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Short communication: Genetic evaluation of mobility for Brown Swiss dairy cattle

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ABSTRACT

Genetic parameters were estimated for mobility score and 16 linear type traits of Brown Swiss dairy cattle. Mobility is an overall assessment trait that measures a cow's ability to move, as well as the structure of her feet, pasterns, and legs. Scores from 50 to 99 were assigned by appraisers for the Brown Swiss Cattle Breeders' Association of the USA beginning in June 2007. Only scores made before 69 mo of age were used. After edits, 32,710 records were available for 19,472 cows in 819 herds. The model included fixed effects for the interaction of herd and appraisal date (2,109 groups), appraisal age within parity (46 groups), and lactation stage within parity (21 groups), as well as random effects for animal, permanent environment, and residual error. A multi-trait analysis was conducted using canonical transformation, multiple diagonalization, and a decelerated expectation-maximization REML algorithm. Heritability was estimated to be 0.21 for mobility and ranged from 0.06 to 0.37 for the other 16 type traits. The traits with the highest genetic correlation with mobility were final score (0.78), rear legs (rear view; 0.74), rear udder width (0.52), and foot angle (0.51). Predicted transmitting ability (PTA) for mobility was calculated using the Brown Swiss multi-trait type evaluation system but included only appraisals for which all traits had been scored. For the 1,868 bulls evaluated, PTA for mobility ranged from 1.6 to −1.8 with a standard deviation of 0.5 and was most highly correlated with PTA for final score (0.88), rear legs (rear view; 0.77), rear udder height (0.70), and rear udder width (0.69), as expected from the trait correlations. When matched with official US national evaluations from August 2011, PTA mobility had moderately high correlations with PTA for milk, fat, and protein yields, as well as productive life (0.31–0.41). The mobility trait may provide a more accurate assessment of the structural soundness required for longevity than does the feet-legs composite.
Key words: mobility, type, genetic evaluation, Brown Swiss

Short Communication

The ability of a dairy cow to easily move about is necessary for profitability, regardless of the management environment. Linearly scored type traits used by the Brown Swiss Cattle Breeders' Association of the USA (**BSCBA**; Brown Swiss Cattle Breeders' Association of the USA, 2011b) measure some individual aspects of a cow's structure that are required for movement. A feet-legs composite (**FLC**) index that incorporates foot angle and rear legs (side view) has also been used as an overall predictor. However, heritability estimates for both of those traits are low in Brown Swiss [0.08 for foot angle and 0.14 for rear legs (side view); Gengler et al., 1999], which would make improvement slow; heritability of Brown Swiss FLC is estimated as 0.15 for US national evaluations (Animal Improvement Programs Laboratory, 2012). Rear legs (rear view), a related trait, is incorporated into FLC for US Holsteins (Holstein Association USA, 2012). Although rear legs (rear view) has been scored for Brown Swiss since 2004, its heritability estimate (0.10) is also low (Wiggans et al., 2006). Many countries use FLC as a proxy to measure a cow's ability to move when a separate locomotion score is not assigned (Lawlor and Klei, 2008), and FLC has been shown to be positively related to cow survival (Caraviello et al., 2004) and functional herd life (Dekkers et al., 1994).

To characterize movement better than with FLC, mobility was included when BSCBA revised its classification scorecard in 2007 (Brown Swiss Cattle Breeders' Association of the USA, 2012b). Mobility is 1 of 5 major breakdown traits and is weighted as 20% when calculating final score. Mobility score is assessed giving consideration to actual movement (7%), foot angle (4%), track and set of the legs and hocks (4%), thurl position (3%), and pasterns (2%) of the cow (Brown Swiss Cattle Breeders' Association of the USA, 2011a).

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A score from 50 to 99 is assigned, with 50 being the poorest score and 99 the ideal score for the trait.

Data were collected from June 2007 through June 2011 during routine appraisals by BSCBA appraisers. Records of animals scored at ≤68 mo old at calving were included. To perform canonical transformation for variance estimation, all 16 linear traits, final score, and mobility must have been scored for an animal. Ancestors born in 1985 or later (53,042) and 9 unknown-parent groups were included. Groups of calving age within parity were defined: 22 to 35 mo for parity 1 (14 groups); 35 to 50 mo for parity 2 (16 groups); and 50 to 65 mo for parity ≥3 (16 groups). Ages from 66 to 68 mo were included in the age group for 65 mo. Groups for lactation stage within parity group were defined according to DIM at appraisal: 1 to 60, 61 to 120, . . ., 241 to 300, and 301 to 400 d. Records with no calving date or >400 DIM were assigned a separate group within parity, for a total of 21 parity-stage groups.

