NET FEED CONVERSION EFFICIENCY AND ITS RELATIONSHIP WITH OTHER TRAITS IN BEEF CATTLE

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SUMMARY

Data on 574 weaned British breed bulls and heifers were used to evaluate variation in net feed conversion efficiency (Net FCE) and its relationship with other production traits. The animals were part of a major research project investigating the potential of reducing the cost of beef production through the genetic improvement of Net FCE. Net (residual) feed intake was used as the measure of Net FCE, and is defined as the difference between actual feed intake and expected feed requirements for maintenance of body weight and growth. Significant variation existed among individual animals and among sire progeny groups for postweaning net feed intake. The trait was not significantly correlated with any of the production traits measured, except actual feed intake, feed conversion ratio and measures of fat depth, with correlation coefficients being 0.49, 0.47 and 0.24, respectively.
Keywords: feed intake, net feed efficiency, beef cattle

INTRODUCTION

Animal genetic improvement programmes in the past have concentrated on increasing production, with very little effort given to reducing the cost of production. The cost of feed is the single largest expense in most commercial beef production enterprises. In the past, attempts at genetic improvement of feed utilisation have been based on feed conversion ratio, which is given by the amount of feed consumed divided by liveweight gain. The results of such studies have indicated that selection for feed conversion ratio is similar to simply selecting for increased growth rate (Mrode *et al.* 1990; Bishop *et al.* 199 1), because of the strong genetic correlation between feed conversion ratio and growth rate. Thus selecting for feed conversion ratio may result in bigger cattle, which is not always desirable. The major drawback in defining the efficiency of feed utilisation in terms of feed conversion ratio is that it does not take into account the feed used for maintenance. Feed cost for maintenance is estimated to represent at least 60-65% of the total feed requirements for the cow herd, with considerable variation among individual animals independent of their body size (Montaño-Bermudez *et al.* 1990). Herd (1992) reported that a significant proportion of the variation in the weight of calf weaned per unit of feed consumed by the cow-calf unit was independent of the body size and growth rate among the cows and calves. Thus any trait which attempts to accurately measure variation in the efficiency of feed utilisation should include consideration of feed requirements for both maintenance and production.

A composite trait referred to as net (residual) feed intakehas been used in the poultry and pig industries to describe net feed conversion efficiency. Net feed intake is the difference between actual feed intake and the expected feed requirements for maintenance of body weight and some measure of production (such as growth in beef cattle or milk production in dairy cattle). There is some evidence of genetic variation in net feed intake in beef (Fan *et al.* 1994) and dairy (Jensen *et al.* 1992) bulls. In 1993 a research project was commenced at Trangie Agricultural Research Centre to investigate the potential for achieving genetic improvement in net feed conversion efficiency in beef cattle. The project includes the estimation of genetic and phenotypic parameters for net feed conversion efficiency, and its relationships with lifetime productivity, including mature cow feed costs. The objective of this paper is to provide initial results on the variation in net feed conversion efficiency (measured as net feed intake) within British breeds of cattle, and the relationship between net feed intake and other production traits.

MATERIALS AND METHODS

A general outline of the design of the net feed conversion efficiency (Net FCE) project, which commenced in 1993, is given in Figure 1. The Trangie Agricultural Research Centre has developed an automated feeding system which delivers and records actual feed consumption of each animal. This feeding system with surrounding yards is referred to as Efficiency Testing Unit (ETU). Two intakes of weaned calves undergo a 120 day postweaning Net FCE test each year, after an adjustment period of at least 21 days.

One intake comprises heifers and bulls bred at Trangie from Angus cows inseminated by contemporary industry Angus sires. The other intake comprises heifers of British breeds purchased from industry herds. While in the ETU, animals are electronically identified and yarded in single sex groups with 24 hour access to feeding stalls containing a pelleted roughage ration. The pellets are composed of 70% hay and 30% grain, and provide per kg DM approximately 10.5 MJ ME and 125 g crude protein. In addition a daily allowance of 0.5 kg/head of oaten straw (containing ~ 6.7 MJ ME per kg dry matter) is provided in open troughs. Pellet samples collected monthly were analysed by the Feed Evaluation Service, NSW Agriculture. Preliminary analysis indicated that the difference in DM between feed offered and residue was negligible.

