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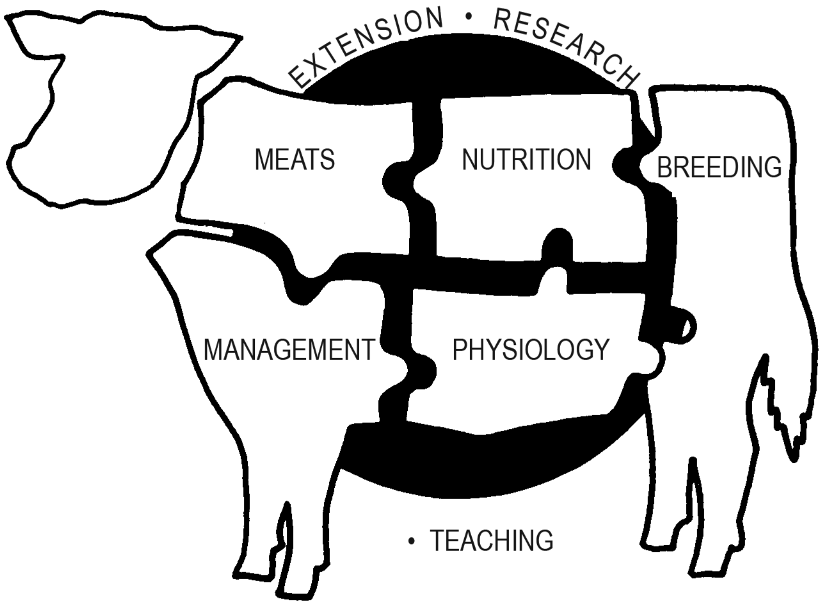

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IANR

Estimation of British- and Continental-Specific Heterosis Effects for Birth, Weaning, and Yearling Weight in Cattle

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Summary

Heterosis, assumed proportional to expected breed heterozygosity, was calculated for 6,834 individuals with birth, weaning, and yearling weight records from Cycle VII of the U.S. Meat Animal Research Center Germplasm Evaluation Program. Heterosis was further estimated by proportions of British x British (BxB), British x Continental (BxC), and Continental x Continental (CxC) crosses. Estimates of BxB, BxC, and CxC heterosis were significant for weaning and yearling weight. This study illustrated that differences among biological types exist and provide an opportunity to utilize specific breeds and exploit heterosis in a crossbreeding system to achieve production goals.

Introduction

The benefits of crossbreeding and the effects of heterosis on growth traits have been well documented. The cumulative effects of heterosis on individual and maternal traits obtained from breed crosses have been shown to be economically important (*Journal of Animal Science*, 1960, 51:1224; *Journal of Animal Science*, 1980, 51:1197). Heterosis achieved through crossbreeding can increase weaning weight per cow exposed by 20% (*Journal of Animal Science*, 1991 69:947-960). Crossing breeds that are more divergent generates increased levels of heterosis as compared to crossing breeds that are more closely related. An example of this is that cumulative effects of heterosis contributing to calf weaning weight per cow exposed may be more than twice as great for crosses of *Bos indicus* breeds with *Bos taurus* breeds than among *Bos taurus* breeds (*Texas Agriculture Experiment Station Tech*., 1964; *Journal of Animal Science*, 1975, 40:826).

However, hypothesized differences in breed-specific and biological type (British vs Continental) heterosis estimates using data where various breed crosses are true contemporaries does not exist. Specific estimates of heterosis for various crosses of breeds could be useful when selecting breeds for a crossbreeding system and developing composite populations for various production environments. Differences in estimates of heterosis based on breed composition could be useful in multibreed evaluations since heterosis and breed differences are used in models for genetic predictions. The objective of this study was to calculate direct and maternal breed and heterosis effects by breed type for birth, weaning, and yearling weight.

Procedures

Animals with birth, weaning, and yearling weight records from Cycle VII and advanced generations of the U.S. Meat Animal Research Center (USMARC) Germplasm Evaluation (GPE) program were used in this study. Purebred Angus (AN), Hereford (HH), Simmental (SM), Limousin (LM), Charolais (CH), Gelbvieh (GV), and Red Angus (AR) sires were mated by artificial insemination (AI) to composite MARC III- [1/4 AN, 1/4 HH, 1/4 Pinzgauer (PZ), 1/4 Red Poll (RP)], AN- and HH-base cows to produce progeny designated as F_1, born in 1999, 2000, and 2001. The 1999- and 2000-born male calves were castrated and fed for slaughter. Female F_1 and the 2001-born F_1 males were kept for breeding and mated in multiple-sire pastures to produce 2-, 3-, and 4-breed cross progeny designated F_1^2. The F_1^2 calves were born from 2003 to 2007 from 3-year-old and older dams. Advanced GPE records were included in the data from individuals that were of varying proportion of the seven breeds used in cycle VII. Male calves were castrated within 24 hours after birth. Calves were weaned in September at approximately 165 days of age. After weaning, steers were managed and fed for slaughter, and heifers were developed for breeding starting the following May.

Outliers were identified and removed if the record was three standard deviations away from the mean after correcting for systematic effects of breed (fitted as genetic groups), sex, age of dam, and year of birth. After outliers were removed, there were 6,804 birth weight records, 6,451 weaning weight records, and 6,293 yearling weight records. Contemporary groups were formed based on year and season of birth, location of birth, and age of dam.

