DIVERGENT SELECTION FOR POSTWEANING FEED CONVERSION IN ANGUS BEEF CATTLE
IV. PHENOTYPIC CORRELATIONS BETWEEN BODY MEASUREMENTS AND FEED CONVERSION[1,2]

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Summary

Postweaning performance data were obtained on 401 group fed purebred Angus calves from 24 selected sires (12 high and 12 low feed conversion sires) from 1983 through 1986 at the Northwestern Branch of the Ohio Agricultural Research and Development Center. The objective of this study was to determine the interrelationships between body measurements and 140-d feed conversion (feed/gain) adjusted for maintenance (ADJFC), 140-d feed conversion unadjusted for maintenance (UNADFC) and feed conversion measured until progeny reached 8.89 mm of backfat (FC). Variables measured at the completion of the 140-d postweaning period included hip height (HH), chest depth (CD), chest width (CW), head width (HDW), head length (HDL), heart girth (HG), muzzle circumference (MC), backfat thickness (BF), length between hooks and pins (HOPIN) and length between shoulder and hooks (SHHO). Measurements were taken from progeny born from 1983 through 1986 for HH and BF, while others, except chest measurements (CD and CW), which were available only in 1985, were taken from progeny born in 1985 and 1986. Negative phenotypic correlations were found for UNADFC, ADJFC and FC, respectively, with HG (−0.76, −0.65 and −0.85), HOPIN (−0.05, −0.28 and −0.09), HDL (−0.63, −0.66 and −0.57), MC (−0.12, −0.35 and −0.25), HH (−0.38, −0.29 and −0.001), BF (−0.29, −0.31 and −0.12) and CW (−0.03, −0.35 and −0.58). In general, fatter animals with larger HG, longer HDL and greater MC had better feed conversion.

(**Key Words**: Beef Cattle, Body Measurements, Feed Conversion)

Introduction

The improvement of input/output efficiency of profitable production of quality meat for consumers is a primary goal of the beef cattle industry. In growing beef cattle, differences among cattle in growth rate and in efficiency of converting feed into body weight gains are important economic traits. Preweaning, postweaning and yearling weights and gains, as objective measures of growth, and maternal traits have been well accepted as selection criteria in the beef cattle industry. However, use of body measurements of beef cattle in breeding programs is less widely accepted than use of weights at standardized ages and gains at standardized weights (Brown et al., 1983). The objective of this study was to determine the interrelationships between body measurements and 140-d feed conversion (feed/gain) adjusted for maintenance (ADJFC), 140-d feed conversion unadjusted for maintenance (UNADFC) and feed conversion measured until progeny reached 8.89 mm of backfat (FC).

[1]Salaries and research support provided by state and federal funds appropriated to the Ohio Agric. Res. and Dev. Center, The Ohio State Univ. journal article no. 59-94.

[2]The authors wish to thank R. M. McConnell, J. D. Wells, P. E. Houdashelt, and G. L. Reid for their excellent technical assistance.

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Received August 10, 1993
Accepted May 23, 1994

Materials and Methods

Source of data

The postweaning data that were examined in this study were collected from 401 group fed purebred Angus calves produced during the period between 1983 and 1986 from 24 selected sires (12 high and 12 low feed conversion sires) at the Eastern Ohio Resource Development Center

(EORDC) in Belle Valley Ohio. The distribution of calves by sex, year and efficiency group is shown in table 1. Body measurements were taken from calves born in 1985 and 1986.

TABLE 1. DISTRIBUTION OF PROGENY BY YEAR, SEX AND CONVERSION GROUP

Year	Bulls	Heifers	Total	High[a]	Low[b]
1983	60	51	111	52	59
1984	57	46	103	57	46
1985	43	46	89	43	46
1986	43	55	98	48	50
Total	203	198	401	200	201

[a] High feed conversion calves were progeny of sires with low feed:gain ratios.
[b] Low feed conversion calves were progeny of sires with high feed:gain ratios.

Description of data

Sires of these calves were selected from 35 individually fed bull calves each year based on feed conversion. The three most efficient (in terms of kilograms of feed required per kilogram of gain) and the three least efficient bulls were randomly mated to approximately 20 cows each in a test herd of Angus cows located at EORDC. A different group of high and low feed conversion, 2-yr-old, Angus sires was used each year. A more detailed description of selection, management and feeding practices for the population from which the sires were selected was given by Davis et al. (1985).

