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Genetic Parameters for Sex-Specific Traits in Beef Cattle[1]

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ABSTRACT: Data from 3,593 beef heifers and 4,079 of their steer paternal half-sibs were used to estimate genetic parameters of and among female growth and reproductive traits and male carcass traits. Estimates of heritability for adjusted 205-d weight, adjusted 365-d weight, age at puberty, calving rate, and calving difficulty measured on females were .16, .38, .47, .19, and .18, respectively; estimates for calving rate and calving difficulty were expressed on a normal scale. Estimates of heritability for hot carcass weight; retail product percentage; fat percentage; bone percentage; rib eye area; kidney, pelvic, and heart fat percentage; adjusted fat thickness; marbling score; Warner-Bratzler shear force; taste panel tenderness; taste panel juiciness; and taste panel flavor that were measured on steers at an average age of 447 d (weaning age = 185, days on feed = 262) were .50, .66, .58, .54, .61, .48, .66, .71, .26, .31, .00, and .04, respectively. Genetic correlations were positive for heifer weights with hot carcass weight, fat percentage, rib eye area, adjusted fat thickness, marbling score, and Warner-Bratzler shear force, and they were negative with retail product percentage and kidney, pelvic, and heart fat percentage of steers. Age at puberty was genetically correlated with taste panel tenderness but not with other carcass traits. Calving rate had positive genetic correlations with fat percentage, rib eye area, adjusted fat thickness, and taste panel flavor, and it had negative genetic correlations with retail product percentage; bone percentage; and kidney, pelvic, and heart fat percentage. Calving difficulty had favorable genetic correlations with hot carcass weight, retail product percentage, and measures of carcass tenderness, but it was unfavorably correlated with traits that involve carcass fatness. These results indicate that selection for some traits expressed in one sex of beef cattle may result in undesirable responses in traits expressed in the opposite sex.

Key Words: Genetic Correlation, Heritability, Carcasses, Reproduction, Growth

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Introduction

The primary objectives in beef cattle breeding are to improve reproductive efficiency and production of lean growth. The potential for change in these economically important traits is largely dependent on their genetic variation and correlations (e.g., Mohiuddin, 1993). Producers need to be aware of possible antagonistic relationships among traits so that they may account for them in selection schemes and breeding programs. Presently there is a lack of such information in the literature for some traits (MacNeil et al., 1984; Marshall, 1994). Numerous studies have reported estimates of genetic or phenotypic parameters for reproductive, growth, or carcass traits (see reviews by Mohuiddin, 1993; Koots et al., 1994a,b), but few have reported estimates of relationships among these groups of traits. The objective of this study was to estimate genetic parameters of and among several reproductive and maternal traits in beef heifers and growth and carcass traits in their steer paternal half-sibs.

Materials and Methods

Data used in this study were collected from the first four cycles of the Germ Plasm Evaluation (GPE) project at the U.S. Meat Animal Research Center in Clay Center, NE. Table 1 shows numbers of sires used and records observed for each sex in each of the four cycles. Table 2 shows number of calves per breed of sire for each cycle.

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Table 1. Number of sires and records for female reproductive and male carcass traits

Trait	Number of sires	Number of records
Female reproductive traits		
Weaning weight (WWT)	593	3,593
Yearling weight (YWT)	587	3,182
Age at puberty (PUB)	580	2,864
Calving rate (RATE)	588	3,183
Calving difficulty (DIFF)	582	3,017
Male carcass traits		
Hot carcass weight (HCWT)	600	4,071
Retail product percentage (RET%)	597	3,692
Fat percentage (FAT%)	597	3,693
Bone percentage (BON%)	597	3,692
Ribeye area (REA)	600	4,079
Adjusted fat thickness (AFAT)	600	4,079
Kidney, pelvic, and heart fat percentage (KPH)	597	3,697
Marbling score (MARB)	597	3,693
Warner-Bratzler shear force (WBSF)	597	3,704
Taste panel tenderness (TPT)	577	2,386
Taste panel juiciness (TPJ)	577	2,386
Taste panel flavor (TPF)	577	2,386

