VARIATION AND HERITABILITY OF FEED INTAKE AND EFFICIENCY OF ANGUS BULLS

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SUMMARY

Feed intake and weight data from Angus bulls was analysed to examine repeatability and heritability of actual and net feed intake. The repeatability of actual and net feed intake over a 28 day test period was 0.77 • .02 and 0.40 • .03, respectively. Heritability estimates for traits measured over 112 days were 0.12 • .07 for actual feed intake and 0.14 • 0.10 for net feed intake. Further knowledge of the phenotypic and genetic relationships of feed intake with production traits is required for selection for efficiency.

INTRODUCTION

Provision of feed to animals is one of the major costs in any livestock production enterprise. This has long been recognised in the intensive monogastric livestock industries where improving feed efficiency has been a major objective. Less attention has been given to improving feed conversion efficiency in the extensive livestock production industries. This is partly due to the difficulty of quantifying feed costs in these industries, and in part because the issues faced in improving feed conversion efficiency differ slightly from those faced by the monogastric industries. Nevertheless, the possibility of improving feed conversion efficiency by genetic means is worth investigating.

Net feed intake (also known in the scientific literature as residual feed intake) has been identified as a possible selection criteria by which feed efficiency may be improved. Net feed intake is calculated as the difference between the actual feed intake measured and that which is predicted from the animal's liveweight and growth rate. Unlike other measures of efficiency, net feed intake is phenotypically independent of growth rate. However, it is not necessarily genetically independent of growth rate, and the response to selection for net feed intake will depend on the underlying genetic relationships between feed intake and the production traits included in the model used to calculate net feed intake (Kennedy et al. 1993). Many of these genetic relationships are not known, and so further work is required before the value of selection for net feed intake can be assessed.

There is very limited data available for the investigation of the phenotypic and genetic properties of feed intake in cattle. This paper reports the results of an analysis of the variation and heritability of feed intake and efficiency in Angus bulls.

MATERIALS AND METHODS

Feed intake and weight data was collected on Angus bulls at the Trangie Agricultural Research Centre from 1964 to 1973. A subset of this data has been analysed and reported previously (Archer et al. 1994). The bulls were born in autumn of each year and raised together until weaning. After weaning the feed intake of each bull was measured for three to six months. During the test period, the bulls were kept in small yards in groups of five with constant access to water but not feed. Twice a day, in the morning and afternoon, the bulls were placed in individual stalls for two hours, where they were given feed ad libitum and feed intake was recorded. The ration consisted of fixed proportions of maize (10 %), oats (23 %), barley (7 %), bran (5 %), linseed meal (3 %), meat meal (2 %), lucerne chaff (13 %) and cereal chaff (37 %), with an average energy concentration of 9.4 MJ/kg dry matter and crude protein level of 12 %. Whilst the composition remained constant from year to year the quality of the ration varied due to differences in the feed value of the ingredients. Liveweight of the bulls was measured every two weeks in all years except for 1964 when weights were recorded monthly.

Data was available for all years from 1964 to 1973 except for 1969. A total of 377 animals by 58 sires were measured. Thirty of the sires used also had individual feed intake records. Table 1. includes details of the number of bulls tested and sires represented in each year. The feed intake data was divided into 5 periods for analysis, consisting of a pre-test period of at least 28 days and four test periods of 28 days each. Data from 1971 and 1973 consisted of only 3 and 2 test periods respectively.

Weight data from the total test period was modelled by regression against time to calculate average weight gain per day and metabolic mid-weight (the weight of the animal at the mid-point of the feeding period, raised to the power of 0.73). Feed intake data was modelled by multiple linear regression (SAS, 1989) to calculate net feed intake. The model included terms for year, age at the start of the test period, weight gain, metabolic mid-weight and the interactions of year with weight gain and metabolic mid-weight. Net feed intake was calculated as the residual error after the model had been fitted. Average daily feed intake and net feed intake were calculated for each of the four test periods separately, and then for three composite periods which incorporated periods 1 and 2, 3 and 4, and the full data set with all four periods included. Partial correlations between different periods were calculated for actual feed intake and net feed intake after adjusting for year and age effects. The coefficient of variation for net feed intake was calculated as the residual variation in feed intake as a proportion of the mean actual feed intake.

Genetic analysis of actual feed intake and net feed intake was performed using DFREML (Meyer 1992). There were 377 records available, with a total of 683 animals in the analysis (including base pedigree information). Heritability estimates were obtained by univariate analysis of each trait using an animal model which included terms for year and age at the start of the test period.

RESULTS

Table 1 contains average weight gains, mid weights and daily feed intakes for each year of the study. Variation in ration quality and climatic conditions resulted in substantial differences in average feed intakes and weight gains across years. Partial correlations for actual feed intake and net feed intake between different periods, after adjustment for year and age at the start of the test period are shown in Table 2. The repeatability of actual feed intake across the four 28 day test periods was 0.77•.02. The repeatability of net feed intake was lower at 0.40 •.03.

Table 3 shows that the coefficients of variation in actual feed intake ranged from 12 to 21 %, while the coefficients of variation in net feed intake were around 5 to 6 % for all periods. The proportion of variation in feed intake explained by the multiple regression models was high, indicating that most of the variation in actual feed intake could be explained by differences in weight maintained and growth rate. Heritability estimates for both traits varied considerably between periods, ranging from 0.1 to 0.2 for actual feed intake and from 0.0 to 0.2 for net feed intake.

