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Genetic Parameter Estimates for Calving Difficulty and Birth Weight in a Multi-breed Population

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ABSTRACT: Birth weight (BWT) and calving difficulty (CD) were recorded on 4,580 first parity females from the Germplasm Evaluation (GPE) program at the U.S. Meat Animal Research Center. Both traits were analyzed using a bivariate animal model with direct and maternal effects. Genetic groups for breed of AI sire were fitted to estimate breed differences. *Bos Indicus* influenced breeds tended to have the largest BWT. Heritability estimates for BWT direct, CD direct, BWT maternal and CD maternal were 0.45 (0.09), 0.40 (0.09), 0.18 (0.08), and 0.18 (0.08), respectively. Genetic correlation estimates were positive between direct BWT and CD direct at 0.82 (0.10). All other genetic correlations were not significant.
Keywords: beef; calving difficulty; breed effects

Introduction

Calving Difficulty (Dystocia) is a significant cost to beef production and is more prevalent in first-calf heifers. Dystocia increases the likelihood of calf and dam mortality, increases the postpartum interval, and increases labor and veterinarian costs (Bennett and Gregory, 2001). Calving difficulty is affected by both direct (calf) and maternal (dam) genotypes. Factors affecting calving difficulty include age of dam, sex of calf, shape and weight of calf, gestation length, breed, sire of calf, pelvic area of dam, and weight of dam (Brinks et al., 1973). Calving difficulty has been shown to have a high and positive correlation with birth weight thus the selection against birth weight can be used to reduce calving difficulty (Bennett and Gregory, 2001). However, using bulls with low BWT genetic predictions (EBV) is often associated with decreased growth. Calving difficulty EBV predicts the ability of calves to be born unassisted and typically includes BWT as an indicator trait.

Different breeds allow for the exploitation of heterosis and complementarity to match genetic potential with markets, feed resources, and climates (Cundiff et al., 1998). However, in the current U.S. beef industry, it is generally not possible to directly compare the EBV of animals across breeds without the aid of adjustment factors. Across-breed adjustment factors have been estimated by Kuehn and Thallman (2013) for birth weight and several growth and carcass traits. Unfortunately, across-breed adjustment factors do not exist for CD.

Consequently, the objectives of this study were to estimate genetic parameters and breed differences for calving difficulty and birth weight as a first step towards the development of across-breed adjustment factors for CD.

Materials and Methods

Animals. Pedigree and performance data used in this study originated from the Germplasm Evaluation (GPE) program at the U.S. Meat Animal Research Center (USMARC). The breeds utilized and the mating procedures used for each of the eight cycles were reported by Smith et al. (1976; Cycle I), Gregory et al. (1978; Cycle II), Arango et al. (2002; Cycle III), Cundiff et al. (1998; Cycle IV), Wheeler et al (2001; Cycle V), Wheeler et al. (2004; Cycle VI), Cushman et al. (2007; Cycle VII) and Wheeler et al. (2010; Cycle VIII). Data from continuous evaluation of eight breeds in GPE were also included (Kuehn et al., 2008).

Data. Data were recorded for CD and BWT on 5,795 calves born to first parity females. Animals were removed from the dataset if they were born with an abnormal presentation (e.g., breach), presented with cryptorchidism, born to a founder female, or a twin. Only animals born after 1970 (spring born) or after 2007 (fall born) were retained for analysis. After edits there were a total of 4,580 records. Cows were monitored closely for calving difficulty and were assigned a calving difficulty score as outlined in Table 1. Birth weights were recorded within the first twenty-four hours of calving.

Table 1. Description of calving difficulty scores[§]

Score	Difficulty Level
1	No assistance given
2	Little difficulty, assisted by hand
3	Little difficulty, assisted by calf jack
4	Slight difficulty, assisted by calf jack
5	Moderate difficulty, assisted by calf jack
6	Major difficulty, assisted by calf jack
7	Caesarean Birth
8[a]	Malpresentation

[§]Records with scores of 8 were removed from the analysis.

