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Sex Effects on Breed of Sire Differences for Birth, Weaning, and Yearling Weights

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Sex Effects on Breed of Sire Differences for Birth, Weaning, and Yearling Weights

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ABSTRACT: Weights of males and females can be considered to be correlated traits with different averages and variances. This study attempted to determine whether defining traits as expressed in males or in females would change estimates of breed of sire differences needed to calculate across-breed factors for adjustment of within-breed EPD to across-breed EPD. Records from the US Meat Animal Research Center of progeny of Hereford, Angus, and MARC III composite dams mated to 12 sire breeds that had been used to calculate breed of sire adjustments in 1996 were used. Breeds of sire were Hereford, Angus, Shorthorn, Brahman, Simmental, Limousin, Charolais, Maine-Anjou, Gelbvieh, Pinzgauer, Tarentaise, and Salers. Female and male records for birth (BWT), weaning (WWT), and yearling (YWT) weights were considered to be separate although correlated traits. Heritability estimates for expression as females and males were as follows: .44 and .47 for BWT, .25 and .19 for WWT, and .55 and .49 for YWT. Corresponding genetic correlations between expression in males and females were .85, 1.00, and .92. Phenotypic standard deviations were slightly larger and coefficients of variation slightly smaller for males than for females; the largest differences were for YWT. Breeds ranked similarly for female and male weights; the major exception was Brahman for BWT. Averages of breed of sire contrasts for expression in females and males were almost identical to contrasts from analyses of combined male and female records. Largest differences between averaged and combined breed of sire contrasts were approximately 1 kg for BWT and WWT and approximately 2 kg for YWT. The results show that considering male and female weights as separate traits is not needed in calculation of across-breed adjustment factors from US Meat Animal Research Center records.

Key Words: Growth, Heritability, Beef Cattle, Breeds

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Introduction

Factors computed for comparing EPD of bulls of different breeds are currently based on estimates of differences due to breed of sire from crossbred calves produced at the Meat Animal Research Center (**MARC**). Those estimates of breed of sire differences are adjusted for genetic trend by comparing the breed association EPD of bulls used to produce the progeny that have records in the analyses to estimate breed of sire differences at MARC with average breed association EPD of bulls of the breed (Notter and Cundiff, 1991; Cundiff, 1994). These adjusted breed of sire estimates are then adjusted to a common base year. A final step is to make all comparisons to a base breed or composite of base breeds. The basic components of the calculations are the breed of sire solutions. In those analyses, expression of a sire's genes is assumed to be the same in his male and female progeny except for a simultaneous additive adjustment for sex, which is assumed to be the same for all breeds of sire. The goals of this study were 1) to examine whether expression of a sire's transmitting ability is the same in male and female progeny, 2) to compare breed of sire differences for males and females, and 3) to determine whether defining weight traits by sex of progeny improves across-breed adjustment factors.

Materials and Methods

Data used in the analyses were those used in 1996 to calculate across-breed adjustment factors (Van Vleck and Cundiff, 1996) to a 1994 base year with a model that considered sex of calf as a fixed factor. The records were from progeny of sires of 12 breeds mated to Hereford, Angus, and MARC III composite dams.

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Table 1. Numbers of measurements (n), means ($\bar{x}$), and raw standard deviations (SD) for males and females for birth, weaning, yearling, and maternal weaning weights

	Female			Male		
Traits	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Birth weight, kg	2,189	37.5	5.6	2,480	41.0	6.2
Weaning weight, kg	2,066	216.6	31.8	2,179	229.1	33.7
Yearling weight, kg	1,844	323.9	46.3	2,108	424.8	49.9
Maternal weaning weight, kg	3,284[a]	220.7	30.4	3,413[a]	236.2	33.5

[a]Progeny of 1,564 daughters of sires of breeds being compared.

Progeny of Hereford × Hereford and of Angus × Angus matings were not included in the analyses. All other edits were the same as in the 1996 analyses. Numbers of measurements by sex are shown in Table 1. For maternal weaning weight, breed of maternal grandsire differences were estimated from grandprogeny of bulls of the 12 breeds produced by pasture-mating their crossbred daughters to unidentified bulls of other breeds. Numbers of male and females by trait and breed of sire are given in Table 2.

