ESTIMATES OF PARAMETERS BETWEEN DIRECT AND MATERNAL GENETIC EFFECTS FOR WEANING WEIGHT AND GENETIC EFFECTS FOR CARCASS TRAITS IN CROSSBRED CATTLE[1]

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Summary

Estimates of heritabilities and genetic correlations were obtained from weaning weight records of 23,681 crossbred steers and heifers, and carcass data of 4,094 crossbred steers using REML applied to animal models. Direct and maternal heritabilities for weaning weight were 0.14 and 0.19, respectively. The genetic correlation between direct and maternal weaning weight was negative (-0.18). Heritabilities for carcass traits of steers were moderate to large (0.34 to 0.60). Genetic correlations between direct genetic effects for weaning weight and carcass traits were small, except with hot carcass weight (0.70), ribeye area (0.29) and adjusted fat thickness (0.26). Genetic correlations of maternal genetic effects for weaning weight with direct genetic effects for carcass traits were: hot carcass weight (0.61), retail product percentage (-0.33), fat percentage (0.33), ribeye area (0.29), marbling score (0.28), and adjusted fat thickness (0.25). These results indicate that maternal genetic effects for weaning weight may be correlated with genetics for propensity to fatten in steers. Selection for only direct weaning weight would be expected to increase carcass weight and ribeye area and slightly decrease marbling and retail product percentage. Selection for either increased maternal or direct weaning weight would be expected to result in increased carcass weight, ribeye area, and fat thickness, but would not be expected to affect tenderness.

Introduction

Recently, the beef industry has moved toward value-based marketing to satisfy consumer preferences for meat quality. Breed associations have responded by incorporating carcass EPDs into annual sire evaluations, in addition to EPDs previously calculated for growth and reproductive traits.

Selection for genetic improvement in several traits is most effective when relationships among the traits selected are known. An estimate of maternal genetic ability for weaning weight has been included in breed evaluation programs for some time, but its relationship to carcass characteristics is relatively unknown. Correlations between total genetic effects for weaning weight and some economically important carcass traits have, in some cases, been

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[1]This article was derived from a research paper published in the Journal of Animal Science. Data were derived from Cycles I-IV of the Germ Plasm Evaluation research program conducted under the leadership of Dr. Larry V. Cundiff at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Dr. Michael E. Dikeman was a collaborator on the carcass and meat data collection.

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estimated to be favorable and may represent opportunities for increased productivity. If genetic antagonisms exist, however, they may compromise selection response and reduce profitability. The objective of this study, therefore, was to estimate correlations among direct and maternal genetic effects for weaning weight and direct genetic effects for carcass and meat traits in beef cattle.

Experimental Procedures

Data were obtained from Cycles I-IV of the Germ Plasm Evaluation project at the Roman L. Hruska U. S. Meat Animal Research Center, Clay Center, NE. Calves in Cycle I (born 1970 to 1972) resulted from AI matings of Hereford, Angus, Jersey, South Devon, Limousin, Charolais, and Simmental sires to Hereford and Angus dams. Cycle II calves (born 1973 to 1974) resulted from mating Hereford, Angus, Red Poll, Brown Swiss, Gelbvieh, Maine Anjou, and Chianina sires to Hereford, Angus, Red Poll and Brown Swiss dams. Cycle III calves (born 1975 to 1976) resulted from AI matings of Hereford, Angus, Brahman, Sahiwal, Pinzgauer, and Tarentaise bulls to Hereford and Angus dams. Cycle IV calves (born 1986 to 1990) resulted from AI matings of Angus, Hereford, Longhorn, Piedmontese, Charolais, Salers, Galloway, Nelore, and Shorthorn bulls to Hereford and Angus dams.

The F_1 heifers were managed to calve at 2 years of age. Heifers born in Cycle I were bred by AI to Hereford, Angus, Holstein, South Devon, and Brahman sires. Cycle II heifers were mated by AI to Hereford, Angus, Brahman, and Santa Gertrudis sires. In the final two cycles, all heifers were bred by natural service to Red Poll sires. Females older than 2 years were subsequently bred by natural service to Simmental sires. Weaning weights (n=23,681) (adjusted to 205 days) included both F_1 males and females, as well as calves of F_1 females.

After weaning, steers were allocated to replicated pens and fed in groups by sire breed. A postweaning adjustment period of 25 to 40 days was followed by an average of 262 days on feed. Each year, steers were serially slaughtered in three or four groups over a period of 56 to 84 d. After a 24-hour chill, ribeye area; kidney, pelvic, and heart fat percentage; adjusted fat thickness, and marbling score were determined. For Cycles I - III (1970 to 1976), carcass sides were processed at K-State; for Cycle IV, sides were processed at the U.S. Meat Animal Research Center. Processing resulted in boneless, closely trimmed retail cuts, fat trim, and bone. Ribeye steaks were aged for 7 days, frozen, later thawed, and cooked for Warner-Bratzler shear force tests.

