FACTORS INFLUENCING FEED EFFICIENCY AND BACKFAT THICKNESS IN STATION TESTED BEEF BULLS

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Summary

Records taken on 372 young beef bulls tested at the Ellerslie Bull Test Station, Alberta, Canada from November 1981 to April 1987 were analyzed to quantify the effects of age of dam, on-test age, on-test liveweight and herd of origin of bull on feed efficiency (feed/gain, kg/kg) in the test period (n = 231) and ultrasonic measurement of bakcfat thickness (mm) at the end of the test (n = 372). The reduction in R^2 due to each influencing factor (i.e. the variation accounted for by the factor) was used to indicate the importance of the influencing factor. Age of dam and on-test age of bull were not important factors on feed/gain and ultrasonic backfat thickness, as they accounted for less than 0.5% of the variation in feed/gain and ultrasonic backfat thickness, respectively ($p > 0.1$). On-test liveweight had some influence on feed/gain and ultrasonic backfat thickness, accounting for 3.5% ($p < 0.01$) and 0.4% ($p < 0.05$) of the total variation, respectively. The regression coefficients of feed/gain and ultrasonic backfat thickness on on-test liveweight were 0.016 (kg/kg)/kg and .013 mm/kg, respectively, both being significant ($p < 0.05$), indicating that lighter bulls entering the test were generally more efficient in feed utilization in the test period and had less backfat at the end of the test than heavier entering bulls. Herd of origin of bull accounted for a substantial amount of the total variation (> 16%) in feed/gain and ultrasonic backfat thickness ($p = 0.08$), indicating that a prolonged adjustment period was needed to reduce the influence of herd of origin when assessing aggregate genetic merit of beef bulls for growth rate, feed efficiency and lean meat production using a central station performance testing program.

(**Key Words** : Beef Bulls, Performance Test, Herd Effect)

Introduction

Performance testing in central test stations provides a means to compare beef bulls from different herds under standard postweaning environmental conditions to identify genetically superior bulls for breeding. In addition to recording growth rate, some test stations record individual feed intake and ultrasonic measurement of backfat thickness to provide additional information for selecting young breeding bulls. Several studies have shown that herd of origin significantly influences liveweight and gain in test stations (Dalton, 1976; Tong et al., 1986; Arnal and Crow, 1987; Liu 1991; Liu and Makarechian, 1993a). Liu and Makarechian (1993b) further proposed a modified testing schedule to reduce the herd of origin influence and to shorten the test period. Instead of the conventional 28-d adjustment period followed by a 140-d test period, a 56-d adjustment period followed by an 84-d test period was more appropriate. Age of dam, shown to affect preweaning growth performance of calves, may also influence postweaning growth rate of bulls on test (Simm et al., 1985). Reports on the effect of on-test age of bull on growth rate during the tests are not consistent (Lewis and Allen, 1974; Batra and Wilton, 1972; Tong, 1982). Several studies indicated that there exists a positive relationship between on-test liveweight and average daily gain during testing (Wilton et al., 1973; Tong, 1982). However, little information is available on the influences

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of these factors on feed to gain ratio and ultrasonic backfat thickness, both of which are related to growth rate of performance tested young beef bulls in test stations.

The objective of this study was to quantify the influences of age of dam, on-test age and liveweight and herd of origin on feed to gain ratio and ultrasonic backfat thickness of beef bulls in a test station.

Materials and Methods

Measurements of feed to gain ratio and ultrasonic backfat thickness taken on 372 young beef bulls from eight breeds (Angus, Blonde d'Aquitaine, Charolais, Gelbvieh, Maine-Anjou, Salers, Simmental and Shorthorn) tested from November 1981 to April 1987 at the Ellerslie Bull Test Station, Alberta, Canada were used for this study. These young bulls with measurements of feed to gain ratio (n = 231) and ultrasonic backfat thickness (n = 372) were a subgroup of those animals previously reported (Liu and Makarechian 1993a, b), since facilities were not sufficient to measure feed to gain ratio and ultrasonic measurements of backfat thickness of all tested animals. After an adjustment period of 28 d, a 140-d postweaning performance test started in mid-November each year (test group). The on-test age of bull ranged from 182 to 307 d. However, the range of on-test age in each test group did not exceed 90 d. The distribution of dams with ages of 2, 3, 4, 5, and ≥ 6 years old were 15, 15, 17, 16 and 37%, respectively. The numbers of tested bulls, herds and years are shown in table 1. Management at the station generally followed the Guidelines for Uniform Beef Improvement Programs (Beef Improvement Federation 1986). The young bulls were cared for under guidelines comparable to those laid down by the Canadian Council of Animal Care. Bulls were fed ad libitum a high energy diet composed of 60% concentrate mixture (approximately 45% barley, 42% oat, 5% canola meal or soybean meal, 4% molasses, and 4% protein-mineral-vitamin supplement) and 40% high qualtiy hay (mainly alfalfa) in pens containing five bulls each. The composition of the diet was fairly constant from year to year. Individual feed intake was recorded by Pinpointer (Model 4000A, Universal Identification System Corp., Cookeville, TN). Feed efficiency was calculated as the ratio of feed intake to gain (feed/gain, kg/kg). Starting in 1985, backfat thickness was also ultrasonically measured (Scanogram Model 722, Ithaca, N.Y.) between the 11th and 12th ribs over the longissimus muscle at a distance of approximately 10 cm from the midback on the right side at the end of the test. Means and standard errors for feed/gain and ultrasonic backfat thickness by breeds are presented in table 2.