Analyses were performed with the MTDFREML package (Boldman et al., 1995). The models for analyses were as in the 1996 analysis (Van Vleck and Cundiff, 1996), except that instead of a fixed factor for sex, the records were recoded as two traits (Falconer, 1952) specified by sex of calf. The random effects for the breed of sire analyses were sires within breeds (374) and dams within dam lines (2,809). Sires were assumed to be unrelated, as were dams. The models for both sexes were the same for the breed of sire analyses and included fixed effects of breed of sire (12), dam line (3), age of dam (2, 3, 4, 5 through 9, ≥10 yr), year of birth (1970–76, 1986–90, 1992–94) and a covariate for day of year of birth. Estimates of heritability were obtained for each sex by multiplying the appropriate ratio of sire to phenotypic variance by four. Genetic correlations were estimated from the sire components of variance and covariance. The proportion of variance due to dams was computed from the ratio of dam to phenotypic variance. Correlation between dam effects was estimated from the dam components of variance and covariance. The residual covariances were assumed to be zero within and across the two traits.

The model for analyses of maternal effects included fixed effects of breed of maternal grandsire (12), maternal grandam line (3), breed of natural service mating sire (14), birth year-cycle-age of dam subclass (56), and mating sire breed-cycle-age of dam subclass (29) to account for confounding of years, mating sire breed and age of dam, and covariate for calendar day of birth. Random effects were maternal grandsire (339) within-breed and daughter (1,564) within maternal grandsire. Maternal grandsires were assumed unrelated, and daughters of maternal grandsires were assumed unrelated except as paternal half-sisters. Components of variance and covariance were used to calculate correlations between sires for maternal grandsire and daughter within maternal grandsire effects. The components of variance were converted to ratios of phenotypic variance but do not relate directly to direct or maternal heritability.

At declared convergence for the covariance components, solutions for fixed effects including breeds of

Table 2. Numbers of females and males by trait for the 12 breeds of sires

	Birth weight		Weaning weight		Yearling weight		Maternal weaning weight	
Breed	Female	Male	Female	Male	Female	Male	Female	Male
Hereford	415	443	411	403	367	383	545	531
Angus	232	277	223	241	208	223	225	247
Shorthorn	82	99	74	96	72	96	132	119
Brahman	195	200	185	149	158	132	126	143
Simmental	207	215	191	177	158	174	405	391
Limousin	179	208	162	176	161	173	378	386
Charolais	241	314	220	264	190	260	399	444
Maine-Anjou	73	101	65	90	64	90	156	199
Gelbvieh	168	197	154	182	153	181	318	317
Tarentaise	91	108	86	105	85	104	163	178
Salers	94	95	90	86	89	84	166	184

Table 3. Estimates of genetic parameters for birth weight (BWT), weaning weight (WWT), and yearling weight (YWT) for expression in female and male calves

	Heritability[a]			Relative dam variance[b]			Phenotypic standard deviation, kg	
Trait	Female	Male	r_g[c]	Female	Male	r_c[d]	Female	Male
BWT	.44	.47	.85	.30	.31	.86	4.63	4.84
WWT	.25	.19	1.00	.46	.34	1.00	23.43	24.42
YWT	.55	.49	.92	.28	.25	.92	31.44	37.39

[a]Intrasire correlation times four.
[b]Intradam correlation.
[c]Genetic correlation.
[d]Correlation between dam effects in males and females.

sire (or breeds of maternal grandsire) were obtained. Convergence was declared when the variance of the –2log likelihood values in the simplex were less than .00001 and after restarting the change in –2log likelihood was less than .02. Breed solutions were differences from the Angus solutions that were constrained to zero.

Results and Discussion

Estimates of Genetic Parameters

Estimates of heritability and of the ratio of component of variance due to dam effects to phenotypic variance, and genetic correlations and correlations between expression of dam effects in males and females are shown in Table 3.

Heritability estimates and relative dam variances were similar for male and female expression. Heritability estimates were within the ranges summarized by Mohiudin (1993) and Koots et al. (1994). Genetic correlations ranged from .85 to approaching 1.00, as did the correlations between dam effects, in agreement with previous reports (Garrick et al., 1989; Rodríguez-Almeida et al., 1995). Heritability was less for weaning weight and the relative dam variance was greater than for birth weight and yearling weight. The correlation between expression of sire effects in male and female progeny approached 1.00 for weaning weight, as did the correlation between expression of dam effects in males and females.

Estimates of relative variance due to maternal grandsires and daughters within maternal grandsires are shown in Table 4. Estimates were similar for both sexes, and both correlations approached unity.

Estimates of phenotypic variance, shown as standard deviations in Tables 3 and 4, were slightly larger for males than for females, in agreement with previous reports (e.g., Rodríguez-Almeida et al., 1995).

The estimates of genetic correlations suggest that genetic expression is highly correlated between males and females. Genetic correlations were large enough to conclude that considering them as two traits is not necessary. Whether the breed effects are the same for both sexes is an additional question.

