DIVERGENT SELECTION FOR POSTWEANING FEED CONVERSION IN ANGUS BEEF CATTLE VI. REALIZED HERITABILITY ESTIMATES[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. A single generation divergent selection experiment was replicated four times (1983, 1984, 1985 and 1986) to obtain a realized heritability estimate for postweaning feed conversion. The 140-d postweaning period was divided into five 28-d periods. Realized heritability estimates for feed conversion by 28-d periods fluctuated greatly and demonstrated no particular pattern. Heritability was highest for the fourth period (between d 85 and 112 of postweaning period, 0.61). Thus, beef producers could successfully select for feed conversion.
(Key Words : Beef Cattle, Realized Heritability, Feed Conversion)

Introduction

Knowledge of certain genetic parameters of the population for the traits for which selection is being practiced can be helpful in predicting or understanding the response that may be realized. The genetic parameter of primary interest is heritability of the traits involved. Heritability is the fraction of total phenotypic variance that may be attributed to the additive effects of genes. Falconer (1981) defined realized heritability as the ratio of response to selection differential. Response to selection (R) is the difference between the mean phenotypic value of the offspring of the selected parents and the whole of the parental generation before selection. Selection differential (S) is the mean phenotypic value of the individuals selected as parents expressed as a deviation from the population mean (Falconer, 1981). Bishop et al. (1991) previously reported that realized heritability of maintenance adjusted and unadjusted postweaning conversion in a population of angus beef cattle was 0.46 and 0.26, respectively. The objective of this study was to determine the realized heritability of feed conversion by 28-d periods and by year in the same population of cattle studied by Bishop et al. (1991).

Materials and Methods

Source of data

Postweaning 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. In 1983 and 1984, sires were selected based upon unadjusted feed:gain ratios, whereas in 1985 and 1986, sires were selected based upon maintenance adjusted feed:gain ratios (BIF, 1981). The distribution of progeny by sex, year and efficiency group, and composition of diet, were given by Park et al. (1994). The data included feed consumption by sire group and sex and individual weights by 28-d periods during the postweaning test period. Thus, 48 experimental units were available for analysis. A detailed description of the calculation of adjusted (ADJFC) and unadjusted (UNADFC) feed conversion was given by Park et al. (1994).

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 the Eastern Ohio Resource Development Center, Belle Valley. A different group of high and low feed conversion 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).

Birth weight, date of birth, sex, and sire and dam of each calf were recorded within 24 h postpartum. During the preweaning period, all calves were reared with their dams and without creep feeding. Weaning weights were obtained at approximately 7 mo of age. Calves were then transported to the Northwestern Branch of the Ohio Agricultural Research and Development Center located at Hoytville and given approximately 2 wk to become accustomed to the feedlot and postweaning diet. During the postweaning period, calves were separated by sire group and sex and group fed *ad libitum* a 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, repectively. Soybean oil meal was fed as a protein supplement.

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. Individual weights and pen feed consumptions were recorded at the end of each 28-d period. Weight gains were calculated as the difference between weights obtained at the end of consecutive 28-d periods. Gains of individual calves in a sire-sex group were summed to obtain total gains of pens. Feed efficiencies were calculated as the ratio of pen feed consumption to weight gain of pen by 28-d periods. Unconsumed feed was reweighed every 28 d. After the first 140 d, those calves with a fat measurement of 8.89 mm or greater were removed from the test and slaughtered.

Statistical analysis

A mixed model least-squares and maximum likelihood Computer Program (LSMLMW; Harvey, 1985) was employed. 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. Covariates of on-test weight, and on-test age were also included if important ($p < 0.20$). Effects of year and conversion group were combined to obtain a unique identification for the nested effect of sire.

