INTERPRETIVE SUMMARY

Multiparity Evaluation for Calving Ease and Stillbirth. *By Wiggans et al., page 000.* Calving ease and stillbirth data were analyzed separately with first and later parities considered to be correlated by about 0.80. Multiparity evaluations were calculated for each trait along with an approximate reliability. Later-parity evaluations were most similar to January 2008 USDA across-parity evaluations, which reflects that later parities were 64% of the data. First-parity reliabilities for calving ease and first-and later-parity reliabilities for stillbirth were lower than January 2008 reliabilities. Implementation of separate evaluations by parity is planned for 2008.

MULTIPARITY CALVING TRAIT EVALUATION

Multiparity Evaluation of Calving Ease and Stillbirth with Separate Genetic Effects by Parity

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ABSTRACT

Evaluations that analyze first and later parities as correlated traits were developed separately for calving ease (CE) from over 15 million calving records of Holsteins, Brown Swiss, and Holstein-Brown Swiss crossbreds and for stillbirth (SB) from 7.4 million of the Holstein CE records. Calving ease was measured on a scale of 1 (no difficulty) to 5 (difficult birth); SB status was designated as live or dead within 48 hr. Scores for CE and SB were transformed separately for each trait by parity (first or later) and calf gender (male or female) and converted to a unit standard deviation scale. For variance component estimation, Holstein data were selected for the 2,968 bulls with the most records as sire or maternal grandsire (MGS). Six samples were selected by herd; samples ranged in size from 97,756 to 146,138 records. A multiparity sire-MGS model was used to calculate evaluations separately for CE and for SB with first and later parities as correlated traits. Fixed effects were year-season, calf gender, and sire and MGS birth years; random effects were herd-year interaction, sire, and MGS. For later parities, gender effects were separated by parity. The genetic correlation between first and later parities was 0.79 for sire and 0.81 for MGS for CE, and 0.83 for sire and 0.74 for MGS for SB. For national CE evaluations, which also include Brown Swiss, a fixed effect for breed was added to the model. Correlations between solutions on the underlying scale from January 2008 USDA CE evaluation with those from the multiparity analysis for CE were 0.89 and 0.91 for first- and later-parity sire effects and 0.71 and 0.88 for first- and later-parity MGS effects; the larger value for later parity reflects that later parities were 64% of the data. Corresponding correlations for SB were 0.81 and 0.82 for first- and later-parity sire effects and 0.46 and 0.83 for first- and later-parity MGS effects. Correlations were higher when only bulls with a multiparity reliability of >65% were included. The multiparity analysis accounted for genetic differences in calving performance between first

and later parities. Evaluations should become more stable as the portion of a bull's observations from different parities changes over his lifetime. Accuracy of the net merit index can be improved by adjusting weights to use evaluations for separate parities optimally.

(**Key words:** calving traits, dystocia, stillbirth)

INTRODUCTION

Calving traits affect the profitability of dairy production. Calving difficulty can reduce the productive life of the cow and decrease the survivability of the calf. Stillbirth (**SB**) reduces the size of the calf crop. Those traits are included in the net merit index (VanRaden, P.M., and Multi-State Project S-1008, 2006) to reflect their impact on profitability.

In the United States, calving traits currently are evaluated as single traits across parity. Genetic evaluations for calving ease (**CE**) have been computed since 1977 (Berger, 1994; Van Tassell et al., 2003); national CE evaluations have been available for Holsteins since 1980 (Berger, 1994) and for Brown Swiss since 2005 (Cole et al., 2005). A sire-maternal grandsire (**MGS**) threshold model in which calvings for all parities were considered to be the same trait was introduced for CE in 2003 (Van Tassell et al., 2003; Wiggans et al., 2003). The same model is used for Holstein SB evaluations, which began in 2006 (Cole et al., 2007a, 2007b).

Evaluations may be improved when calving traits are considered to be separate traits by parity (Klassen et al, 1990; Wiggans et al., 2006). The purpose of this study was to determine the genetic correlation between first and later parities for sire and MGS effects for CE and SB and to develop an evaluation system if correlations between parities showed that first and later parities are biologically distinct traits.

53 **MATERIALS AND METHODS**

54 ***Data***

55 Calving ease scores were from 15,137,220 Holstein, 36,151 Brown Swiss, and 14,743
56 crossbred calving records that were included in January 2008 USDA evaluations. The scores
57 were reported on a 1 (no difficulty) to 5 (difficult birth) scale (Van Tassel et al., 2003). Of the
58 Holstein CE records, 7,370,423 had SB scores recorded as 1 (live) or 2 (dead within 48 h of
59 birth); number of SB records available for Brown Swiss and crossbreds were insufficient for
60 analysis (Cole et al., 2007a). First-parity records comprised 36% of the data for both CE and SB.
61 Numbers of records are in Table 1 by original trait score, parity, calf gender, and breed.