Table 1. Descriptive statistics for net feed intake and other production traits for individual animals and sire progeny groups involved in the 120 day postweaning Net FCE test at Trangie

	Individual animals			Sire progeny groups		
Trait	Range	Mean	SD	Range	Mean	SE
Angus[A]						
Start of test livewt. (kg)	178 - 407 (250 - 467)	290 (347)	44 (40)	296 - 380	326	14
Av. daily gain (kg/day)	0.71 - 1.45 (0.87 - 1.85)	1.09 (1.36)	0.14 (0.19)	1.02 - 1.36	1.21	0.05
365 day liveweight (kg)	275 - 524 (333 - 571)	392 (460)	39 (39)	384 - 486	428	16
Feed intake (kg)[B]	906 - 1667 (1107 - 1881)	1324 (1477)	146 (151)	1278 - 1594	1416	53
Net feed intake (kg)[C]	-183 - 151 (-205 - 242)	3 (0)	60 (75)	-64 - 52	0	24
Feed conversion ratio	6.8 - 13.3 (6.8 - 12.9)	9.8 (8.8)	1.2 (1.0)	8.6 - 10.2	9.5	0.3
Fat depth (mm)[D]	3.0 - 18.0 (2.0 - 16.0)	9.5 (7.2)	2.6 (2.5)	6.4 - 11.4	8.5	0.8
Eye muscle area (cm^2)[D]	43 - 102 (64 - 112)	71 (82)	9 (8)	73 - 87	78	2
Hereford[A]						
Start of test livewt. (kg)	142 - 283	201	28	183 - 240	207	14
Av. daily gain (kg/day)	1.01 - 1.58	1.25	0.12	1.21 - 1.29	1.25	0.04
365 day liveweight (kg)	288 - 466	370	41	325 - 383	356	14
Feed intake (kg)[B]	850 - 1462	1098	104	1003 - 1180	1110	35
Net feed intake (kg)[C]	-138 - 201	-22	61	-68 - 38	-28	26
Feed conversion ratio	5.7 - 8.8	7.1	0.6	6.3 - 7.7	7.1	0.3
Fat depth (mm)[D]	3.0 - 10.0	5.6	1.6	4.2 - 7.0	5.4	0.5
Eye muscle area (cm^2)[D]	43 - 71	56	6	51 - 60	56	3
Shorthorn[A]						
Start of test livewt. (kg)	187 - 312	252	25	225 - 269	249	15
Av. daily gain (kg/day)	0.98 - 1.53	1.22	0.12	1.15 - 1.28	1.21	0.05
365 day liveweight (kg)	328 - 460	387	31	381 - 411	394	15
Feed intake (kg)[B]	1016 - 1508	1269	112	1216 - 1352	1257	38
Net feed intake (kg)[C]	-161 - 145	10	63	-33 - 51	7	28
Feed conversion ratio	6.9 - 10.8	8.3	0.7	8.0 - 8.7	8.3	0.3
Fat depth (mm)[D]	4.0 - 10.0	6.9	1.3	6.1 - 7.8	6.4	0.6
Eye muscle area (cm^2)[D]	47 - 82	63	7	57 - 71	63	3

[A]Individual animal results are for females. For Angus, males are presented as well, in parentheses.
[B]Actual feed intake standardised to an energy content of 10 MJ ME per kg dry matter.
[C]Net feed intake is the difference between actual feed intake and expected feed intake.
[D]At the end of test.