For this replicated study, realized heritability was calculated as the cumulative response (R; obtained by summing the responses weighted by number of progeny in each year) divided by cumulative selection differential (S; obtained by summing the appropriately weighted selection differentials of the sires). The response to selection for feed conversion was estimated as the deviation of the response of the low feed conversion group from the response of the high feed conversion group. Response for the high or low feed conversion group was calculated as the sum of weighted (by the number of offspring of each selected sire) differences between the mean feed conversion values of the offspring of each sire in a feed conversion group and the mean value of the offspring of all selected sires in a feed conversion group in that respective year divided by the total number of offspring produced in a feed conversion group in that year. Selection differential for the high or low feed conversion group was calculated as the deviation of the mean feed conversion value of all tested bulls from which the sires were selected in each year from the mean value of the three high or three low bulls selected to become sires. Because progeny born in 1983 were the offspring of sires born in both 1979 and 1980 (two sires from 1979 and one sire from 1980 were used in the high efficiency group; one sire from 1979 and two sires from 1980 were used in the low efficiency group), the selection differential for these sires was calculated as the sum of differences between the mean feed conversion value of all bulls before selection and the mean feed conversion value of selected sires in each year, weighted by the number of sires

selected in each year, then divided by three (number of sires selected in each year in each conversion group). In the present study, cows were unselected. Thus, it is appropriate to multiply the cumulative response to selection by two as follows:

$h^2 = 2 \times$ cumulative response/cumulative selection differential

Realized heritability estimated in this way is primarily a description of response to selection. Heritability was calculated by year and by 28-d period.

Results and Discussion

Realized heritability estimates of 140-d feed conversion (feed:gain) unadjusted for maintenance (UNADFC) and 140-d feed conversion adjusted for maintenance (ADJFC) by year for five 28-d periods are presented in table 1. The yearly heritability estimates by 28-d period varied from less than 0 to greater than 1.0, exceeding the theoretical limits for heritability. Sampling errors likely were large for the yearly estimates. Hence, combined estimates were obtained by pooling the heritability estimates from each year (table 2). Heritabilities were larger in 1985 and 1986 when sires were selected based upon adjusted feed:gain ratios than in 1983 and 1984 when sires were selected based upon unadjusted feed:gain ratios.

Differences were apparent among heritability estimates for the five 28-d periods and also between estimates for adjusted and unadjusted feed conversion. Heritability was higher for ADJFC than for UNADFC in each year except 1983. From

this same study, Bishop et al. (1991) reported realized heritability estimates for unadjusted feed conversion of 0.26 and for adjusted feed conversion of 0.46 when all 4 yr of data were considered. They explained that higher heritability for ADJFC than UNADFC may have been due in part to culling of low feed conversion sires for body size and weight before selection of sires used for the first 2 yr of this study. Heritability estimates by 28-d periods fluctuated greatly and demonstrated no particular pattern (table 2). This might be due to sampling error. The estimate for the third period was disappointingly low (-0.02) compared to other estimates. Heritability was highest for the fourth period (0.61) and then decreased to 0.14 for the next period.

Knapp and Nordskog (1946) estimated heritability of feed conversion in beef cattle using two methods, parental half-sib correlation (0.75) and regression of progeny average on sire (0.54). Koch et al. (1963) obtained heritability estimates of 0.28 ± 0.11, 0.62 ± 0.12 and 0.36 ± 0.10 for regression of feed consumption on gain, regression of gain on feed consumption and the ratio of gain to feed consumption, respectively. The following heritability estimates for feed conversion in beef cattle have also been reported: Dawson et al. (1952), 0.32; Brown and Honea (1969), 0.22 and Mavrogenis et al. (1978), 0.26. Woldehawariat et al. (1977) reported an average weighted regression estimate of 0.38, an average parental half-sib estimate of 0.47 and an overall weighted regression and weighted parental half-sib estimate of 0.45 in his summary of a large number of feed conversion

TABLE 1. REALIZED HERITABILITY[a] OF 140-D FEED CONVERSION (FEED:GAIN) UNADJUSTED FOR MAINTENANCE (UNADFC) AND 140-D FEED CONVERSION ADJUSTED FOR MAINTENANCE (ADJFC) BY YEAR FOR FIVE 28-D PERIODS