Statistical analysis. A bivariate linear-linear animal model was fitted with breed effects represented as genetic groups (Arnold et al., 1992). All industry artificial insemination (AI) sires were assigned a genetic group according to their breed of origin. Dams mated to AI sires and natural service sires mated to F_1 females were also assigned to different genetic groups (i.e., Hereford dams were assigned to different genetic groups than Hereford AI sires. Herefords from selection lines (Koch et al., 1994) were also assigned their own genetic groups. Most dams were Angus, Hereford and MARC III (¼ Angus, ¼

Hereford, ¼ Pinzgauer, ¼ Red Poll) composite lines through Cycle VII. Only sires with an EBV for the trait of interest were included in the analysis.

Systematic effects fitted in the model included sex, breed (fitted as genetic group), contemporary group (concatenation of year and season of birth and location of birth at USMARC), and a covariate for direct heterosis. Random effects included animal, maternal effect, and a residual. The covariate for heterosis was calculated as expected breed heterozygosity. For heterosis calculation sire and dam breeds were considered the same, Red Angus was assumed the same as Angus, and composite breeds were considered according to their nominal breed composition.

Variance components and fixed effects were estimated using ASReml version 3.0 (Gilmour et al., 2009). Breed differences were adjusted to current (2011) breed breeding value levels by accounting for the weighted (using average relationship to phenotyped progeny) average EBV of AI sires that had descendants, with records, deviated from the mean EBV of their breed for calves born in 2011. Calving difficulty scores were scaled by a factor of 10 for analysis to reduce numerical problems.

Results and Discussion

Genetic parameters. Estimates of direct and maternal heritability for BWT and CD and their correlations are presented in Table 2. Mujibi and Crews (2009) reported similar direct and maternal heritability estimates for BWT and Bennett and Gregory (2001) reported similar direct heritability for CD and a slightly higher maternal heritability for CD in 2-yr old females. Variance estimates for BWT and CD are reported in Table 3. Direct and maternal variances and correlations between direct and maternal for BWT are similar to those obtained by Mujibi and Crews (2009). Bennett and Gregory (2001) reported smaller direct and maternal estimates of variance for CD but similar correlations. The positive correlation between BWT direct and CD direct and between BWT maternal and CD maternal suggest that as birth weight increases calving difficulty score also increases. The other correlations were generally small and non-significant, implying selection pressure across trait complexes (direct vs. maternal) may not result in large correlated responses.

Breed effects for birth weight. Breed effects for BWT are presented in Table 4. For the most part, these breed differences were similar to those presented in Kuehn and Thallman (2013). The main exception was that Brangus, Salers, Maine-Anjou, and Tarentaise are all predicted to have lower birth weights (4-6 kg) relative to those reported in Kuehn and Thallman (2013). There are several likely reasons for this discrepancy. Kuehn and Thallman (2013) used cow data as well as the heifer data used in this study for a total of over 30,000 birth weight records. The standard error reported there were smaller and the means more likely to be accurate. The breeds with the largest changes between the studies had over half of their data coming from continuous GPE where heifers were bred back to their breed of sire via artificial insemination. Thus direct and maternal breed effects were partially confounded.

Table 2. Estimates of direct and maternal heritability and genetic correlations (SE) for birth weight (BWT) and calving difficulty(CD)

Trait §¥	BWT_d, kg	CD_d	BWT_m, kg	CD_m
BWT_d, kg²	0.45 (0.09)			
CD_d	0.82 (0.10)	0.40 (0.09)		
BWT_m, kg²	-0.27 (0.21)	0.09 (0.25)	0.18 (0.08)	
CD_m	-0.09 (0.25)	-0.05 (0.27)	-0.06 (0.32)	0.18 (0.08)

§Birth weight direct (BWT_d), calving difficulty direct (CD_d), birth weight maternal (BWT_m), and calving difficulty maternal (CD_m).
CE 1 = unassisted, 2 = little difficulty hand assistance , 3 = little difficulty use of calf jack, 4 = slight difficulty, 5= moderate difficulty, 6= major difficulty, and 7= caesarean.
¥Heritabilities and their standard error are on the diagonal and genetic correlations are on the off diagonal.