During the preweaning period, all calves were reared with their dams and without creep feeding. Blue-grass, brome and fescue pasture was available to both the dam and progeny. Composition of the calves postweaning diet is given in table 2. Weaning weights were obtained at approximately 7 mo of age. Progeny were then transported to the Northwestern Branch of the Ohio Agricultural Research and Development Center in Hoytville, Ohio. Calves were given approximately 2 wk to become accustomed to the feedlot and diet consisting primarily of non-protein nitrogen corn silage. Shelled corn was also fed at the rate of 1.0 and 0.75% of body weight per head per day for bull and heifer calves, respectively. Soybean oil meal was fed as a protein supplement. After the adjustment period, all calves were placed on full fed until they reached 8.89 mm of backfat as measured via sonoray. Feed conversions were calculated as the ratio of feed consumption to weight gain of pen. Pen feed conversions were calculated because the calves were fed by sire group and sex. Thus, there were 48 experimental units for HH and BF, 24 for HG, HOPIN, SHHO, HDL, HDW and 12 for CD and CW.

TABLE 2. COMPOSITION OF PROGENY POSTWEANING DIET (%[a])

Ingredient	Bulls	Heifers
Corn silage	56.7	62.2
Shelled (whole) corn	36.9	27.9
SBOM[b]	6.3	4.2
MGA[c]	0.0	5.6
RABON[d]	0.1	0.1

[a] Dry matter basis.
[b] Soybean Oil Meal, 44% crude protein.
[c] *Melengestrol Acetate* used to control estrus.
[d] Rabon used to control flies.

In this study, feed conversion for the first 140 d on test involved a time-constant interval. The Beef Improvement Federation (BIF, 1981) recommends that when feed consumption per unit of gain is evaluated in time-constant intervals, feed: gain ratios should be adjusted for differences in maintenance requirements by multiplying by a ratio of test group average metabolic mid weight ($W_{i.}^{.75}$) to individual (pen average in the case of progeny group feeding) metabolic mid weight ($W_{ij}^{.75}$) as follows:

BIF-adjusted feed conversion = ($W_{i.}^{.75}/W_{ij}^{.75}$) (*feed/gain*), *where* i = i^{th} *year of the test and* j = j^{th} pen within i^{th} year of the test.

Midweights were estimated as (initial weight on test + final weight off test)/2. This procedure adjusts feed:gain ratios of heavier-than-average animals downward because they are expected to have above-average maintenance requirements and. therefore, above average metabolic weights. Feed: gain ratios of lighter-than-average animals will be adjusted upward because they are expected to have below-average maintenance requirements and metabolic weights.

Collection of data

Weights were taken at the beginning of the postweaning test and at the end of each 28-d period until each progeny reached 8.89 mm of backfat as measured via sonoray. After the first 140 d of the test, those calves with a fat measurement of 8.89 mm or greater were removed from the test and slaughtered.

At the completion of the 140-d postweaning period, 10 body measurements including height at hips (HH), depth of chest (CD), width of chest (CW), length of head (HDL), width of head (HDW), heart girth (HG), length between hooks and pins (HOPIN), length between shoulder and hooks (SHHO), circumference of muzzle (MC) and backfat thickness (BF) were obtained on both bull and heifer calves. Least-squares means and standard errors for 140-d feed conversion unadjusted for maintenance (UNADFC), 140-d feed conversion adjusted for maintenance (ADJFC), feed conversion measured until calves reached 8.89 mm of backfat (FC) and the 10 body measurements are presented in table 3. Except BF, body measurements were obtained using a flexible steel or cloth measuring tape and metal calipers. Green and Carmon (1976) found these instruments to be accurate for such measurements. Since depth of chest and width of chest were not taken in 1986, only one year (1985) of data was available for these traits. Points used in taking the measurements were as follows (Park et al., 1993).

Height at hips (HH) — vertical distance from the floor to the highest point in the region of the hooks (tuber coxae) as measured with a metal caliper.

Depth of chest (CD) — vertical distance from the chest floor just behind the forelegs to the top of the withers as measured with a metal caliper.

Width of chest (CW) — horizontal distance across the widest part of the top of the chest in the region of the withers as measured with a metal caliper.

TABLE 3. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR 140-D FEED CONVERSION UNADJUSTED FOR MAINTENANCE (UNADFC), 140-D FEED CONVERSION ADJUSTED FOR MAINTENANCE (ADJFC), FEED CONVERSION MEASURED UNTIL CALVES REACHED 8.89 mm OF BACKFAT (FC) AND 10 BODY MEASUREMENTS (cm)

Traits	Least-squares means and standard errors
UNADFC	5.59±0.05
ADJFC[a]	6.00±0.06
FC	5.59±0.03
Height at hip	114.92±0.33
Heart girth	174.94±0.84
Width of chest	44.20±0.34
Depth of chest	58.08±0.43
Length of head	41.97±0.24
Width of head	21.10±0.16
Length between hooks and pins	46.43±0.38
Length between shoulder and hooks	94.00±0.74
Circumference of muzzle	41.29±0.26
Backfat thickness	0.91±0.02

[a] Feed conversion adjusted for maintenance requirements as recommended by BIF (1981).