Table 1. Angus bulls tested for feed intake and efficiency at Trangie during 1964 to 1973

Year	Number of bulls tested	Number of sires represented	Number of test periods	Pre-test period (days)	Age at start (days)	Average weight gain (kg/day)	Average mid-weight (kg)	Average feed intake (kg/day)
1964	35	8	4	28	255	1.14	356	8.94
1965	39	8 (+1)[a]	4	49	223	1.17	299	8.31
1966	19	3 (+3)	4	57	251	1.20	351	8.91
1967	29	4 (+2)	4	58	234	1.21	340	7.69
1968	51	4 (+5)	4	41	247	1.06	274	7.96
1970	55	8	4	42	260	0.98	324	8.95
1971	46	7 (+2)	3	42	260	0.82	247	4.43
1972	53	11	4	28	255	1.08	288	7.42
1973	50	5	2	35	258	0.94	292	7.21
Total :	377	58[b]	*Average:*	42	249	1.07	308	7.76

[a] sires in parentheses also used in previous year; [b] average number of progeny per sire = 6.5

Table 2. Partial correlations[a] between test periods for actual feed intake (above diagonal) and net feed intake (below diagonal) in Angus bulls. Figures in bold type on the diagonal are the partial correlations between actual feed intake and net feed intake for each period

Period	1	2	3	4	1 & 2	3 & 4	1, 2, 3 & 4
		Actual feed intake					
1	**0.59**	0.82	0.74	0.66	0.95	0.72	0.87
2	0.53	**0.60**	0.85	0.76	0.96	0.83	0.93
3	0.30	0.58	**0.54**	0.85	0.84	0.96	0.94
4	0.13	0.32	0.58	**0.58**	0.74	0.97	0.90
1 & 2	0.87	0.88	0.51	0.26	**0.54**	0.82	0.95
3 & 4	0.23	0.49	0.86	0.95	0.42	**0.50**	0.96
1, 2, 3 & 4	0.64	0.80	0.82	0.72	0.82	0.86	**0.51**
				Net feed intake			

[a] adjusted for year of birth and age at start of test

Table 3. Estimates of variation and heritability for actual feed intake and net feed intake

	Actual feed intake (kg/day)		Net feed intake (kg/day)		
Periods	Coefficient of variation (%)	Heritability (h^2 • s.e.)	Coefficient of variation (%)	Heritability (h^2 • s.e.)	Model r^2
1	21.2	0.17 • .09	6.3	0.21 • .12	0.92
2	19.1	0.07 • .07	6.3	0.07 • .09	0.88
3	21.2	0.11 • .09	5.0	0.00 -	0.95
4	14.1	0.18 • .10	5.7	0.08 • .10	0.85
1 & 2	19.7	0.12 • .08	5.5	0.19 • .11	0.93
3 & 4	12.2	0.17 • .10	4.7	0.08 • .11	0.86
1, 2, 3 & 4	20.5	0.12 • .07	4.9	0.14 • .10	0.95

DISCUSSION

The results of this analysis suggest that feed intake of bulls measured over a 28 day period is moderately repeatable and is likely to be a good predictor of feed intake over a longer period. However the feeding regime was not truly ad libitum, as the bulls only had access to feed for four hours per day. This may have contributed to the high repeatability of feed intake. It is not possible to assess impact of the feeding regime on the results of this study, and so it would be appropriate to test the results on another data set.

Net feed intake had a lower repeatability than actual feed intake. Measurement of net feed intake over a 28 day period is unlikely to be a satisfactory predictor of efficiency over a longer period. An alternative test may be to record feed intake over two separate periods while growth data is recorded over a longer period with the animals remaining under the same feeding regime. In this study the correlations between net feed intake calculated using alternate feeding periods (ie. periods 1 and 3 or 2 and 4) and the total test period were high (0.90 and 0.93), suggesting that this type of test may be feasible.

The heritability estimates for actual and net feed intake in this study were lower than most published estimates. This may be due to the feeding regime the bulls were on. Heritability estimates for feed intake of growing cattle include 0.36 • 0.24 (Brelin and Brannang 1982), 0.57 • 0.11 (Korver et al. 1991) and 0.45 • 0.17 (MacNeil et al. 1991), with corresponding coefficients of variation of 6.9 %, 9.7 % and 9.7 %. Koch et al. (1963) reported a heritability of 0.28 • .11 for net feed intake. Brelin and Brannang (1982) and Korver et al. (1991) estimated the heritability of net feed intake as 0.27 • 0.23 and 0.22 • 0.11 with coefficients of variation of 4.3 % and 7.7 %, respectively.

The published heritability estimates and the amount of phenotypic variation in net feed intake suggest that it may be possible to achieve a selection response in net feed intake. The correlated response in actual feed intake and growth traits can be predicted with knowledge of the genetic and phenotypic parameters of these traits (Kennedy et al. 1993). Unfortunately insufficient data was available in this data set to estimate these genetic correlations. Knowledge of the genetic relationships of net feed intake with other traits, such as reproduction, body composition, and mature cow maintenance efficiency is also required before its usefulness as a selection criteria for the beef industry can be properly assessed.

ACKNOWLEDGEMENTS

This research was supported by a grant from the Australian Meat Research Committee (currently known as the Meat Research Corporation) under project DAN.8. The inputs of W. Murphy, L. Williams, R. Barlow, B. Johnston and the cattle section staff at Trangie between 1964-73 are gratefully acknowledged.

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