Breed of Sire and Maternal Grandsire Solutions

Solutions as differences from Angus are in Tables 5, 6, 7, and 8 for female and male expression considered as separate but correlated traits. Rankings for birth weight were similar for males and females with generally small changes in ranking. The largest change in rank was for Tarentaise, with heifer calves being smallest except for Angus but with bull calves being in the middle of the range. The most important change in rank was for Brahman crossbred calves. Although the heifer calves were second-heaviest, the bull calves were heaviest of all sire breeds with a spread of 2.85 kg to the next sire breed. The *t*-statistic for the difference in the sex-specific differences from Angus was 5.49, which suggests an important sex difference in crossbred calves sired by Brahman bulls compared with crossbred calves sired by Angus bulls. This result has possible implications for ease of calving. Breed of sire × sex of calf interactions involving Brahman and *Bos taurus* breeds have been previously reported (e.g., Gregory et al., 1979; Paschal et al., 1991), although the male difference from Angus was somewhat larger in the current analysis. Other sex × breed of sire interactions were not statistically significant.

Table 4. Estimates of parameters for genetic expression in males and females of maternal weaning weight

Item	Female	Male	Correlation[a]
Fractional variance due to			
Maternal grandsire/breed	.080	.066	1.00
Daughter/maternal grandsire	.369	.392	1.00
Phenotypic standard deviation, kg	20.66	21.99	—

[a]Correlations between effects of maternal grandsires and daughters within maternal grandsires on female and male calves.

Table 5. Breed of sire solutions as differences from Angus (DIF) with standard errors (SE) of differences by sex, averaged, and from combined analysis: birth weight (kg)

	Females		Males		Averaged[a]		Combined[b]	
Sire breed	DIF	SE	DIF	SE	DIF	SE	DIF	SE
Hereford	1.99	.50	1.92	.50	1.95	.41	1.95	.41
Angus	.00	.00	.00	.00	.00	.00	.00	.00
Shorthorn	3.15	.75	3.32	.76	3.24	.60	3.26	.60
Brahman	4.36	.60	8.19	.62	6.28	.50	6.27	.50
Simmental	3.31	.73	4.47	.73	3.89	.60	3.92	.60
Limousin	1.58	.76	2.56	.75	2.07	.62	2.08	.62
Charolais	4.01	.60	4.68	.59	4.34	.48	4.36	.48
Maine-Anjou	4.76	.90	5.34	.90	5.05	.73	5.05	.73
Gelbvieh	2.87	.69	3.07	.72	2.97	.58	2.96	.58
Pinzgauer	2.78	.71	3.16	.73	2.97	.61	2.92	.61
Tarentaise	1.14	.97	3.28	1.00	2.21	.85	2.24	.85
Salers	2.25	.72	2.85	.75	2.55	.59	2.56	.59

[a]Male and female differences from Angus weighted equally.
[b]Male and female records analyzed as a single trait with sex effect in model.

Differences from Angus ranked by sex were more variable for weaning weight, yearling weight, and maternal weaning weight than for birth weight. The rankings, however, were generally similar. Sex differences for Brahman and Tarentaise became larger for weaning than for birth weight but were not statistically significant ($P > .05$). Simmental female calves were relatively larger than male calves relative to Angus female and male calves at weaning and also at 1 yr of age.

Tables 5, 6, and 7 show the effect of age of progeny on the difference from Angus for Brahman. Under the MARC conditions, Brahman were among the heaviest, especially the males at birth and weaning, but were lightest at 1 yr of age, when the differences from Angus were essentially the same for females and males. A similar but less pronounced pattern was seen for Tarentaise calves.

Comparison of Breed of Sire Differences Averaged by Sex vs Combined

Even if the breed of sire (or maternal grandsire) differences were different for males and females, the practical importance may be less because of the lack of control of sex of calf, generally assumed to be about 50% of each. Thus, in calculation of breed adjustment factors, the likely method would be to average the breed of sire solutions for the two sexes before proceeding with other steps in the procedure. The right sides of Tables 5, 6, 7, and 8 show a comparison of breed of sire (maternal grandsire) differences from Angus with the two sexes averaged and the breed of sire differences from the 1996 analyses with both sexes combined in a model that included the fixed effects of sex of calf (Van Vleck and Cundiff, 1996). The values in the tables for the two ways of expressing

Table 6. Breed of sire solutions as differences from Angus (DIF) with standard errors (SE) of differences by sex, averaged, and from combined analysis: weaning weight (kg)

