GENETIC VARIATION IN NET FEED EFFICIENCY IN BRITISH HEREFORD CATTLE

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SUMMARY

Variation in net feed efficiency, that is, variation in feed intake in relation to liveweight (LW) and growth rate, was investigated using data from 540 progeny of 154 British Hereford sires, collected over ten 200-day postweaning performance tests conducted between 1979 and 1988. Net feed efficiency was measured as net feed intake (NFI) calculated for each test as the difference between actual feed and expected feed intake predicted from a multiple regression of feed intake on average metabolic LW and average daily gain. NFI was heritable (0.16 ± 0.08; se) and phenotypically and genetically independent of size and growth rate. NFI had favourable phenotypic and genetic correlations with feed conversion ratio and estimated maintenance energy expenditure. It was negatively correlated with estimated lean-content of the carcase and appeared to be genetically independent of mature cow LW. Selection against NFI has the potential to increase the efficiency of beef production by reducing feed intake without changing the growth rate of the young animal, or increasing mature cow size.

Keywords: Beef cattle; selection; efficiency; net feed intake

INTRODUCTION

The cost of feeding animals is a major determinant of profitability in livestock production enterprises. Recent research has shown that there is genetic variation in the feed eaten by young growing beef cattle beyond that explained by their size and growth rate (Archer *et al.* 1998). This is termed net feed efficiency because it refers to variation in feed efficiency net of expected requirements based on size and growth. Net feed efficiency is measured as net feed intake (NFI). NFI is calculated as the difference between actual feed intake by an animal and the expected feed intake based on an animal's size and growth rate. Selection to reduce NFI offers to reduce feed intake, without compromising growth performance, and thereby to improve the profitability of beef production.

Evidence demonstrating genetic variation in NFI in beef cattle was reviewed by Arthur *et al* (1998). Notable in this review were the small number of published estimates of the heritability for this trait and the relatively small datasets upon which they were based. The purpose of this study was to establish whether there exists genetic variation in NFI in young British Hereford bulls during postweaning performance testing, and to determine the phenotypic and genetic correlations of NFI, growth rate and feed conversion ratio (FCR) with some key production traits, including mature cow size.

MATERIALS AND METHODS

Source of data. The data consisted of performance measurements on 540 bull calves taken over 10 years, from 1979 to 1988, and bimonthly weight records taken on the cow herd. In years 1 to 6 of the experiment, bulls were assigned to one of three rearing treatments: weaning at birth, weaning at 84 days, or weaning at 168 days of age. After year 6, all bull calves were weaned at about 84 days of age. Prior to performance testing, the bulls were introduced to the test diet and trained to use individual Calan-Broadbent electronic feed gates. From approximately 200 to approximately 400 days of age, LW and feed intake were recorded at 30-day intervals on each bull calf. During this performance test the cattle were offered a complete grass/barley pelleted diet offered *ad libitum* with a small quantity of hay to stimulate rumination. Carcase lean content (as kg of lean per kg of carcase; LEAN) was predicted at the end of test for each animal from backfat thickness measured by ultrasound scanning at the 10th and 13th ribs and the 3rd lumbar vertebrae. Bulls used for breeding were selected for lean growth rate (LGR; growth rate to 400 days x LEAN) or lean feed conversion ratio (LFCR; feed intake / (weight gain x LEAN) from 200 to 400 days, or unselected (control line). Detailed descriptions of the husbandry, selection methods and responses to selection are given by Simm (1983) and Mrode *et al* (1990a, b).

Derivation of traits. The traits analysed were those described by Bishop (1992), plus NFI over the performance test and a trait describing the mature LW of the dam. The performance test traits were: LGR; LFCR; FCR; feed intake (FI); 200-day weight (W200); 400-day weight (W400); 200 to 400-day daily weight gain (ADG); and average metabolic weight (MBW; the mean of W200 and W400 raised to 0.75). Bishop (1992) also derived traits to describe the energy required for the deposition of fat and protein in the body of the growing animal (DEP), for maintenance energy expenditure (MAINT), and for maintenance energy expenditure per unit MBW (MMBW).

Net feed intake for each animal was calculated as the difference between its actual feed intake over the 200-day performance test, less its expected feed intake over the test. Separately for each of the 10 performance tests, FI's was regressed on MBW and ADG, and NFI for each animal was calculated as the residual from the multiple regression. The LW of cows at just over 4.5 years-of-age (COWWT) was used as an estimate of cow mature size. This weight was taken after the 4-year-old cows had weaned their calves. Weight records were available for 331 cows. The mean weight of the cows was 498 ± 59 kg (s.d.).