TABLE 1. NUMBERS OF BULLS, HERDS AND YEARS

Breed	No. of bulls		No. of herds		No. of years	
	FGR[a]	BF	FGR	BF	FGR	BF
Angus		50		27		1
Blonde d'Aquitaine	40	79	17	20	1	2
Charolais	32	25	10	19	1	1
Gelbvieh	15	49	4	16	1	1
Maine-Anjou	27	49	13	22	1	1
Salers	80	40	35	21	2	1
Shorthorn		31		15		1
Simmental	37	49	11	30	1	1
Total	231	372				

[a] FGR and BF represent feed to gain ratio (kg/kg) and ultrasonic backfat thickness (mm), respectively.

TABLE 2. BREED MEAN ± STANDARD ERROR FOR FEED TO GAIN RATIO AND ULTRASONIC BACKFAT THICKNESS

Breed	Feed to gain ratio (kg / kg)	Ultrasonic backfat thickness (mm)
Angus		7.6 ± 0.3
Blode d'Aquitaine	6.4 ± 0.1	2.1 ± 0.1
Charolais	6.0 ± 0.1	3.1 ± 0.2
Gelbvieh	6.7 ± 0.3	2.8 ± 0.2
Maine-Anjou	6.4 ± 0.1	2.3 ± 0.2
Salers	7.4 ± 0.1	6.4 ± 0.4
Simmental	8.0 ± 0.1	3.0 ± 0.2
Shorthorn		5.9 ± 0.2

The mixed model used for statistical analysis was:

$$Y_{ijkl} = \mu + t_i + d_j + b_1 a_{ijkl} + b_2 W_{ijkl} + h_{ik} + e_{ijkl}$$

where y_{ijkl} was an observation on the l^{th} bull; μ was the population mean; t_i was a fixed effect common to bulls of the i^{th} breed-year group; d_j was a fixed effect of the j^{th} age group of dam (j = 2, 3, ⋯, ≥ 6); b_1 and b_2 were linear partial regression coefficients of the trait on on-test age and liveweight, respectively; a_{ijkl} was on-test age (covariate in days); w_{ijkl} was on-test liveweight (covariate in kg); h_{ik} was assumed to be a random effect of the k^{th} herd within the i^{th} breed-year group, following a normal, independent and identical distribution with null mean and variance σ^2_h;

and e_{ijkl} was a random residual associated with the l^{th} bull, following a normal, independent and identical distribution with null mean and variance σ^2_e. Preliminary analyses indicated that the effects of breed, year and their interaction could not be separated because some breed-year combinations were not present. Therefore, breed and year were combined as a single factor in the analysis as described in Liu and Makarechian (1993a, b). Preliminary analyses also indicated that other interactions were not significant, and that pooled linear partial regression coefficients of the traits on on-test age and liveweight of bull were appropriate for the breeds. A hierarchial arrangement of herds within breed-year was assumed, even though there were a few exceptions, to reduce sparseness of the data (Liu and Makarechian 1993a, b). In addition, data were edited to ensure there were repeated observations in each herd subclass. The relative importance of a factor influencing the traits was calculated as the percentage of the total corrected sum of squares due to that factor. This was equivalent to the reduction in the coefficient of determination (R^2) after dropping that factor from the full model. Reduction in R^2 due to an influencing factor accounts for the amount of differences among observations caused by the factor. The differences among observations expressed as total corrected sum of squares are caused by many fixed and random factors. In this paper the word "variation" is used for the differences among observations or total corrected sum of squares, as the word "variance" is usually reserved for the differences among observations caused by only random factors. SAS GLM procedure (SAS 1988) was used for data analysis.