62 With a threshold model, thresholds are estimated from the data and usually change the
63 distance between scores. The CE and SB scores were transformed to a standard normal deviate
64 across breeds within first or later parity and calf gender as described by Wiggans et al. (2006) to
65 enable a linear model to approximate results from a threshold model. Each CE and SB score was
66 set to the middle of the range between scores, and a constant for each trait was added to each
67 score to make them all positive (Table 2). For both traits, the transformed score for a first-parity
68 male birth with a score of 1 was 0.01.

69 ***Model***

70 A sire-MGS model was used to calculate evaluations separately for CE and SB with effects
71 for first and later parities included as correlated traits. Fixed effects included year-season of
72 calving (2 per year starting in April and October), calf gender, and sire and MGS birth years. For
73 later parities, the effect for calf gender was divided by parity: parity 2 and parity ≥ 3. For CE, a
74 breed effect was included (Holstein, Brown Swiss, and Brown Swiss × Holstein F_1 crossbreds).

Random effects were herd-year, sire, MGS, and residual. Birth year effects were included to capture trend in maternal granddams because the relationship matrix included only sire and MGS.

For variance component estimation, Holstein data were selected for the 2,968 bulls with the most calving records as either a sire or MGS. Six samples were selected by herd and ranged in size from 97,756 to 146,138 records. The program AIREMLF90 (Misztal et al., 2002) was used for variance component estimation. For both CE and SB, heritabilities for sire and MGS effects were estimated, and variance components were chosen from the sample that included estimates closest to the median.

The selected set of (co)variances was applied to calculate evaluations from all the data, including Brown Swiss and crossbred records. The same pedigree file for 145,208 bulls was used separately for CE and SB in the program BLUP90IOD2 (Misztal et al., 2002). Of those bulls, 49,230 were enrolled in genetic programs of the National Association of Animal Breeders (Columbia, MO), and 955 were Brown Swiss. Reliabilities were calculated with the program ACCF90 (Strabel et al., 2001) as modified for sire-MGS models (Wiggans et al., 2008). Results on the underlying scale were compared with January 2008 results from the current threshold model (Cole et al., 2005; Van Tassell et al., 2003).

RESULTS AND DISCUSSION

Genetic correlations (Table 3) of around 0.80 (0.79, CE sire; 0.81, CE MGS; 0.83, SB sire; and 0.74 for SB MGS) indicate the potential benefit of considering first- and later-parity calvings as separate traits. Previous estimates of genetic correlations in dairy cattle for first- and later-parity calvings ranged from 0.52 to 0.63 for CE sire effects and from 0.74 to 0.90 for CE

97 maternal effects (Jamrozik et al., 2005; Boelling et al., 2007); SB correlation estimates ranged
98 from 0.38 to 0.62 for sire effects and from 0.31 to 0.60 for maternal effects (Jamrozik et al.,
99 2005; Boelling et al., 2007). Some studies with dual-purpose and beef cattle (Carnier et al, 2000;
100 Lee, 2002; Degano and Vicario, 2007) have reported higher genetic correlations for CE, with
101 some estimates that were nearly 1. Differences between dairy and beef cattle may reflect
102 differences in population selection and management. Although this study's correlation estimates
103 for CE and SB were higher than literature estimates for dairy cattle, they were still low enough to
104 warrant evaluation of first and later parities as separate traits. The literature had indicated that
105 maternal CE and SB should have first and later parities considered to be separate traits, and
106 results of this study validated that conclusion with large data sets.

107 Table 4 shows heritability estimates and ranges for sire and MGS effects. The heritability
108 estimates in the table are from the SB or CE sample that had the most estimates nearest the
109 sample median. In most cases, the heritability estimate from that sample was nearest the median
110 of the 6 samples. The MGS effect included both direct and maternal effects and, therefore,
111 cannot be compared directly with purely maternal effects. Heritability estimates for CE were
112 lower for later parities (0.03 for both sire and MGS effects) than for first parity (0.06 for sire
113 effect; 0.08 for MGS effect); later-parity estimates for SB heritability also were lower (<1% for
114 both sire and MGS effects) than for first parity (0.04 for sire effect; 0.07 for MGS effect).
115 Ranges were generally small, which indicated good agreement among samples. Previous
116 estimates of heritability for first-parity CE ranged from 0.04 to 0.18 for sire effects (Cue et al.,
117 1990; Groen et al., 1999; Jamrozik et al., 2005; Boelling et al., 2007) and from 0.05 to 0.14 for
118 maternal effects (Cue and Hayes, 1985; Groen et al., 1999; Jamrozik et al., 2005; Boelling et al.,
119 2007); later-parity heritabilities were more uniform and ranged from 0.02 to 0.08 for sire effects