Breed fractions were assigned for each individual based on pedigree information. Expected breed heterozygosity for each individual was calculated as one minus the proportion of the same breed from the sire and dam. Proportions of heterozygosity were then assigned as either British (AN, AR, HH, RP) or Continental (CH, GV, LM, SM, or PZ) to form the fixed linear covariates of British x British (BxB), Continental x Continental (CxC) or British x Continental (BxC). Angus and Red Angus were considered a single breed in developing the covariates above. The breed proportions for the MARC III composites, which are 3/4 British and 1/4 Continental, were partitioned based on expected breed contribution to all three biological type classifications (BxB, CxC, and BxC).

All traits were analyzed using ASReml (*ASReml User Guide Release 3.0*, 2009). Fixed effects included sex; breed (fitted as genetic groups),

Table 1. **Number of observations (N) and mean (SD) (lb) for birth, weaning, and yearling weight.**

Trait	N	Mean (SD), lb
Birth weight	6,804	88.6 (13.0)
Weaning weight	6,451	540.1 (77.8)
Yearling weight	6,293	940.3 (146.4)

Table 2. **Variance component and parameter estimates (SE) for birth weight (BWT), weaning weight (WT205D), and yearling weight (WT365D).**

Parameter[1]	BWT[2]	WT205D	WT365D
Variance Component[3]			
V_p	122.5 (2.2)	2864.4 (61.0)	7321.2 (153.4)
V_a	51.9 (5.8)	625.8 (101.9)	2819.8 (395.1)
$Cov_{a,m}$	2.3 (3.0)	-184.7 (88.7)	-393.8 (233.4)
V_m	5.6 (3.5)	475.3 (140.9)	377.4 (263.9)
V_{pe}	2.3 (2.5)	682.4 (99.1)	771.9 (185.8)
V_e	57.6 (3.7)	1264.1 (68.9)	3745.8 (252.6)
Heritabilities			
h^2_a	0.42 (0.04)	0.22 (0.03)	0.39 (0.05)
h^2_m	0.05 (0.03)	0.17 (0.05)	0.05 (0.04)
c^2	0.04 (0.02)	0.24 (0.03)	0.11 (0.03)

[1]V_p = phenotypic variance, V_a = direct genetic variance, $Cov_{a,m}$ = direct by maternal covariance, V_m = maternal genetic variance, V_{pe} = permanent environmental variance, V_e = residual variance, h^2_a = direct heritability, h^2_m = maternal heritability, c^2 = proportion of phenotypic variance due to permanent environmental effects.
[2]BWT=birth weight, WT205D= weaning weight, WT365D= yearling weight.
[3]units = lb^2.

Table 3. **Estimates of breed-specific heterosis (SE) and differences among heterosis (SE) of breed groups (British x British, British x Continental and Continental x Continental) for birth, weaning, and yearling weight.**

Covariate[1]	BWT, lb[2]	WT205D, lb	WT365D, lb
BxB	1.02 (0.82)	14.17 (3.98)	38.78 (6.74)
BxC	1.65 (0.70)	19.06 (3.39)	30.61 (5.81)
CxC	1.61 (1.19)	12.95 (5.66)	20.11 (9.57)
Contrast[1]			
BxB - CxC	-0.55 (1.34)	1.25 (6.57)	18.74 (11.02)
BxC - CxC	0.04 (1.10)	6.13 (5.31)	10.58 (9.04)
BxC - BxB	0.57 (0.84)	4.89 (3.97)	-8.16 (6.83)

[1]B = British, C = Continental.
[2]BWT = birth weight, WT205D = weaning weight, WT365D = yearling weight.

covariates of expected breed heterozygosity from British x British, Continental x Continental, and British x Continental from the cross; contemporary group (birth year and season, birth location and age of dam), and maternal heterosis. Random effects included direct and maternal additive genetic effects, maternal permanent environmental effect, and a residual. Contrasts among heterosis of breed groups were obtained after adding overall direct heterosis as a fixed effect to the model described above.

Results

Means and SD for growth traits are reported in Table 1. Variance components and parameter estimates are presented in Table 2. The direct heritability estimates (SE) of birth, weaning, and yearling weight were 0.42 (0.04), 0.22 (0.03), and 0.39 (0.05), respectively. Maternal heritability estimates were 0.05 (0.03), 0.17 (0.05), and 0.05 (0.04) for birth, weaning, and yearling weight, respectively. Sex had a significant effect on all traits ($P < 0.001$). As expected, heifers were lighter at birth, weaning, and yearling ages and steers were intermediate to bulls and heifers at weaning and yearling ages.

The heterosis estimates for British x British and Continental x Continental proportions were not significantly different from zero for birth weight. The British x Continental proportions were significant for birth weight. The British x British, British x Continental, and Continental x Continental heterosis covariates were significant for weaning and yearling weight. Heterosis estimates were lower than expected based on previous heterosis studies (*Journal of Animal Science*, 1991, 69:3202) (Table 3).

Contrasts among the estimates of British x British, British x Continental, and Continental x Continental are presented in Table 3. Heterosis due to British x British and Continental x Continental differed by 18.74 (11.02) lb of yearling weight ($P < 0.01$). The same contrast for birth and weaning weight were not different from zero. British x Continental and British x British heterosis differed by -8.16 (6.83) lb of yearling weight ($P < 0.01$). However, British x Continental and British x British heterosis differed by 4.89 (3.97) lb of weaning weight ($P < 0.05$).

Differences between breeds and biological type exist and provide an opportunity to utilize specific breeds and exploit heterosis in a crossbreeding system to achieve production goals in various environments. Growth traits provide a valuable starting point in estimating breed-specific heterosis because of the availability of the data and the traits are moderately heritable. Further investigation of specific heterosis by breeds will provide useful estimates for the comparison and estimation of breeding values for various crosses.

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