Cycle I calves born in 1970 to 1972 were the result of Hereford (Polled and Horned), Angus, Jersey, South Devon, Limousin, Charolais, or Simmental sires mated to Hereford or Angus dams by artificial insemination. Cycle II calves produced in 1973 and 1974 resulted from crosses of Angus and Hereford (including reference sires repeated from Cycle I), as well as Red Poll, Brown Swiss, Gelbvieh, Maine Anjou, or Chianina bulls mated to Hereford, Angus, Red Poll, or Brown Swiss dams. Cycle III calves born in 1975 and 1976 were produced by Hereford and Angus sires (again including repeated sires from Cycle I) and Brahman, Sahiwal, Pinzgauer, or Tarentaise bulls bred to Hereford or Angus dams. In Cycle IV, semen from Angus and Hereford sires (current sires and reference bulls repeated from Cycle I), Longhorn, Piedmontese, Charolais, Salers, Galloway, Nelore, and Shorthorn was used to inseminate Hereford or Angus dams to produce progeny for 1986 through 1990. Some dams were used in two or all of the first three cycles. To increase ties to earlier cycles and to aid in pooling data over the four cycles, one or two clean-up bulls each of Charolais, 7/8 Gelbvieh, or 7/8 Pinzgauer breeds were used by natural service in single-sire breeding pastures for about 21 d in Cycle IV, following an artificial insemination period of about 45 d (Cundiff et al., 1993). Therefore, animals used for this study were generally two-breed crosses. Details of management of calves from birth to weaning were reported by Smith et al. (1976) and Gregory et al. (1978, 1979b).

All heifers were retained to evaluate several reproductive and maternal traits through mature ages, although only records on first calving were used in this study. Heifers were managed to first calve at 2 yr of age and were fed a diet of approximately 50% corn silage and 50% alfalfa or grass haylage, as well as protein or mineral supplement. See Laster et al. (1976, 1979), Gregory et al. (1979a), and Cundiff et al. (1993) for details regarding postweaning heifer management. In Cycle I, heifers were bred to Hereford, Angus, Devon, Holstein, and Brahman bulls by artificial insemination. Cycle II heifers were bred by artificial insemination to Hereford, Angus, Santa Gertrudis, and Brahman bulls. In Cycles III and IV, heifers were bred by natural service to Red Poll sires to produce their first calves.

After a postweaning adjustment period of 25 to 40 d, steers were allocated to replicated pens and fed separately by sire breed for about 200 d. The diet varied over the duration of the project but averaged 2.79 Mcal ME/kg, 12.8% crude protein, and 9.2% digestible protein. Steers were serially slaughtered in commercial packing plants each year in three to four groups over a period spanning 56 to 84 d. Details of postweaning management of steers and slaughter protocol can be found in Koch et al. (1976, 1979, 1982b) and Wheeler et al. (1996).

Adjusted 205-d (**WWT**) and adjusted 365-d (**YWT**) weights were determined for all heifers. Age at puberty (**PUB**) was defined as the date of the first observed standing estrus confirmed by a subsequent estrus observed within 45 d. Penectomized males equipped with chin ball markers were used to aid in visual detection of estrus. Females were checked

Table 2. Number of calves by breed of sire for each cycle of the GPE project

Breed of sire	Cycle I (1970–72)	Cycle II (1973–74)	Cycle III (1975–76)	Cycle IV (1986–90)
Hereford	352	273	208	391
Angus	321	289	130	376
Jersey	287			
South Devon	219			
Simmental	392			
Limousin	355			
Charolais	368			182
Red Poll		264		
Brown Swiss		321		
Maine Anjou		210		
Chianina		221		
Gelbvieh		199		141
Brahman			338	
Sahiwal			317	
Pinzgauer			362	58
Tarentaise			192	
Shorthorn				168
Galloway				161
Longhorn				189
Nelore				184
Piedmontese				188
Salers				182
7/8 Gelbvieh				72
7/8 Pinzgauer				151

visually from early spring until the start of the breeding season to determine age at puberty. Calving rate (**RATE**) was scored as 1 if the heifer produced a live calf at birth and 0 if the heifer failed to produce a live calf. Calving difficulty (**DIFF**) was subjectively scored at parturition and classified as 0 for heifers having no difficulty or requiring only hand assistance and as 1 for heifers requiring the use of a calf jack or caesarian section. For these analyses, abnormal birth data were not used.