	FE028[b]	FE2956[c]	FE5784[d]	FE85112[e]	FE113140[f]	UNADFC	ADJFC[g]
1983	−0.25	1.15	−1.02	7.52	0.02	0.02	−0.09
1984	0.07	0.18	0.08	0.30	0.21	0.13	0.24
1985	0.12	−1.20	0.10	0.24	−0.17	0.14	0.54
1986	1.03	0.15	0.55	0.42	0.34	0.55	0.63

[a] Two × response/selection differential.
[b] Unadjusted feed conversion between d 0 and 28 of postweaning test period.
[c] Unadjusted feed conversion between d 29 and 56 of postweaning test period.
[d] Unadjusted feed conversion between d 57 and 84 of postweaning test period.
[e] Unadjusted feed conversion between d 85 and 112 of postweaning test period.
[f] Unadjusted feed conversion between d 113 and 140 of postweaning test period.
[g] Adjusted for maintenance as recommended by BIF (1981).

studies. Blum (1976) reported a realized heritability estimate for unadjusted feed conversion of 0.61 for two generations of selection in Polled Hereford cattle. Realized heritability estimates for feed conversion in swine were reported by Bernard and Fahmy (1970), 0.11 ± 0.13; and by Jungst et al. (1981), 0.09 ± 0.08.

TABLE 2. COMBINED (ACROSSYEARS) REALIZED HERITABILITY, SIRE SELECTION DIFFERENTIAL AND PROGENY RESPONSE TO SELECTION FOR 140-D FEED CONVERSION (FEED:GAIN) UNADJUSTED FOR MAINTENANCE BY FIVE 28-D PERIODS

	R[a]	SD[b]	h[2c]
FE028[d]	−0.58	−6.40	0.18
FE2956[e]	−1.96	−6.86	0.57
FE5784[f]	0.04	−3.41	−0.02
FE85112[g]	−0.87	2.85	0.61
FE113140[h]	−0.75	−10.71	0.14

[a] Response to selection was adjusted for number of progeny of each sex by each sire within feed conversion group.
[b] Selection differential.
[c] Two × response/selection differential.
[d] Unadjusted feed conversion between d 0 and 28 of postweaning test period.
[e] Unadjusted feed conversion between d 29 and 56 of postweaning test period.
[f] Unadjusted feed conversion between d 57 and 84 of postweaning test period.
[g] Unadjusted feed conversion between d 85 and 112 of postweaning test period.
[h] Unadjusted feed conversion between d 113 and 140 of postweaning test period.

Conclusion

An accurate estimate of heritability is needed to make effective breeding plans for improvement of economic characters in livestock. In divergent selection, each selected group acts as 'control' for the other and the response is measured as the divergence between the two groups. Elimination of common environmental effects provides more precise measurement of realized heritability. The effect of random drift does not bias the realized heritability estimate in this study because the study consisted of a single generation selection experiment replicated four times.

Realized heritability estimates for feed conversion by 28-d periods fluctuated greatly. The estimate for the third period (FE5784) was the lowest (−0.02). Heritability was highest for the fourth period (FE85112; 0.61) and decreased to 0.14 for FE113140. Bishop et al. (1991) reported that 140-d unadjusted feed conversion ratio (0.26) and 140-d adjusted (BIF, 1981) feed conversion ratio (0.46) using these same data were moderately heritable. Thus, beef producers could successfully select for feed conversion over a 140-d postweaning period, even though measurement of feed intake is costly and labor intensive. Producers should base selection on maintenance adjusted feed conversion rather than unadjusted feed conversion due to the high realized heritability reported by Bishop et al. (1991) for the adjusted value when all 4 yr of data were combined and reported in the present study for 3 of the 4 yr when data were analyzed separately by year.

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