On the basis of the results of the Net FCE tests, bulls and heifers are divided into either a High Efficiency or Low Efficiency demonstration herd. Heifers will remain in the demonstration herds for 2 calvings to evaluate their reproductive performance and lifetime efficiency, prior to evaluation of maintenance feed requirement and body composition as mature cows. All progeny from the demonstration herds will also be evaluated for postweaning Net FCE. In addition to animals evaluated at Trangie, steer siblings of both the Trangie bred animals and the heifers sourced from industry herds will be evaluated for feedlot performance, car-case characteristics and meat quality at the Cattle and Beef Industry CRC at Armidale. The overall design will provide data required for the estimation of genetic and phenotypic parameters and relationships between Net FCE and all important traits in the breeding and finishing phases of beef production.

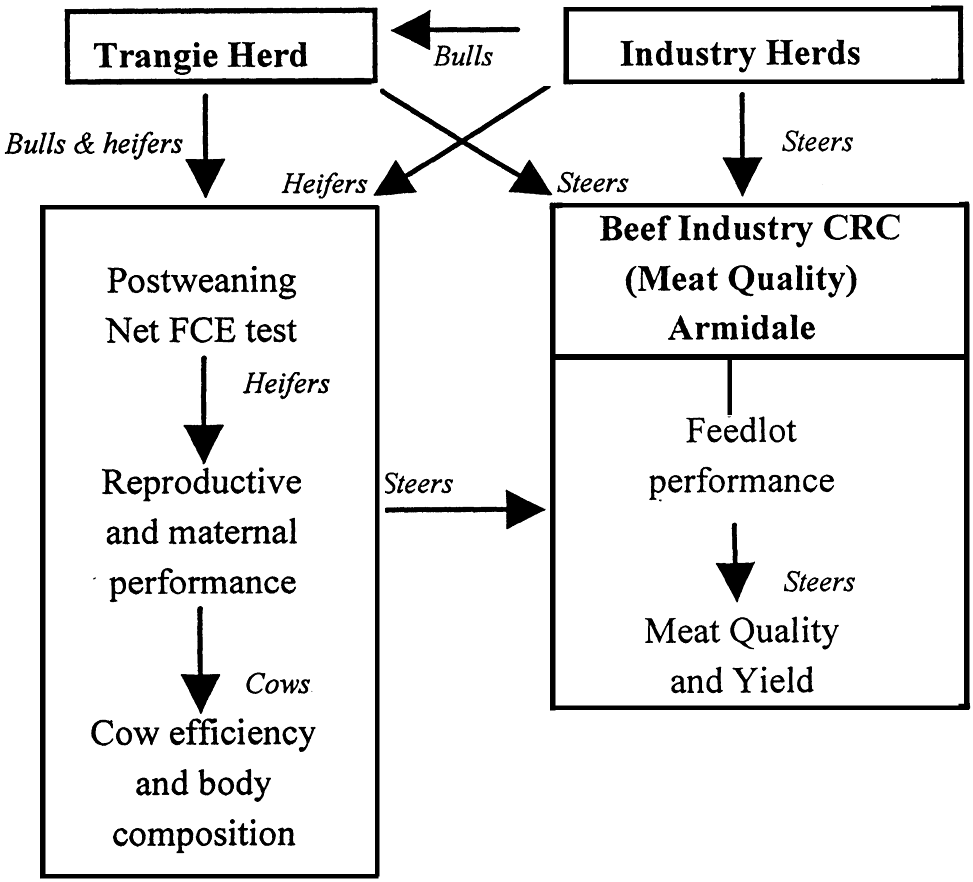

Figure 1. Design of net feed conversion efficiency project

The results presented are based on the 3 postweaning Net FCE tests which have been completed so far. A total of 574 weaned cattle from 3 British breeds have been tested. The cattle comprised 262 Angus heifers and 185 Angus bulls (from 33 sires), 65 Hereford heifers (from 11 sires) and 62 Shorthorn heifers (from 9 sires). All animals were weighed weekly and measurements of subcutaneous fat depth, eye muscle area, linear body dimensions, pelvic area and scrotal circumference were taken at the start, middle and end of the 120 day test period.