Hot carcass weight (**HCWT**) was recorded for each steer. After a 24-h chill, adjusted fat thickness (**AFAT**); rib eye area (**REA**); kidney, pelvic, and heart fat percentage (**KPH**); and marbling score (**MARB**) were determined. Fat thickness was measured over the rib eye at the 12th rib and adjusted for distortion as a result of hide pull and to reflect fat thickness over the round, chuck, and other parts of the carcass. Marbling was scored on a 100-point scale within each of seven categories and then converted to a numeric scale. In the first three cycles of the GPE project (1970 to 1976), the right side of each carcass was shipped to Kansas State University, Manhattan, KS, for processing. In Cycle IV (1986 to 1990), evaluations were performed at the U.S. Meat Animal Research Center in Clay Center, NE. Carcass halves were processed into boneless, closely trimmed retail product, fat trim, and bone. Retail product, fat trim, and bone were doubled to estimate total yield from the carcass and converted into a percentage of actual carcass weight (**RET%**, **FAT%**, and **BON%**, respectively). Steaks removed from the longissimus muscle were aged 7 d and then frozen for future evaluation. After thawing up to 24 h at 2 to 4°C, steaks were prepared for shear force and taste panel tests. For 1970 through 1976, steaks were cooked to an internal temperature of 65°C, cooled at room temperature for 30 min, and cut into eight 1.27-cm cores. For 1986 through 1990, steaks were cooked to an internal temperature of 70°C, stored at 5°C for 24 h, and cut into six 1.27-cm cores. Shear force values (**WBSF**) were recorded with all cores sheared using an Instron 1132/Microcon II United Testing Instrument (Instron, Canton, MA) equipped with a Warner-Bratzler-type blade (Cundiff et al., 1994; Wheeler et al., 1996). Trained, eight-member, descriptive-attribute sensory panels sampled and scored 1.27-cm cubes that were prepared and cooked as for shear tests. Scores for taste panel tenderness (**TPT**), juiciness (**TPJ**), and flavor (**TPF**) recorded from taste panels at Kansas State University were based on a hedonic 9-point scale (1 = extremely tough/dry/bland, 9 = extremely tender/juicy/flavorful), and taste panels at the U.S. Meat Animal Research Center used an 8-point scale (1 = tough/dry/bland, 8 = tender/juicy/flavorful).

Statistical Analyses

The mixed linear sire model used to describe measurements on heifers for WWT, YWT, PUB, and RATE included fixed effects of age of dam (2, 3, and 4 or more yr of age), year of birth (1970 through 1976, 1986 through 1990), and line (breed composition). The models for WWT and YWT incorporated the covariate of calendar day of birth, and the models for WWT, YWT, PUB, and DIFF included the dam of the heifer as an uncorrelated random effect. Fixed effects for DIFF included sex of calf, year of calf's birth (1972 through 1978, 1988 through 1992), and line of calf. The model for DIFF also included the covariate of calf's calendar day of birth.

The mixed linear sire model used to describe measurements on steers for all traits included fixed effects of age of dam (2, 3, and 4 yr or older), year of birth (1970 through 1976, 1986 through 1990), and line. Covariates of slaughter age and age at weaning were also included, as was an uncorrelated random effect of the dam of the steer.

Estimates of heritability were obtained from single-trait analyses of sire models, and correlations were estimated from pairwise analyses. All estimates of variance components for estimates of heritabilities were obtained with a derivative-free REML algorithm. The associated standard errors were obtained through a combination of Fisher scoring and Newton-Raphson algorithms. This method uses the average information matrix to obtain standard errors of variance component estimates and their ratios (Johnson and Thompson, 1995). Variance and covariance components for estimates of genetic correlations were obtained through the use of a multiple-trait derivative-free restricted maximum likelihood (**MTDFREML**) algorithm (Boldman et al., 1995). For female growth and reproductive traits, all traits were treated as traits of the heifer. To account for the different scales of measurement for taste panel scores at the two locations, as well as for differences in variation by year and location, records for each trait were standardized by dividing the original record by the phenotypic standard deviation for that year, similar to standardization by Van Vleck et al. (1992) and Barkhouse et al. (1996).

Results and Discussion

Components of Variance and Heritability

Estimates of variance components and heritabilities for female and male traits are shown in Table 3. Because a sire model was used, estimates of ratios of sire to total variance generated through the use of the MTDFREML algorithm were multiplied by four to yield heritability estimates. Because traits were initially standardized, estimates of phenotypic variance components were multiplied by the standard deviation from a chosen "average" year (1989) to convert back to an original scale. Genetic and environmental variance components were then calculated using the

Table 3. Estimates of variance components and heritabilities for female growth and reproductive traits and male carcass traits

