Genetic And Phenotypic Parameter Estimates For Feed Intake And Other Traits In Growing Beef Cattle

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Introduction

Approximately two-thirds of the cost of U.S. beef cattle production is attributed to the cost of feed and feed supplementation (Anderson, et al., 2005), but less than 20% of feed energy is converted to beef (Williams and Jenkins, 2006). Thus, the genetic component of variation in feed energy utilization is an area of interest. Temperament may be useful in genetic evaluations either as an indicator trait for other economical traits such as feed intake, or it may have direct economic value in some systems. The objectives of this work were to estimate genetic and phenotypic parameters for growth, feed intake, feed efficiency, and temperament traits in a mixed-breed population of growing beef cattle.

Material and methods

Animals and Measurements. Steers (n=1165) were born in the spring of years 2003 through 2007 at the U.S. Meat Animal Research Center, Clay Center, NE, USA. They were produced by mating F_1 sires to F_1 and straightbred females. Multiple breeds were represented in varying percentages in the steers, and these breeds were: Hereford, Angus, Simmental, Charolais, Limousin, Gelbvieh, Red Angus, and MARC III (1/4 of each of Hereford, Angus, Pinzgauer and Red Poll). Either Hereford or Angus or both was represented as a fraction of each steer.

Steers were weaned at an average age of 165 (± 15) d and then moved to a large pen feeding facility for about 60 d. Then the steers were randomly assigned to smaller pens (n=4 or 8) equipped with the Calan Broadbent Feeding System for collection of individual feed intake. Feed intake was then measured for an average of 140 (± 17) d. The diet was consistent across years and contained about 83% corn, 11% alfalfa, 6% soybean meal with the remainder supplements. Body weights were taken on two consecutive days at the start and end of each animal's feeding period. Each year, steers were serially harvested in 4 groups. Because steers differed in time on feed and data collection, final body weight, cumulative feed intake, back fat and marbling were adjusted to the average time on feed.

Performance traits were average daily gain (ADG), dry matter intake (DMI), mid-period body weight (MBW), residual feed intake (RFI, derived from DMI adjusted for $MBW^{0.75}$ and ADG), adjusted residual feed intake (RFI_a, adjusted for carcass fatness), gain to feed ratio

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(G:F), and adjusted gain to feed ratio ($G:F_a$, adjusted for carcass fatness). Flight speed (FS) was collected at least twice and separated by ~60 d and was measured as the amount of time for a steer to travel 4.32 m following their release from a scale a short distance away; however, only the first FS was used in the results presented.

Statistical Analyses. Restricted maximum likelihood methods (REML) were used in univariate and multivariate models (ASREML®, Gilmour et al., 2000; WOMBAT, Meyer, 2006) that accounted for the fixed effects of year, pen size (4 or 8 head), age at weaning, breed heterozygosity (expected to be proportional to expressed heterosis), and fraction of each breed; random effects were animal genetic, pen within pen size, and error.

Results and discussion

The mean, standard deviation and coefficient of variation for each characteristic are shown in Table 1. Flight speed was by far the most variable characteristic in the data set. Adjusting DMI for $MBW^{0.75}$ and for ADG, thus considering average feed costs for maintenance and for production for a given animal, reduced the variation for RFI to about a third of the variation in DMI.

Table 1: Descriptive statistics for traits[α]

Trait	Mean	Standard Deviation	Coefficient of Variation
ADG, kg	1.59	0.22	14
MBW, kg	465	50	11
DMI, total kg	1202	152	13
RFI, kg	0	86	7[b]
G:F	0.19	0.03	12
FS, m/s	2.55	1.13	44

[α]ADG = average daily gain; MBW = mid-period body weight; DMI = 140-d dry matter intake; RFI = residual feed intake for 140 d; G:F = gain to feed ratio; FS = flight speed.
[b]Relative to the mean for DMI.

Adjusting for carcass fatness had little effect on the heritability estimates of RFI and G:F, as well as phenotypic and genetic correlations with other traits. Therefore, only non-adjusted RFI and G:F measures are presented and discussed. Table 2 contains heritability and correlation estimates for the various measures of growth, body size, feed intake, efficiency and flight speed.