	Females		Males		Averaged[a]		Combined[b]	
Sire breed	DIF	SE	DIF	SE	DIF	SE	DIF	SE
Hereford	3.46	2.34	−1.69	2.35	.88	1.85	.79	1.85
Angus	.00	.00	.00	.00	.00	.00	.00	.00
Shorthorn	7.96	3.61	7.37	3.51	7.66	2.73	8.06	2.72
Brahman	9.08	2.82	15.76	2.98	12.42	2.28	11.88	2.27
Simmental	13.24	3.37	7.04	3.37	10.14	2.67	10.21	2.67
Limousin	4.95	3.49	4.38	3.44	4.66	2.75	4.35	2.75
Charolais	13.51	2.85	10.38	2.78	11.94	2.19	11.98	2.18
Maine-Anjou	9.13	4.18	11.14	4.10	10.14	3.24	10.02	3.24
Gelbvieh	12.26	3.19	12.08	3.26	12.17	2.56	11.92	2.56
Pinzgauer	6.71	3.17	1.85	3.20	4.28	2.62	3.79	2.62
Tarentaise	2.49	4.29	6.98	4.18	4.74	3.58	4.78	3.57
Salers	9.63	3.39	6.46	3.59	8.05	2.69	8.60	2.69

[a]Male and female differences from Angus weighted equally.
[b]Male and female records analyzed as a single trait with sex effect in model.

Table 7. Breed of sire solutions as differences from Angus (DIF) with standard errors (SE) of differences by sex, averaged, and from combined analysis: yearling weight (kg)

	Females		Males		Averaged[a]		Combined[b]	
Sire breed	DIF	SE	DIF	SE	DIF	SE	DIF	SE
Hereford	.17	3.66	−6.46	4.22	−3.15	3.25	−3.24	3.40
Angus	.00	.00	.00	.00	.00	.00	.00	.00
Shorthorn	12.48	5.55	10.00	6.10	11.25	4.68	11.91	4.91
Brahman	−12.48	4.47	−11.60	5.46	−12.04	4.08	−12.54	4.25
Simmental	17.11	5.47	6.91	5.98	12.01	4.72	11.47	4.95
Limousin	1.10	5.61	−7.67	6.17	−3.29	4.89	−5.16	5.11
Charolais	13.08	4.45	17.20	4.87	15.14	3.77	17.29	3.96
Maine-Anjou	11.34	6.54	18.12	7.24	14.73	5.64	13.08	5.92
Gelbvieh	4.33	5.03	11.90	5.82	8.12	4.51	7.77	4.72
Pinzgauer	2.26	5.46	−4.84	5.94	−1.29	4.85	−2.78	5.06
Tarentaise	−7.91	7.41	−7.69	7.95	−7.80	6.68	−6.08	6.96
Salers	11.88	5.20	7.11	6.23	9.50	4.61	10.11	4.83

[a]Male and female differences from Angus weighted equally.
[b]Male and female records analyzed as a single trait with sex effect in model.

breed of sire differences are the ones that would be adjusted for genetic trend and to a common base year. If the averaged and combined differences are the same, then the across-breed adjustment factors would be the same. The tables indicate that the two ways of obtaining breed of sire differences yielded essentially the same differences from Angus. The rankings were exactly the same except for a switch for weaning weight for Brahman and Charolais for ranks 1 and 3, for which the absolute differences are small. Actual differences from the averaged and combined methods were essentially the same for birth weight (**BWT**), weaning weight (**WWT**), and maternal weaning weight (**MWWT**). Some of the differences between the methods for yearling weight (**YWT**) were slightly larger but are generally small. The obvious conclusion is that treating the expression of weight in males and females as separate but correlated traits does not affect the across-breed adjustment factors if the male and female differences are averaged. Some caution might be required if data were used with disproportionate numbers of males and females for some breeds. In such cases, combining records might lead to misleading breed of sire differences, particularly for birth weight of Brahman-sired crossbred calves and for weaning weight for crossbred calves of other breeds.