Trait	Phenotypic variance	Additive genetic variance	Proportion of phenotypic variance that is due to dam effects	h^2 ± SE
Female growth and reproductive traits				
Weaning weight (WWT), kg	877.7	140.4	.34 ± .02	.16 ± .04
Yearling weight (YWT), kg	1458	553.8	.29 ± .03	.38 ± .06
Age at puberty (PUB), d	867.0	407.5	.11 ± .03	.47 ± .07
Calving rate (RATE), %	.130	.012	—	.09 ± .04[a]
Calving difficulty (DIFF), %	.180	.020	.03 ± .03	.11 ± .05[a]
Male carcass traits				
Hot carcass weight (HCWT), kg	770.7	385.4	.20 ± .02	.50 ± .06
Retail product percentage (RET%)	4.69	3.10	.19 ± .02	.66 ± .07
Fat percentage (FAT%)	6.44	3.74	.18 ± .02	.58 ± .07
Bone percentage (BON%)	.577	.312	.12 ± .02	.54 ± .07
Ribeye area (REA), cm^2	.991	.605	.14 ± .02	.61 ± .06
Kidney, pelvic, and heart fat percentage (KPH)	.307	.147	.12 ± .03	.48 ± .06
Adjusted fat thickness (AFAT), cm	.037	.025	.13 ± .02	.66 ± .07
Marbling score (MARB), score	.455	.323	.14 ± .02	.71 ± .07
Warner-Bratzler shear force (WBSF), kg	1.83	.475	.05 ± .02	.26 ± .06
Taste panel tenderness (TPT), score	.678	.210	.05 ± .03	.31 ± .08
Taste panel juiciness (TPJ), score	.184	.000	.00 ± .03	.00 ± .05
Taste panel flavor (TPF), score	.094	.004	.01 ± .03	.04 ± .06

[a] Heritabilities are expressed on the binomial scale. Heritabilities transformed to the underlying normal scale for RATE and DIFF are .19 and .18, respectively.

estimated heritabilities and converted phenotypic variances.

Variance due to dam effects was important for heifer growth traits and accounted for 34 and 29% of the total phenotypic variance for WWT and YWT, respectively. These results agree with findings from previous studies (e.g., Marquez, 1994). The importance of maternal effects on weaning and yearling weights have been shown by Eler et al. (1995), Koch et al. (1974a,b, 1995), and Buchanan et al. (1982a,b), among others. Proportions of phenotypic variance due to dam effects for carcass traits ranged from 0 to 20%, with largest fractions for traits such as HCWT, RET%, and FAT%.

Estimates of heritability for female growth and reproductive traits were in general agreement with estimates from previous studies (Koots et al., 1994a). The estimate of heritability for WWT from this study was less than the average heritability estimate of .27 reported by Koots et al. (1994a), but it was well within the range of estimates (.06 to .63) reported by Mohiuddin (1993) in a comprehensive review. In his review, Mohiuddin (1993) found a wide variety of estimates of heritability for female YWT (.16 to .71), with an average estimate of .48, which is in agreement with the estimate of heritability found in this study. The estimate of heritability for PUB from this study is somewhat higher than estimates found in previous literature. Arije and Wiltbank (1971) estimated heritability of PUB in Hereford heifers to be .20, and Smith et al. (1989) reported an estimate of .10 for Hereford, Angus, and Red Angus females. Laster et al. (1979) estimated heritability of PUB to be .41 from crossbred heifers. In another review, Martin et al. (1992) reported an average heritability for age at puberty of .40, with a range of from .07 to .67.

For traits expressed on a binomial scale (RATE and DIFF), REML estimates of heritability were also transformed to the supposed underlying normal scale using the formula from Robertson (1950). Estimates of heritability for RATE and DIFF expressed on a binomial scale were .09 and .11, respectively. Previous studies indicate that RATE is lowly heritable. The estimate of heritability for calving rate from this work was .09 on the binomial scale and .19 transformed to the normal scale. Buddenberg et al. (1989) estimated heritability (adjusted to the normal scale) for calving rate to be .08 for first-calf Hereford heifers and .10 for first-calf Polled Hereford heifers. Meyer et al. (1990) reported binomial estimates of heritability of .08, .02, and .10 for Australian Hereford, Angus, and Zebu cross females, respectively. Koots et al. (1994a) reported an average heritability estimate for RATE of .09 on the normal scale for heifers. Even though heritability of RATE may be low, there seems to be enough variation in the trait to allow for possible selection.