Data analysis. Heritabilities, and phenotypic (r_p) and genetic correlations (r_g) for all traits were estimated within multivariate analyses by ASREML (Gilmore *et al.* 1996; version 28 February 1998), fitting an animal model along with the fixed effects of birth year (10 levels), rearing treatment (3 levels), age of dam (10 levels) and selection line (3 levels). As only males were performance tested, no animals had both performance and cow traits available. Calculation of phenotypic correlations for COWWT with performance test traits was therefore not possible. Values for genetic parameters are presented with standard errors so readers may judge if the value differs significantly from zero.

RESULTS AND DISCUSSION

The phenotypic and genetic correlations between FI and MBW (0.67 ± 0.03 (s.e.) and 0.89 ± 0.08, respectively), and between FI and ADG (0.47 ± 0.04 and 0.70 ± 0.14) were medium to high, but less than one, indicating that there was both phenotypic and genetic variation in the relationship between FI and growth performance. Our estimate of the heritability for NFI (0.16 ± 0.08) is modest and similar to five other estimates reported in the review by Arthur *et al* (1998), but low compared to the estimate of 0.46 reported for British-breed cattle by Archer *et al* (1998). NFI was phenotypically independent of growth and size (r_p with ADG, W400 and MBW all zero; Table 1). NFI appeared to be genetically independent of ADG, but the genetic correlations with size (ie. r_g with W400 and MBW) were not so close to zero, even though not statistically-different from it.

Table 1. Means and heritabilities (h^2) for bull performance test traits, and their phenotypic (r_p) and genetic (r_g) correlations with net feed intake

	FI (kg)	ADG (kg/day)	MBW ($kg^{0.75}$)	W400 (kg)	LEAN (kg/kg)	LGR (kg/day)	FCR (kg/kg)	LFCR (kg/kg)
Mean	1458	1.21	69.2	408	0.600	0.32	6.14	17.76
(s.d.)	(176)	(.18)	(5.6)	(41)	(.024)	(.04)	(1.07)	(3.24)
h^2	.31	.38	.36	.42	.49	.47	.17	.26
(s.e.)	(.08)	(.10)	(.09)	(.10)	(.11)	(.10)	(.09)	(.09)
r_p	.70	-.01	-.01	-.01	-.22	-.33	.61	.63
(s.e.)	(.02)	(.05)	(.04)	(.04)	(.04)	(.04)	(.03)	(.03)
r_g	.64	.09	.22	.15	-.43	-.47	.70	.72
(s.e.)	(.16)	(.29)	(.29)	(.28)	(.23)	(.17)	(.22)	(.18)

NFI was positively correlated with FCR and LFCR, both phenotypically and genetically, such that lower NFI was associated with improved FCR and LFCR (Table 1). NFI was negatively associated with LEAN and LGR, implying that superior net feed intake was accompanied by a greater proportion of lean in the weight gain and final carcase of the bulls. NFI was phenotypically independent of feed energy required for gain of lean and fat (DEP; r_p=0.06 ± 0.04), although the genetic correlation (r_g=0.27 ± 0.30) was not so close to zero, even though not statistically-different from it. NFI was highly-correlated, both phenotypically and genetically, with variation in feed energy attributed to maintenance (MAINT; r_p=0.78 ± 0.02 and r_g=0.77 ± 0.13) and to maintenance energy expenditure per unit MBW (MMBW; r_p=0.91 ± 0.01 and r_g=0.93 ± 0.06).

There was genetic variation in mature cow size (COWWT) as evidenced by its heritability of 0.69 ± .11. COWWT appeared to be genetically independent of NFI measured during the postweaning performance test (r_g= -0.09 ± .26), implying that selection to improve NFI in young bulls should not be accompanied by an increase in mature cow size. The genetic correlations between growth traits (ADG, W400 and LGR) and COWWT were all positive (0.40 ± .18, 0.40 ± .16 and 0.43 ± .16, respectively), implying that selection on these growth traits could lead to an increase in cow size, which might not be desirable. The genetic correlations between other measures of feed efficiency (FCR and LFCR) and COWWT were less than zero, although not significantly different from it (-0.29 ± .24 and -0.23 ±.22, respectively).

This study has shown that selection against NFI (ie. for superior net feed efficiency) has the potential to improve FCR in the young growing animal, to improve the efficiency of maintenance energy expenditure, and to avoid increasing the size of the cow. These are key responses to improvement in enterprise efficiency and profitability.

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