(Cue et al., 1990; Jamrozik et al., 2005; Boelling et al., 2007) and from 0.01 to 0.06 for maternal effects (Cue et al., 1990; Groen et al., 1999; Jamrozik et al., 2005; Boelling et al., 2007). Previous SB studies (Jamrozik et al., 2005; Boelling et al., 2007) reported heritability estimates for sire effect from 0.02 to 0.04 for first parity and 0.01 for later parities; maternal SB estimates were 0.04 for first parity and ranged from 0.01 to 0.02 for later parities. For Danish first-parity Holsteins, Hansen et al. (2004) reported SB heritability estimates of 0.05 for sire effects and 0.06 for maternal effects from a linear model. The extremely low heritabilities for later-parity SB effects resulted from genetic variances that were 15 to 20 times smaller for later parities than for first.

Correlations between January 2008 evaluations from the USDA across-parity threshold model and multiparity linear model evaluations (Table 5) show that later-parity evaluations (correlations of 0.91, CE sire; 0.88, CE MGS; 0.83, SB sire; and 0.83, SB MGS) are more similar to January 2008 across-parity evaluations than are first-parity evaluations (correlations of 0.89, CE sire; 0.71, CE MGS; 0.81, SB sire; and 0.46 SB MGS). That result is expected because of the preponderance (65%) of later-parity records.

Corresponding correlations for bulls with an evaluation reliability of >65% under the multiparity model (Table 5) were higher than for all bulls but generally support the same conclusions. Correlations between January 2008 across-parity and linear model evaluations for later-parity effects were 0.87 to 0.95 for bulls with a reliability of >65%, which indicates that large evaluation changes would not be expected; first-parity correlations were slightly lower (0.75 to 0.91). Because calving difficulties are greatest for first parity, first-parity evaluations will be reported to the International Bull Evaluation Service (Uppsala, Sweden). The first-parity evaluations will be affected by later-parity observations through the correlations (Table 3).

143 Evaluations for both first and later parities will be provided to bull owners and will be used in the
144 net merit index. If the first-parity evaluation is the primary evaluation reported to producers,
145 much of the change that they notice will result from excluding later-parity data. Because the
146 linear model generates evaluations with the same interpretation as those from the threshold
147 model, released evaluations will be converted to a probability scale as is currently done for
148 USDA evaluations for calving traits (Wiggans et al., 2006).

149 Table 6 compares mean January 2008 bull reliabilities from the current threshold model with
150 those from the multiparity linear model. Threshold reliabilities were calculated using only the
151 diagonal of the coefficient matrix and probably are overestimates. The multiparity model
152 provides reliabilities that are highly correlated with the true values from inversion of the
153 coefficient matrix (Wiggans et al., 2008), which makes them more accurate than those from the
154 threshold model. For CE, later-parity reliabilities were similar to those for January 2008
155 evaluations, and first-parity reliabilities were lower because of prediction with different
156 heritabilities and fewer records. For SB, both first- and later-parity reliabilities were lower than
157 January 2008 reliabilities because of heritability differences from across-parity heritability. The
158 later-parity reliabilities are low because of the extremely low heritability estimate for later-parity
159 SB, which increases the number of records needed to achieve a given reliability. Comparison of
160 reliabilities by birth year (not shown) showed the same trend for the threshold and 2 linear model
161 reliabilities.

162 More comprehensive models were investigated: an animal model and including SB and CE
163 in the same analysis. A single analysis was attractive because correlations of SB with CE would
164 partially compensate for missing SB data, particularly for historical data. Problems in estimation
165 of reasonable variance components led to retaining a sire-MGS model and not combining CE and

SB in a single analysis. For current bulls, SB data generally are available; therefore, separate analysis by trait would not sacrifice much accuracy.

A Bayesian analysis using a multitrait threshold model and Gibbs samplings (Sorensen et al., 1995) also was examined. Convergence was extremely slow (>7 d for the national data set) and is not currently a feasible alternative for use in routine evaluation of CE and SB.

