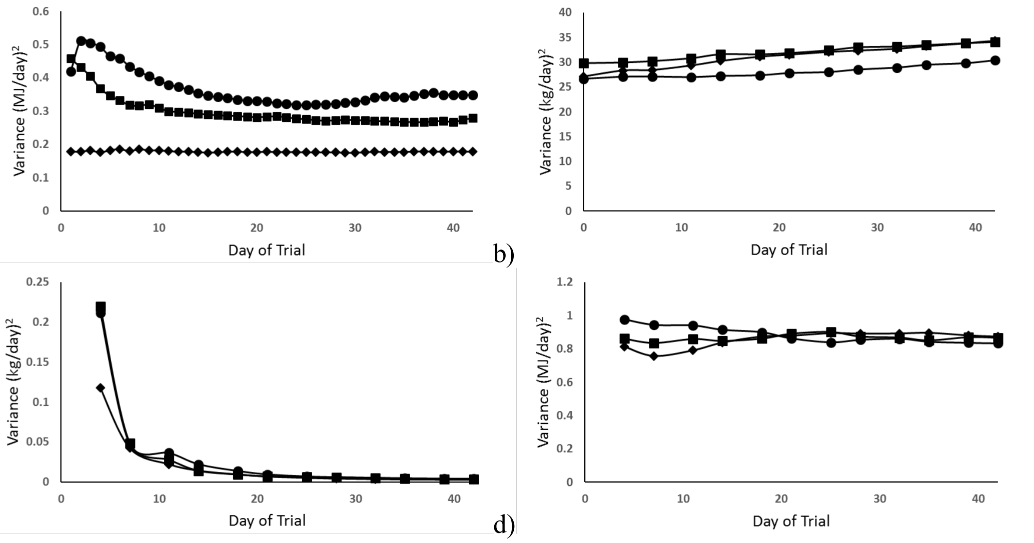

Figure 1. Cumulative error (environmental) variance with additional test length for a) daily energy intake, b) live weight, c) average daily gain and d) residual energy intake for three cohorts (◆,1; ■,2; ●,3) of New Zealand maternal ewe lambs measured for daily intake through an indoor facility capturing daily feed intake data with live weight measured twice weekly

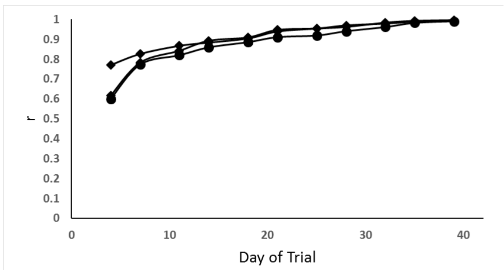

Figure 2. Correlation coefficient for residual energy intake calculated within increasing test length compared to the full 42-day test length for three cohorts (◆,1; ■,2; ●,3) of New Zealand maternal ewe lambs measured for daily intake through an indoor facility capturing daily feed intake data

In beef studies, it has been concluded that the length of time required for the variance of feed intake to stabilise is less than is required to obtain stable variances for the growth rate of the animals being measured (Archer *et al.* 1997; Wang *et al.* 2014). However, further research has demonstrated that the frequency with which the live weight measurements are made also influences the test length required to obtain stable growth rate data (Archer *et al.* 1999; Kearney *et al.* 2004). The conclusion from these studies was that feed intake in cattle can accurately be estimated with 35 days data, with growth estimated accurately with 56 days using daily automated weighing, but up to 70 days if only weighed fortnightly.

There is less published literature investigating test length in sheep. In the study of Cockrum *et al.* (2013) only variance estimates for REI were reported, and did not observe the same level of stabilisation within the short time frames observed in this study. However, the proportion of variation in RFI explained by live weight and growth rate in their study was considerably lower than that reported for Cohort 1 by Johnson *et al.* (2016), which suggests that overall their feed intakes were influenced by other factors not accounted for in their models which could have contributed to increased variability. Unpublished results from a study in Merinos support the findings of this study, in that their feed intakes stabilised by 3 weeks (*B. Pagagoni pers. comm.*).

All production traits are subject to environmental variance, as they are not strictly under genetic control. The results from this study support that the trial design, including the feed offered and the facility developed do not result in a large amount of ongoing environmental variability, and as such allow phenotypic estimates of REI to be obtained within a relatively short time frame when compared to the cattle equivalents.

Given the ultimate aim of the genetic selection for REI, as reported by Archer *et al.* (1997), there is a further need to consider the genetic correlations for different test lengths. Such an analysis will be conducted once further cohorts are collected. Based on the results of Archer *et al.* (1997) it is likely the genetic correlations will be high for at least an equivalent if not shorter time period than is required to obtain high phenotypic correlations. At the time of publication, the feed intake facility used in this study is being re-located. Further analysis on subsequent cohorts measured in the new facility will be required to confirm the findings of this paper. If it is validated, the current test length for growing maternal lambs has the potential to be reduced.

ACKNOWLEDGEMENTS
This is a Beef + Lamb New Zealand Genetics project funded by the Ministry for Business, Innovation and Employment and Beef + Lamb Zealand. The animals sourced from the Woodlands Progeny Test and the Greenhouse Gas Selection lines were funded by the New Zealand Agricultural Greenhouse Gas Research Centre and Pastoral Greenhouse Gas Research Consortia, who are partners in this project for extended measurements not reported herein. AgResearch capital expenditure funding supported the development and production of the automated feeders.

REFERENCES

Archer, J.A., Arthur, P.F., Herd, R.M., Parnell, P.F. and Pitchford, W.S. (1997) *J. Anim. Sci.* **75:** 2024.

Archer, J.A., Arthur, P.F., Herd, R.M., Richardson, E.C. and Burton, D.A. (1999) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **13:**247.

Cockrum, R.R., Stobart, R.H., Lake, S.L. and Cammack, K.M. (2013) *Small Rumin. Res.* **113:**313.

Elmes, S.N., Bain, W.E., Greer, G.J., Hickey, S.M., Young, E.A., Pickering, N.K., Rowe, S.J., Knowler, K.J., Pinares-Patino, C.S. and McEwan, J.C. (2014) *Proc N.Z. Soc. Anim. Prod.* **74:** 142.

Johnson, P.L., Miller, S.P. and Knowler, K.J. (2016) *Proc N.Z. Soc. Anim. Prod.* **76:** 34.

Kearney, G.A., Knee, B.W., Graham, J.F. and Knott, S.A. (2004) *Aust. J. Exp. Agric.* **44:**411.

Koch, R.M., Siger, L.A., Chambers, D. and Gregory, K.E. (1963) *J. Ani. Sci.* **22:** 486.

Payne, R.W., Murray, D.A., Harding, S.A., Baird, D.B. and Soutar, D.M. (2009) *GenStat for Windows 12th Edition. Introduction.* Hemel Hempstead, UK: VSN International.

Wang, Z., Nkrumah, J.D., Li, C., Basarab, J.A., Goonewardene, L.A., Okine, E.K., Crews Jr, D.H. and Moore, S.S. (2014) *J. Anim. Sci.* **84:** 2289.