Width of head (HDW) — distance between right and left zygomatic arches as measured with a measuring tape.

Length of head (HDW) — distance from the center of the poll to the tip of the muzzle as measured with a measuring tape.

Heart girth (HG) — body circumference measured immediately posterior to the shoulder.

Length between hooks and pins (HOPIN) — distance from the hooks to the point of the pin bone (ischial tuberosity) as measured with a measuring tape.

Length between shoulder and hooks (SHHO) — distance from the shoulder point (ridge of blade bone of scapula) to the hooks as measured with a measuring tape.

Circumference of muzzle (MC) — circumference of the muzzle measured with a measuring tape drawn snugly around the muzzle.

Backfat thickness (BF) — fat thickness over the longissimus muscle between the 12th and 13th ribs estimated with an ultrasound (sonoray) machine.

Statistical analysis

A mixed model least-squares and maximum likelihood computer program (LSMLMW; Harvey, 1985) was employed. Weights used in the weighted least-squares analysis of pen means were based on the number of progeny in pen. The statistical model included the fixed effects of year-conversion group (conversion group was either high or low, where high feed conversion calves were progeny of sires with the lowest feed:gain ratios and low feed conversion calves were progeny of sires with the highest feed:gain ratios), sex (bulls vs heifers), and interaction between year-conversion group and sex, and the random effect of sire nested within year-conversion group. Effects of year and conversion group were combined to obtain a unique identification for the nested effect of sire. After fitting this preliminary model with covariates for on test weight, on test age and backfat thickness at removal from the test, nonsignificant ($p > 0.20$) interactions and covariates were omitted.

Bishop (1987) illustrated the phenotypic correlation using a path diagram. Phenotypic correlations under model 3 of LSMLMW (Harvey, 1985) for paternal half-sibs with no interaction of sires with fixed effects were derived in the following manner:

$$r_{p(hh')} = \frac{\hat{\sigma}_e(hh') + \frac{1-NW}{NR1} \times \hat{\sigma}_s(hh')}{\sqrt{[\hat{\sigma}_e^2(h) + \frac{1-NW}{NR1} \times \hat{\sigma}_s^2(h)]\,[\hat{\sigma}_e^2(h') + \frac{1-NW}{NR1} \times \hat{\sigma}_s^2(h')]}}$$

where

$r_{p(hh')}$ = the phenotypic correlation between two traits,

$\hat{\sigma}_e^2(h)$ = the within "family" variance component estimate for trait 1,

$\hat{\sigma}_e^2(h')$ = the within "family" variance component estimate for trait 2,

$\hat{\sigma}_s^2(h)$ = the between "family" variance component estimate for trait 1,

$\hat{\sigma}_s^2(h')$ = the between "family" variance component estimate for trait 2,

$\hat{\sigma}_e(hh')$ = the within "family" covariance component between traits 1 and 2,

$\hat{\sigma}_s(hh')$ = the nested "family" covariance component between traits 1 and 2,

NW = the decimal percentage of additive genetic variance in σ_e^2 (0.75 for half-sib families in a random mating population),

NR1 = the decimal percentage of additive genetic variance in σ_s^2 (0.25 for half-sib families in a random mating population).

Results and Discussion

Phenotypic correlations of several body measurements with UNADFC, ADJFC and FC are presented in table 4. These correlations were obtained after adjusting variances and covariances for fixed effects of year-conversion group, sex, year-conversion group × sex, the random effect of sire nested within year-conversion group and important ($p < 0.20$) covariates for on-test weight and on-test age and backfat thickness at removal from the test.