Results and Discussion

Both feed/gain and ultrasonic backfat thickness were significantly influenced by breed-year. The percentages of variation explained by breed-year was 12.8% and 25.3% for feed/gain and ultrasonic backfat thickness, respectively ($p < 0.001$, table 3). The significant influences of breed-year indicate that selection of bulls should be based on a within breed and year basis as practised in the industry.

Neither trait was significantly influenced by age of dam ($p > 0.1$, table 3). the variation in the traits explained by age of dam was too small (0.47% for feed/gain and 0.09% for ultrasonic backfat thickness) for practical consideration.

The reductions in the coefficient of determination (R^2) due to on-test age of bull were 0.23% for feed/gain ($p > 0.1$) and 0.01% for ultrasonic backfat thickness ($p > 0.1$). The regression coefficients of the traits on on-test age were −0.01 (kg/kg)/day for feed/gain ($p > 0.1$) and −0.003 mm/d for ultrasonic backfat thickness ($p > 0.1$). These non-significant influences (tabel 3) indicate that the effects of on-test age of bull on both traits were negligible and unimportant under the guidelines of central beef bull test program (Beef Improvement Federation 1986). Brown et al. (1988) also found that the regressions of feed/gain on on-test age in Angus and Hereford bulls to be non-significant.

TABLE 3. NUMBER OF OBSERVATIONS, REDUCTIONS IN R^2, AND REGRESSIONS ON ON-TEST AGE AND LIVEWEIGHT FOR FEED TO GAIN RATIO AND ULTRASONIC BACKFAT THICKNESS

Items	Feed to gain ratio (kg / kg)	Ultrasonic backfat thickness (mm)
Number of observations	231	372
Reductions in R^2 (%)		
Year-breed	12.78***	25.32***
Age of Dam	.47	.09
Age of Bull	.23	.01
On-test liveweight	3.45***	.40**
Herd of Origin	16.13*	16.11*
Linear regressions on		
Age of bull (day)	−0.008	−0.003
	±.005[a]	±.011
On-test liveweight (kg)	.016	.013
	±.002***	±.005**

[a] Standard error.
***, ** and *, Significant at $p < 0.01$, $p < 0.05$ and $p < 0.1$, respectively.

The influences of on-test liveweight on feed/gain and ultrasonic backfat thickness were significant ($p < 0.05$). However, on-test weight explained less than 4% of the total variation in the traits (table 3). Feed/gian was more influenced by on-test liveweight than ultrasonic backfat thickness, with the reductions in R^2 being 3.45% and 0.40%, respectively. The regression coefficients of feed/gain and ultrasonic backfat thickness on on-test liveweight were 0.016 (kg/kg)/kg and 0.013 mm/kg, respectively, both being significant ($p < 0.05$). The regression coefficients indicate that lighter bulls entering the test were generally more efficient in feed utilization in the test period and had less backfat at the end of the test than heavier entering bulls.

The influences of age of dam, on-test age and liveweight on growth rate were so small that they were not of practical importance (Liu 1991; Liu and Makarechian 1993a).

Herd of origin accounted for a substantial amount of the total variation in both traits. The reductions in R^2 were 16.13% and 16.11% for feed/gain and ultrasonic backfat thickness, respectively (table 3), and approached the 5% significance level ($p = 0.08$) based on F test. It should be noted that as data are unbalanced, the test is an approximate test and is conservative. Significant effects of herd of origin on liveweight and gain measurements are reported in the literature (Dalton, 1976; Tong et al., 1986; Amal and Crow, 1987; Liu 1991; Liu and Makarechian, 1993a, b). In addition, the effect of herd of origin is not entirely environmental as it contains a genetic component. However, the data available for this study did not allow the estimation of the genetic component. Cundiff et al. (1975) reported that the genetic component accounted for approximately 20% of the between-herd variation in yearling weight. It may be justified to regrad herd of origin as a major environmental factor for practical purpose, simply because after accounting for the genetic portion, herd of origin would still have much more influence on growth rate (Liu 1991; Liu and Makarechian 1993a, b), feed/gain and ultrasonic backfat thickness than all other environmental factors combined, including age of dam, on-test age and liveweight of the young bulls. The importance of herd of origin effects on feed/gain and ultrasonic backfat thickness indicate the importance of carry-over effects of pre-testing conditions and management and the requirement for a prolonged adjustment period for accurate performance testing.

In the literature, little work has been reported on the partition of total corrected sum of squares to determine the contributions of factors in the context of station performance testing. Therefore, literature were not available for comparisons.

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