For BWT, WWT, and YWT, comparison of age of dam solutions for the two sexes was possible. The age of dam solutions expressed as a difference from age 5

Table 8. Breed of sire solutions as differences from Angus (DIF) with standard errors (SE) of differences by sex, averaged, and from combined analysis: maternal weaning weight (kg)

	Females		Males		Averaged[a]		Combined[b]	
Sire breed	DIF	SE	DIF	SE	DIF	SE	DIF	SE
Hereford	−5.37	2.59	−3.96	2.67	−4.66	2.38	−4.49	2.48
Angus	.00	.00	.00	.00	.00	.00	.00	.00
Shorthorn	13.53	3.44	15.81	3.58	14.67	3.17	14.31	3.30
Brahman	16.78	3.47	21.33	3.52	19.05	3.12	19.11	3.24
Simmental	16.66	3.24	16.76	3.35	16.71	3.04	17.12	3.19
Limousin	−.18	3.32	−.48	3.42	−.33	3.12	−.03	3.28
Charolais	8.65	2.75	8.81	2.83	8.73	2.55	8.83	2.66
Maine-Anjou	11.89	3.88	18.27	3.99	15.08	3.64	15.21	3.81
Gelbvieh	16.09	3.04	20.69	3.15	18.39	2.84	18.12	2.98
Pinzgauer	8.62	3.33	13.14	3.41	10.88	3.09	10.81	3.26
Tarentaise	11.89	4.35	17.49	4.40	14.69	4.10	14.24	4.37
Salers	13.08	3.22	16.00	3.28	14.54	2.95	14.31	3.08

[a]Male and female differences from Angus weighted equally.
[b]Male and female records analyzed as a single trait with sex effect in model.

Table 9. Age of dam effects (kg, difference from age 5 through 9 yr) by sex of progeny

	Birth weight				Weaning weight				Yearling weight			
Age, yr	Female	Male	DIF[a]	SE[b]	Female	Male	DIF	SE	Female	Male	DIF	SE
2	−4.05	−4.63	.58	.70	−37.83	−48.08	10.27*	3.81	−31.21	−48.08	16.89*	5.75
3	−2.85	−2.42	−.44	.59	−16.47	−21.95	5.52	3.13	−11.07	−17.42	6.36	4.78
4	−.77	−.20	−.58	.45	−4.54	−6.53	2.01	2.40	−1.04	−4.99	3.93	3.60
5–9	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
≥10	−1.34	−1.70	.36	.47	−8.71	−11.52	2.83	2.41	−12.66	−14.97	2.31	3.63

[a]DIF = female − male difference.
[b]SE = standard error of DIF.
*Significantly different from zero ($P < .05$).

Table 10. Coefficients (b) and standard errors (SE) for regression (kg/d) of weights on calendar birth date by sex of calf

	Birth weight		Weaning weight		Yearling weight		Maternal weaning weight	
Sex	b	SE	b	SE	b	SE	b	SE
Female	.0633	.0068	−.0986	.0347	−.1648	.0524	−.0262	.0209
Male	.0544	.0066	−.1221	.0361	−.1125	.0570	−.1075	.0224
Contrast	.0089	.0092	.0235	.0484	−.0523	.0747	−.0813*	.0301

*Difference between regression coefficients for males and females significantly different from zero ($P < .05$).

through 9 yr group are given in Table 9. The contrasts for the female age of dam differences from age 5 through 9 yr minus the male age of dam differences from age 5 through 9 yr also are shown in Table 9. The differences in sex effects for 2-yr-old dams were significantly different ($P < .05$) for weaning weight and yearling weight. None of the other interaction contrasts was statistically significant. The first age of dam effect, however, is important because nearly all cows will have calves at that age. The results suggest that if sexes are combined for analysis, then sex by age of dam classes should be included in the model rather than separate sex and age of dam classes.

Comparisons of the effects of calendar day of birth are shown in Table 10. The individual regression coefficients were significantly different ($P < .05$) from zero for weaning and yearling weights and for males for maternal weaning weight. Only the difference in regression coefficients between females and males for maternal weaning weight was significant ($P < .05$). That result suggests for analyses with combined sexes that separate regression coefficients for females and males should be included in the model to estimate breed of maternal grandsire effects. The similarity of regressions for males for WWT and YWT suggests that the effect of calendar day of birth remains constant for males for weight from weaning to yearling ages but that the effect on females may become greater from weaning to yearling age.

Implications

Genetic correlations between the expression of a sire's genotype in male and female progeny for birth, weaning, and yearling weights are large enough (≥ .85) that expression in either males or females can be used for selection for response in the other sex. Because of some indication of reranking of breeds of sires by sex of progeny, progeny of both sexes should be represented in calculation of breed differences used for across-breed adjustment factors needed for comparison of within-breed expected progeny difference of different breeds. Across-breed adjustment factors would be improved by including sex by age of dam subclass effects in the model for weaning and yearling weights. Similarly, separate covariates for calendar birth date for progeny of each sex would improve the model for estimating breed of maternal grandsire effects for maternal weaning weight and breed of sire effects for weaning and yearling weights.

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