CONCLUSIONS

Estimation of separate evaluations for calving traits by parity should increase evaluation accuracy because the genetic correlation between parities is <1. The separate effects should be more stable over time as the proportion of parities included in a bull's evaluation changes. Separate evaluations by parity should be particularly beneficial in assessing progeny-test bulls because later-parity calving traits would be specifically represented by parent information and first-parity information regressed by the correlation of <1. Differing economic impact of calving traits by parity can be accommodated in the net merit index.

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Table 1. Numbers of calving ease and stillbirth records by trait score, breed, parity, and calf gender

Trait	Original trait score	Holstein				Brown Swiss				Holstein × Brown Swiss			
		First parity		Later parities		First parity		Later parities		First parity		Later parities	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Calving ease	1	1,313,109	1,595,543	4,782,528	4,716,007	3,245	4,219	11,887	12,194	536	630	5,914	4,810
	2	268,129	211,643	500,744	335,626	459	315	861	594	116	91	797	420
	3	256,196	157,441	332,746	187,112	369	209	578	300	100	42	497	206
	4	106,157	48,935	108,524	48,305	133	61	205	99	49	21	188	78
	5	56,204	22,596	62,978	26.697	115	32	194	82	28	11	141	68
Stillbirth[1]	1	856,987	884,874	2,673,507	2,450,701	—	—	—	—	—	—	—	—
	2	125,599	98,193	125,588	125,588	—	—	—	—	—	—	—	—

[1]Insufficient Brown Swiss and crossbred records available for analysis.

Table 2. Transformed scores for calving ease and stillbirth by parity and calf gender

Trait	Original trait score	First parity		Later parities	
		Male	Female	Male	Female
Calving ease	1	0.01	0.18	0.27	0.34
	2	1.02	1.40	1.62	1.90
	3	1.48	1.87	2.04	2.33
	4	2.04	2.44	2.53	2.83
	5	2.66	3.01	3.03	3.29
Stillbirth	1	0.01	0.05	0.10	0.11
	2	1.71	1.84	2.11	2.16

Table 3. Genetic correlations between first- and later-parity sire and maternal grandsire (MGS) effects for calving ease and stillbirth

			Sire		MGS	
Trait	Effect	Parity	First	Later	First	Later
Calving ease	Sire	First	1.00	0.79	0.47	0.51
		Later		1.00	0.57	0.75
	MGS	First			1.00	0.81
		Later				1.00
Stillbirth	Sire	First	1.00	0.83	0.07	−0.20
		Later		1.00	0.34	0.13
	MGS	First			1.00	0.74
		Later				1.00

Table 4. Heritabilities of sire and maternal grandsire[1] (MGS) effects for first and later parities by calving trait

		First parity			Later parities		
Calving trait	Effect	Estimate	Median	Range	Estimate	Median	Range
Calving ease	Sire	0.060	0.056	0.034	0.033	0.0311	0.0152
	MGS	0.078	0.079	0.034	0.030	0.0264	0.0135
Stillbirth	Sire	0.038	0.022	0.261	0.004	0.0046	0.0002
	MGS	0.069	0.064	0.009	0.006	0.0062	0.0007

[1]The MGS effect includes both maternal and direct components and is not a true heritability.

Table 5. Correlations between evaluations from a multiparity linear model and from the 2008 USDA across-parity threshold model for calving ease and stillbirth by calving trait, model effect, parity, and reliability from the multiparity model

Calving trait	Effect	Parity	Reliability (%)	Bulls (no.)	Correlation
Calving ease	Sire	1	All	49,230	0.89
			>65	4,300	0.91
		≥2	All	49,230	0.91
			>65	19,634	0.95
	MGS[1]	1	All	49,230	0.71
			>65	8,121	0.79
		≥2	All	49,230	0.88
			>65	13,416	0.91
Stillbirth	Sire	1	All	48,275	0.81
			>65	1,929	0.88
		≥2	All	48,275	0.83
			>65	1,755	0.93
	MGS	1	All	48,275	0.46
			>65	2,484	0.75
		≥2	All	48,275	0.83
			>65	1,461	0.87

[1]Maternal grandsire.

Table 6. Mean reliability by parity for sire and maternal grandsire (MGS) effects and for January 2008 USDA evaluations for calving ease and stillbirth

Trait	Effect	January 2008 USDA evaluations	Parity	
			First	Later
Calving ease	Sire	0.63	0.50	0.60
	MGS	0.58	0.53	0.58
Stillbirth	Sire	0.45	0.39	0.40
	MGS	0.46	0.42	0.38