Average daily gain was less heritable (0.26) as compared to MBW (0.35), the measure of body size. Measures of feed intake had greater heritability estimates with DMI at 0.40 and RFI at 0.52. One might expect much greater genetic variability in feed costs for maintenance, adjusted for body size (MBW), as compared to feed costs for production, adjusted for level of production (ADG) (Eggert and Nielsen, 2006). Evidence in cows by Montano-Bermudez et al. (1990) points to genetic variation in feed costs for maintenance independent of body size. This may be the cause for the greater heritability estimate for RFI than for DMI. Estimated heritability of RFI was greater than the corresponding measure investigated in a purebred Angus population by Arthur et al. (2001).

Strong positive genetic (r_g) and moderate phenotypic (r_p) correlation estimates between ADG and MBW were found (r_g = 0.86 and r_p = 0.51). Further, moderate to strong positive correlation estimates were also found between DMI and ADG and DMI and MBW (r_g = 0.56 and 0.71, respectively; r_r = 0.64 and 0.72, respectively). The genetic and phenotypic correlation estimates between RFI and DMI were strong and positive and quite similar (r_g = 0.66 and r_p 0.61). As expected, no phenotypic correlation existed between RFI and ADG or between RFI and MBW, thus gaining the desired phenotypic independence. As shown by Kennedy et al. (1993), some genetic correlation still existed between RFI and ADG (-0.15) but little between RFI and MBW (-0.02). Conversely, G:F was correlated with component trait ADG (r_g = 0.31 and r_p = 0.51). The genetic correlation between RFI and G:F was very strong and negative (-0.92), and the phenotypic correlation between these two measures was also quite strong (-0.67) and not surprising.

Table 2: Estimates of heritabilities[a] and genetic[b] and phenotypic[c] correlations for traits[d]

	ADG	MBW	DMI	RFI	G:F	FS
ADG	0.26	0.86	0.56	-0.15	0.31	0.07
	(0.10)	(0.13)	(0.16)	(0.25)	(0.25)	(0.27)
MBW	0.51	0.35	0.71	-0.02	-0.02	-0.17
	(0.03)	(0.12)	(0.11)	(0.24)	(0.28)	(0.26)
DMI	0.64	0.72	0.40	0.66	-0.60	-0.14
	(0.02)	(0.02)	(0.02)	(0.12)	(0.18)	(0.25)
RFI	-0.01	-0.01	0.61	0.52	-0.92	-0.07
	(0.04)	(0.04)	(0.02)	(0.14)	(0.07)	(0.24)
G:F	0.51	-0.19	-0.32	-0.67	0.27	0.18
	(0.03)	(0.04)	(0.03)	(0.02)	(0.10)	(0.27)
FS	-0.04	-0.28	-0.22	-0.09	0.19	0.34
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.11)

[a]Heritability estimates are on the diagonal (±standard error, below).
[b]Genetic correlation estimates are above the diagonal (±standard error, below).
[c]Phenotypic correlation estimates are below the diagonal (±standard error, below).
[d]See Table 1 for trait definitions.

FS had a moderate estimate of heritability (0.34). Despite this, estimates of both genetic and phenotypic correlations of DMI and RFI with FS were small and negative (r_g = -0.14 and -0.07; r_p = -0.22 and -0.09) and of G:F with FS were low and positive.

In general, breed differences were small; still, some breed effects were detected. Relative to Angus, the Limousin breed effect was greater for ADG (P < 0.05) and also gave greater effect for G:F (P < 0.01), indicating that this breed contributed toward greater efficiency. The Simmental breed effect contributed to steers that were heavier (P < 0.10) mid-test. The Charolais breed effect influenced steers to consume less feed throughout the trial (P < 0.05), and thus also contributed to a lower, more favorable RFI (P < 0.01). Finally, the Gelbvieh breed effect produced faster FS (P < 0.01) and perhaps more excitable steers. Breed heterozygosity, and thus heterosis, contributed to greater DMI (P < 0.01), RFI (P < 0.05) and MBW (P < 0.05), but it was not an important source of variation affecting ADG, F:G or FS.

Conclusion

Heritability estimates obtained from these data for measures of feed intake are greater than some found in previous literature, likely due in part to the larger range of genetic variation found in the breeds included in this population of cattle. Level of heritability and amount of variation indicated that selection for or against feed intake and efficiency measures would be successful in production of more efficient cattle. Care would need to be taken to not hurt production or output while aiming to reduce feed intake. Flight speed would not be recommended as an indicator trait for selection to change feed intake or efficiency.

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