Weekly liveweights were modelled by simple regression to calculate daily weight gain and metabolic mid-weight (the liveweight of the animal at the mid-point of the test period, raised to the power 0.73). Feed intake (including daily straw allowance) data were standardised to an energy content of 10 MJ ME per kg dry matter, and modelled by multiple regression with liveweight gain and metabolic mid-weight as independent variables. Net (residual) feed intake (which is the measure for Net FCE) was calculated as the residual error after fitting the multiple regression model within test and sex groups. Thus a net feed intake value represents the difference between the amount of feed an animal actually consumed and expected requirements for maintenance of its liveweight and growth. Hence an animal with a negative net feed intake value is more efficient than one with a positive value. Partial correlations, adjusting for the effects of age at start of test, test group, breed, sex and herd, were computed between net feed intake and all the production traits measured. Sire progeny group means were also computed using a generalised linear model which included the fixed effects of test group, breed, sex and herd, with age at start of test as a covariate.

RESULTS AND DISCUSSION

Descriptive statistics of the traits measured during the 120 day postweaning Net FCE test are provided in Table 1. Large differences in feed intake were observed among individual animals. After feed intake has been adjusted for expected requirements for maintenance and growth (net feed intake), differences existed among individual animals (Table 1). Coefficient of determination (R^2) obtained for the 3 Net FCE tests were 0.74 - 0.75 for males and 0.75 - 0.87 for females. These large R^2 values indicate that the regression models used explain a high proportion of the variation in feed intake. Among Angus heifers and bulls, the most efficient animals consumed 14% and 14% less feed than expected, while the least efficient animals consumed 11% and 16% more feed than expected, respectively. Among Hereford and among Shorthorn heifers, the most efficient animals consumed 13% and 13% less feed than expected, while the least efficient animals consumed 18% and 11% more feed than expected, respectively. In addition to the individual animal differences, significant variation existed among sire progeny groups for both feed intake and net feed intake (Table 1). The significant variation among individual animals and among sire progeny groups for feed intake and net feed intake indicates that the traits are heritable, and thus genetic improvement could be achieved through selection. These results are in general agreement with those obtained by Jensen *et al.* (1992) and Fan *et al.* (1994).

Results of partial correlations (after adjusting for all fixed effects and age) indicate that there are no significant relationships between net feed intake and liveweight, average daily gain, eye muscle area, scrotal circumference and pelvic area. Significant correlations were obtained between net feed intake and 4 traits, with partial correlation coefficients being 0.49 for feed intake, 0.47 for feed conversion ratio, 0.24 for either fat depth at the end of test or change in fat depth. These phenotypic correlations suggest that higher net feed conversion efficiency (lower net feed intake) is associated with lower feed intake, better feed conversion ratio and lesser deposition of subcutaneous fat during the three 120 day tests.

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REFERENCES

BISHOP, M.D., DAVIS, M.E., HARVEY, W.R., WILSON, G.R. and Van STAVERN, B.D. (1991). *J. Anim. Sci. 69: 4360-7.*

FAN, L.Q., BAILEY, D.R.C. and SHANNON, N.H. (1994). *J. Anim. Sci. 73: 365-72.*

HERD, R.M. (1992). *Proc. Aust. Assoc. Anim. Breed. Genet.* **10: 334-7.**

JENSEN, J., MAO, I.L., ANDERSEN, B.B. and MADSEN, P. (1992). *J. Anim. Sci. 70: 386-95.*

MONTANO-BERMUDEZ,M. NEILSEN,M.K. and DEUTSCHER,G.H. (1990). *J. Anim. Sci. 68: 279-88.*

MRODE, R.A., SMITH, *C.* and THOMPSON, R. (1990). *Anim. Prod.* **51: 35-46.**