Table 3. Estimated direct and maternal (co)variance components (SE) for birth weight(BWT) and calving difficulty (CD).

Trait § ¥	BWT_d, kg	CD_d	BWT_m, kg	CD_m
BWT_d, kg²	8.94 (1.77)			
CD_d	2.03 (0.22)	0.69 (0.16)		
BWT_m kg²	-1.56 (1.53)	0.14 (0.30)	3.38 (1.67)	
CD_m	-0.15 (0.30)	-0.02 (0.13)	-0.07 (0.33)	0.32 (0.14)

§Birth weight direct (BWT_d), calving difficulty direct (CD_d), birth weight maternal (BWT_m), and calving difficulty maternal (CD_m).
CE 1 = unassisted, 2 = little difficulty hand assistance , 3 = little difficulty use of calf jack, 4 = slight difficulty, 5= moderate difficulty, 6= major difficulty, and 7= caesarean.
¥Heritabilities and their standard errors are on the diagonal and genetic correlations are on the off diagonal.

Breed effects for calving difficulty. An underlying issue relative to the development of across-breed EBV for CD direct and maternal is correctly accommodating the differences in models used by various beef breed associations in the estimation of EBV for these traits. All breeds use a multi-trait model fitting BWT, but some use a linear-linear model while others use a threshold-linear model. Even within these two broad categories of model specification other differences exist. Some breeds combine categories, thus shrinking the number of potential scores on a linear scale. For breeds that utilize a probit function treating CD as a threshold character, the point at which CD is centered on the underlying scale differs. Also, the mean incidence of difficulty (e.g., 50%, 80%, etc.) at which the back-transformed EBV is calculated from the underlying EBV can be different. To correctly estimate breed differences towards the development of adjustment factors for breeders to use when comparing animals of different breeds for CD direct and maternal this larger issue of scaling must be addressed. Differences due to sire sampling undoubtedly impact these estimates. For breeds where sampled sires' EBV deviate from their breed's mean, EBV of calves born in a reference year (e.g. 2011), estimates should be adjusted for the sampling bias. However, this requires rescaling. Furthermore, sires that were born several decades ago may have had CD recorded in some breeds, but not in others. Genetic trend will be underestimated in breeds which began recording CD more recently and the disparity in data between breeds could bias estimates of breed differences.

Table 4. Direct breed effects for birth weight (BWT; kg) from progeny of first parity heifers only

Breed	BWT§
Angus	2.13 ± 1.18
Hereford	3.62 ± 1.32
Red Angus	0.19 ± 1.68
Shorthorn	6.90 ± 1.96
South Devon	3.74 ± 2.08
Beefmaster	2.80 ± 3.26
Brahman	9.22 ± 2.62
Brangus	-0.99 ± 4.17
Santa Gertrudis	7.85 ± 2.46
Braunvieh	5.68 ± 2.28
Charolais	5.65 ± 1.27
Chiangus	2.78 ± 2.49
Gelbvieh	0.49 ± 1.67
Limousin	4.17 ± 1.20
Maine-Anjou	-1.60 ± 2.50
Salers	-3.48 ± 2.11
Simmental	4.14 ± 1.36
Tarentaise	-1.75 ± 2.89

§BWT breeding values are adjusted for EBV of sampled sires deviated from the mean EBV of all calves born in 2011 that were recorded by the respective breed association.

Implementation of existing across-breed EBV has been through a table of additive adjustment factors. The scaling differences between breeds makes this approach problematic for CD. An updated delivery model (perhaps web-based) would be required to effectively implement across-breed EBV for CD. It would also allow substantial improvements to the system for other traits.

Conclusions

Both BWT and CD are moderately heritable allowing for genetic selection to improve calving difficulty. Results show that the diverse biological types of cattle have different effects on both BWT and CD. These differences can be used to match breeds to complement needs of production systems. This work will serve as the foundation for the estimation of across-breed EBV for calving difficulty in the U.S.

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