Most previous work has shown that DIFF has a low heritability when treated as a trait of the dam, as in this study. The estimate of heritability for DIFF from this work was .11 on the binomial scale, and .18 when transformed to the normal scale. MacNeil et al.

(1984) estimated heritability of DIFF to be .22 on the normal scale, similar to the estimate of heritability from this study. Burfening et al. (1978) reported an estimate of heritability for calving difficulty of .32 from Simmental cows. In his review of previous literature, Koots et al. (1994a) reported an average heritability for DIFF in heifers of .10.

Estimates of heritability for male traits were generally in agreement with the literature. Several previous studies, however, have reported estimates of parameters from subsets of this data set, so comparisons may not be independent. The estimate of heritability for HCWT from this study agrees with those from MacNeil et al. (1984) and Koots et al. (1994a), who reported estimates of heritability of .44 and .45, respectively. Benyshek (1981) reported an estimate of heritability for HCWT of .54 from Hereford steers. Marshall (1994) found an average estimate of heritability for HCWT of .41 in a review of previous literature, with estimates ranging from .31 to .68. The estimate of heritability for retail product percentage is comparable to results from Koch et al. (1982a), who reported an average heritability estimate of .63. Koch et al. (1982a) obtained an estimate of heritability of .53 for BON% and .57 for FAT%.

Varying estimates of heritability have been previously reported for REA, ranging from .25 to .56 (Koots et al., 1994a). The estimate from this research is comparable to the estimate of .56 of Koch et al. (1982a). Benyshek (1981) estimated heritability for REA to be .45 from Hereford steers. Marshall (1994) reported an average heritability of REA to be .37, with literature estimates that ranged from .01 to .60. The estimate of heritability of AFAT obtained in this study is larger than previous estimates of heritability for actual fat thickness. Wilson et al. (1976) and Koch et al. (1982a) estimated the heritability of actual fat thickness to be .41, and Benyshek (1981) reported an estimate of .50. Koots et al. (1994a) reported an average estimate of heritability of backfat of .44, from 26 studies with animals adjusted to a constant age. Koch et al. (1982a) reported an estimate of heritability of KPH to be .82, compared with the estimate from this study of .48.

The estimate of heritability for MARB in this study is larger than most previous estimates. Koch et al. (1982a) reported an estimate of .40, and Benyshek (1981) an estimate of heritability of .56 in Hereford steers. Van Vleck et al. (1992) estimated the heritability of MARB to be .45 from *Bos taurus* and *Bos indicus* crosses. In his review, Marshall (1994) reported a range of estimates of heritability of MARB from .23 to .47, with an average estimate of .35. Tenderness, as measured by WBSF, was estimated to have a heritability of .26 in this study, a value similar to the average estimate of .29 summarized by Koots et al. (1994a) and the estimate of .31 found by Koch et al. (1982a). Marshall (1994) reported estimates of heritability of WBSF ranging from .09 to .71, with an average of .37.

The estimate of heritability for TPT from the current analyses is in general agreement with Wilson et al. (1976), who reported an estimate of heritability for this trait to be .23. Van Vleck et al. (1992) reported an estimate for this trait of .10, and Barkhouse et al. (1996) estimated a heritability of .06 from crossbred steers and heifers. Even though previous work suggests the heritability of TPJ is low to moderate, there was no evidence in this study that any of the phenotypic variation of TPJ was explained by genetic variance. Wilson et al. (1976) estimated heritability of TPJ to be .26, and Van Vleck et al. (1992) reported an estimate of .14. Flavor, the third characteristic evaluated by sensory panels for this study, is assumed to have a low heritability, based on estimates from the literature. The heritability of TPF was estimated to be .04 in this study, which is not significantly different from zero. Van Vleck et al. (1992) estimated heritability for TPF to be .03, and Wilson et al. (1976) reported an estimate of heritability for TPF of –.06, with a standard error of .06.

Genetic Correlations

Estimates of genetic correlations between carcass and reproductive traits are shown in Table 4. Estimates involving the sensory panel traits of juiciness and flavor ranged from positive to negative unity. These traits are associated with estimates of heritability not significantly different from zero and have undoubtedly high standard errors. Therefore, presentation of correlations involving TPJ and TPF have been omitted.