Table 1 shows the summary statistics for weaning weight and carcass traits. The multiple-trait, derivative-free, residual-maximum likelihood suite of programs applied to animal models was used for analyses of all traits.

Results and Discussion

Estimates of heritability and direct-maternal correlation for weaning weight are shown in Table 2. The estimate of direct heritability for weaning weight was slightly less than expected, though not outside the range of values reported in the literature (0.14 to 0.58). The estimate of maternal heritability was only slightly greater than the estimate for direct heritability. Estimates of heritability for carcass traits, and direct and maternal genetic correlations with weaning weight are shown in Table 3. Estimates of heritability for carcass traits were moderate to large. Estimates between direct and maternal weaning weight and percentage retail product were negative (-0.12 and -0.33, respectively).

Estimates of genetic correlations for direct and maternal effects of weaning weight with adjusted fat thickness were moderate and positive (0.26 and 0.25, respectively), suggesting that as weaning weight increases, adjusted fat thickness will also increase. Estimates of genetic correlations between kidney, pelvic, and heart fat percentage and the direct and maternal genetic effects for weaning weight were relatively small and positive. The genetic correlation between direct effect of weaning weight and marbling score was slightly negative (-0.12), whereas the genetic correlation for the maternal effect for weaning weight and direct effect for marbling score was positive (0.28). These results suggest that selection for direct weaning weight may result in a slight decrease in marbling score, but selection for maternal weaning weight would result in increased marbling.

Near-zero estimates of genetic correlations were found between direct and maternal effects of weaning weight and Warner-Bratzler shear force, suggesting that selection for weaning weight will not have an effect on meat tenderness. Selection for increased direct genetic value for weaning weight would be expected to increase hot carcass weight, fat percentage, adjusted fat thickness, ribeye area, and kidney, pelvic, and heart fat percentage. At the same time, it would be expected to decrease retail product percentage, bone percentage and marbling score, and to have almost no effect on Warner-Bratzler shear force. Selection for maternal milk, or maternal effects on weaning weight, may lead to positive correlated responses in hot carcass weight, fat percentage, adjusted fat thickness, ribeye area, marbling score, and kidney, pelvic, and heart fat percentage; a negative correlated response in retail product percentage; and almost no effect on Warner-Bratzler shear force. Genetic correlations of direct and maternal effects on weaning weight with carcass traits were generally similar. Only for marbling score were the relationships with direct and maternal effects on weaning weight different. Genetic correlations between maternal effects of weaning weight and carcass traits were moderate for carcass traits involving fat percentage (0.33), retail product percentage (-0.33), and marbling score (0.28).

To meet consumer demands for quality beef, seedstock breeders and commercial producers need to consider not only the traditional traits of growth, maternal ability and production efficiency in their selection decisions, but also carcass traits. Carcass traits, including tenderness, can be improved through selection because of the moderate to high heritability of the traits. Selection for either increased maternal or direct weaning weight would be expected to result in increased carcass weight, ribeye area, and fat thickness. Selection for only maternal weaning weight would also be expected to result in increased carcass fat percentage and marbling, and decreased retail product percentage. Selection for only direct weaning weight would be expected to slightly decrease marbling and retail product percentage. Selection for either increased maternal or direct weaning weight would not be expected to affect tenderness.

Table 1. Summary Statistics for Weaning Weight and Carcass Traits

Trait	n	Mean[a]	SD[a]
Weaning weight, lb	23,681	403.70	67.70
Hot carcass weight, lb	4,088	664.50	90.50
Retail product percentage, %	3,708	68.70	4.10
Fat percentage, %	3,708	18.42	4.72
Bone percentage, %	3,704	12.88	1.07
Ribeye area, $inch^2$	4,094	11.39	1.40
Adjusted fat thickness, inch	4,091	0.48	0.29
Kidney, pelvic, and heart fat, %	3,707	3.95	1.13
Marbling score	3,696	5.29	1.00
Warner-Bratzler shear force, lb	3,705	9.15	3.37

[a]Unadjusted means and standard deviations
[b]Small[29] = 5.29.

Table 2. Estimates of Direct (h^2_d) and Maternal (h^2_m) Heritabilities and Genetic Correlation ($r_{d,m}$) Between Direct and Maternal Weaning Weight

Parameter	Estimate
h^2_d	0.14
h^2_m	0.19
$r_{d,m}$	-0.18

Table 3. Estimates of Direct Heritability (h^2) and Direct (r_d) and Maternal (r_m) Genetic Correlations with Weaning Weight

Trait	H^2	r_d	r_m
Hot carcass weight	0.49	0.70	0.61
Retail product percentage	0.58	-0.12	-0.33
Fat percentage	0.49	0.14	0.33
Bone percentage	0.48	-0.13	-0.08
Ribeye area	0.58	0.29	0.29
Adjusted fat thickness	0.46	0.26	0.29
Kidney, pelvic, and heart fat	0.60	0.17	0.19
Marbling score	0.35	-0.12	0.28
Warner-Bratzler shear force	0.34	0.05	-.06