Negative correlations were found for UNADFC, ADJFC, and FC with HG, HOPIN, HDL, MC, HH, BF, and CW. These correlations indicate that progeny with lower feed:gain ratios were fatter, with larger HG and MC, were greater in body length and length of head, and were taller. Very littel has been reported in the literature concerning the relationships between body measurements and feed conversion of beef cattle. Brown et al. (1973a,b) reported varying effects of increasing body dimensions on feed conversion of Hereford and Angus bulls at 8 mo of age. Their measurements included two heights (wither and hip), three widths (hip, shoulder and loin), two depths (rear flank and chest), one circumference (heart girth) and body length from point of shoulder to pin bone. An increase in any one body dimension improved feed conversion of Hereford bulls, but had an adverse effect on feed conversion of Angus bulls. These results indicated that genes having a positive effect on size of Hereford bulls at 8 mo improved feed conversion, whereas, genes with similar effects in Angus bulls tended to result in less desirable feed conversion. At 12 mo of age, however, all body measures except height were nearly equally correlated with feed conversion. Correlations were small among Angus bulls and only the correlation with width at hip approached significance among Hereford bulls. Davis et al. (1985) reported that correlations of adjusted and unadjusted feed conversion ratios (feed:gain) were −0.11 and 0.11, respectively, with backfat thickness, and −0.34 and −0.14 respectively, with hip height at the end of a 140-d test in Angus bulls. These results indicated that when unadjusted feed:gain ratios were used to evaluate efficiency, bulls that were more efficient

TABLE 4. PHENOTYPIC CORRELATIONS[a] OF BODY MEASUREMENTS WITH 140-D FEED CONVERSION UNADJUSTED FOR MAINTENANCE (UNADFC), 140-D FEED CONVERSION ADJUSTED FOR MAINTENANCE (ADJFC) AND FEED CONVERSION MEASURED UNTIL PROGENY REACHED 8.89 mm OF BACKFAT (FC)

Measurement	UNADFC	ADJFC[b]	FC
Heart girth	−0.76	−0.65	−0.85
Length between hooks and pins	−0.05	−0.28	0.09
Length between shoulder and hooks	−0.04	0.08	0.21
Length of head	−0.63	−0.66	−0.57
Width of head	−0.12	−0.19	0.14
Circumference of muzzle	−0.12	−0.35	−0.25
Height at hip	−0.38	−0.29	−0.001
Backfat thickness	−0.29	−0.31	−0.12
Depth of chest	−0.32	−0.06	0.37
Width of chest	0.03	−0.35	−0.58

[a] Phenotypic correlations were adjusted for the fixed effects of year-conversion group, sex and year-conversion group × sex, the random effect of sire nested within year-conversion group and important ($p < 0.20$) covariates for on-test weight, on-test age and backfat thickness at removal from the test.

[b] Feed conversion adjusted for maintenance requirements as recommended by BIF (1981).

were taller and leaner.

In our study involving subsequent progeny of the potential sires studied by Davis et al. (1985), negative phenotypic correlations of UNADFC (−0.29), ADJFC (−0.31) and FC (−0.12) with BF indicate that fatter animals are more efficient. HG and HDL showed the strongest phenotypic correlations with all three measure of feed conversion, while HOPIN, SHHO, and CW showed almost no phenotypic correlation with UNADFC. Gilbert et al. (1993) reported values of 0.62 and 0.36 for the correlation of postweaning ADG with HG and HDL, respectively. The near zero value of HH with FC indicates that HH had little association with feed conversion over the entire test. Thus, selection for HH, which is a common practice in today's beef industry, would not be expected to improve postweaning feed conversion. HH, BF, and CD were moderately associated with UNADFC. MC was moderately correlated with ADJFC. A possible explanation for this result is that calves with larger muzzle circumference tend to consume more feed than calves with smaller muzzle circumference, especially in the situation of group feeding, because of competition. Consequently, they have more energy available for weight gain. The phenotypic correlation of 0.39 between circumference of muzzle and BF indicates that larger muzzle size may be associated with a higher rate of fat deposition. Good et al. (1961) reported a negative correlation between width of muzzle and fat cover over the 12th rib.

In general, fatter animals with larger HG, taller HH and longer HDL had better feed conversion in our study.

Conclusions

Previous authors have reported that selection for increased rate of gain may improve feed conversion (Koch et al., 1963) nearly as rapidly (Wang and Dickerson, 1984) as direct selection for the trait. Respective phenotypic correlations for UNADFC, ADJFC and FC with HG and HDL were −0.76 and −0.63, −0.65 and −0.66 and −0.85 and −0.57. Therefore, according to our study, selection for HG and/or HDL may improve feed conversion.

Brown et al. (1973b) concluded from their studies that, "With a variety of body shapes showing acceptable feedlot performance, the problem concerning the breeder becomes one of identifying those body types which are consistent with efficiency in other phases of beef production." Also, with different feeding programs, the relationships of feed conversion and body measurements may not be constant from one feeding program to another. Caution therefore must be used in interpreting relationships between feed conversion and body measurements. However, the results of the present study, which demonstrate relationships of body measurements with feed conversion, are applicable to the cattle feeding segment of the beef industry.

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