Genetic correlations between heifer weight traits and male carcass traits were quite variable. The largest genetic correlations reported were between heifer weights and HCWT, as expected. Marshall (1994) reported several estimates of genetic correlation between weaning weight and hot carcass weight, with values ranging from .48 to 1.11. Small to moderate positive genetic correlations were also estimated between heifer weights and REA as well as with AFAT and MARB, traits associated with carcass fatness. Lamb et al. (1990) reported genetic correlations between WWT and REA, ultrasonic backfat, and MARB of .43, .49, and .71, respectively, from data on Hereford bulls. Koch (1982a) reported small to moderate positive genetic correlations between daily gain to weaning and REA, AFAT, and MARB. These correlations indicate that heavier females have steer sibs with relatively larger amounts of lean muscle as well as fat, presumably because of their own increased size. In this study, heifer weights were also positively associated with FAT%, negatively correlated with RET%, and had little relationship with BON%. Koch et al. (1982a) reported genetic correlations between

Table 4. Estimates of genetic correlations between female reproductive and male carcass traits

	Female traits				
Male traits	Weaning weight (WWT)	Yearling weight (YWT)	Age at puberty (PUB)	Calving rate (RATE)	Calving difficulty (DIFF)
Hot carcass weight (HCWT)	.92	.88	.06	.05	–.17
Retail product percentage (RET%)	–.16	–.28	–.01	–.13	.18
Fat percentage (FAT%)	.13	.27	–.01	.18	–.23
Bone percentage (BON%)	.01	–.03	.01	–.33	.27
Ribeye area (REA)	.37	.29	.04	.15	–.04
Adjusted fat thickness (AFAT)	.30	.34	–.01	.19	–.14
Kidney, pelvic, and heart fat percentage (KPH)	–.21	–.06	–.12	–.12	–.29
Marbling score (MARB)	.21	.11	–.04	–.05	–.09
Warner-Bratzler shear force (WBSF)	.36	.09	.01	.11	.19
Taste panel tenderness (TPT)	–.30	.01	–.32	.07	–.42

gain to weaning and FAT%, RET%, and BON% of .31, –.29, and –.27, respectively. These results imply that retail product as a percentage of carcass weight would decrease and fat percentage would increase as heifer weights increase.

Some traits showed a moderate genetic correlation with WWT but not with YWT. Kidney, pelvic, and heart fat percentage and TPT were negatively correlated with WWT but had essentially no correlation with YWT. Koch et al. (1982a) reported an estimate of genetic correlation between gain to weaning and KPH of .17. Warner-Bratzler shear force showed a moderate positive genetic correlation with WWT but almost no relationship with YWT. Koch et al. (1982a) found no significant genetic correlation between gain to weaning and WBSF. Correlations of traits associated with carcass fat were generally greater with YWT than with WWT, except MARB and KPH, which tended to have a higher genetic correlation with WWT than with YWT.

Genetic correlations that involved PUB and carcass traits were essentially zero except for a moderate negative genetic correlation with TPT. MacNeil et al. (1984) estimated the genetic correlations between PUB and HCWT, retail product, and fat trim to be .17, .30, and –.29, respectively. Results from Koch et al. (1982a) also indicated that PUB was positively associated with carcass weight and retail product. However, studies by Smith et al. (1989) and Brinks (1994) have demonstrated that growth rate in females seems to be favorably correlated with age at puberty. Speer (1993) reported that female mature weight had positive genetic correlations with carcass weight, fat thickness, rib eye area, and yield grade.

Calving rate had small to moderate negative estimates of genetic correlations with RET%, BON%, and KPH. Genetic correlations between RATE and the remaining carcass traits were generally low to moderate and positive, except with HCWT, MARB, and TPT, with genetic correlations close to zero.

Genetic correlations between DIFF and carcass traits were generally low to moderate. Estimates of genetic correlations were negative between DIFF and HCWT, TPT, and measures of carcass fatness (FAT%, AFAT, and KPH), whereas estimates of genetic correlations between DIFF and RET%, BON%, and WBSF were positive. Genetic correlations between DIFF and REA and MARB were near zero.

Implications

Producers should be aware of possible antagonistic relationships between or among traits so that they may incorporate these relationships into their breeding programs. This study indicates that even though there is evidence for favorable genetic relationships between carcass traits of males and growth and reproductive traits of females, undesirable relationships may also exist. Various methods have been proposed to deal with economically important, but antagonistic, traits in beef cattle. Selection indexes that incorporate female productivity and male carcass value may be one solution. Producers also might choose to restrict change in some traits as they improve others. Specialized sire and dam lines, terminal sires used on females selected for increased reproductive efficiency, may have some merit. Progeny of females with high reproductive value may be managed after weaning to reduce fat deposition.

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