Variances and genetic correlations between traits were estimated by multi-trait REML using an animal model and canonical transformation (Gengler et al., 1997) with 32,710 records of 19,472 Brown Swiss cows in 819 herds. The model included fixed effects for herd appraisal date, calving age within parity, and lactation stage within parity, as well as random effects for permanent environment, animal, and error. Inbreeding was ignored for estimation of variance components but was included in formation of the inverse of the relationship matrix for evaluation calculation. An effect for interaction of herd and sire was included in the evaluation model and the restriction that all traits be scored was eliminated. The evaluation model used the same edits and methodology as in routine type evaluations for Brown Swiss (Gengler et al., 1999). Multiple scores on a cow were included, but the initial score must have been in parity 1 or 2.

Figure 1 shows the distribution of the edited mobility scores. Few cows had scores below 65, likely because most animals with extreme structure and movement problems have been culled early in life before first appraisal. Because the final score a Brown Swiss cow can receive is restricted by the breed association rules, no scores exceeded 95 points. Overall mean for mobility was 83.7 with a standard deviation of 4.3. The UNIVARIATE procedure of SAS (SAS Institute Inc., 2007) was used to test for skewness and normality (Kolmogorov-Smirnov test). Scores were negatively skewed (−1.74) and a departure ($P < 0.01$) from normality was detected. The study of rear legs (rear view) in Brown Swiss by Wiggans et al. (2006) attributed a similar departure to breed appraisal program restrictions, rather than biological differences. No score adjustment was made in this study.

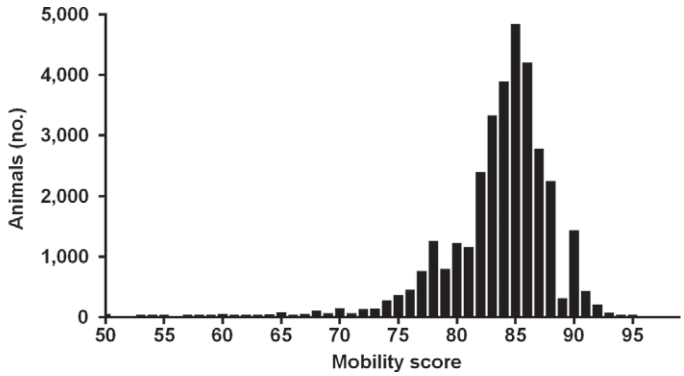

Figure 1. Distribution of mobility scores for Brown Swiss cows scored from 2007 through 2011.

Heritability and repeatability for mobility, 16 linear type traits, and final (overall) score are in Table 1. Because of limitations with the software used, standard errors for the heritabilities were obtained using formulas described by Falconer (1989). Estimated heritability for mobility was moderate at 0.21; standard errors (not given) averaged 0.013, ranging from 0.009 to 0.018. Locomotion is a similarly defined trait, and its heritability has been estimated to be somewhat lower, ranging from 0.06 to 0.11 for Holsteins and Holstein-Friesians (Boelling and Pollott, 1998; Van Dorp et al., 2004; Onyiro and Brotherstone, 2008; Laursen et al., 2009). Using a threshold model, Boettcher et al. (1998) reported an estimate (0.22) for clinical lameness similar to that reported here using a threshold model. Heritability of locomotion for non-Holstein breeds, such as Red Danish and Jersey, has been reported to be 0.10

Table 1. Heritability and repeatability estimates for Brown Swiss mobility, 16 linear type traits, and final (overall) score

Trait	Heritability[1]	Repeatability[2]
Mobility	0.21	0.46
Stature	0.37	0.57
Strength	0.13	0.26
Dairy form	0.14	0.29
Foot angle	0.09	0.21
Rear legs (side view)	0.14	0.29
Body depth	0.21	0.37
Rump angle	0.18	0.31
Rump width	0.16	0.28
Fore udder attachment	0.20	0.40
Rear udder height	0.18	0.37
Rear udder width	0.15	0.29
Udder depth	0.27	0.49
Udder cleft	0.20	0.40
Front teat placement	0.24	0.42
Teat length	0.34	0.50
Rear legs (rear view)	0.06	0.13
Final score	0.33	0.74

[1]SE of heritability ranged from 0.009 to 0.018; $P < 0.01$.

[2]SE of repeatability ranged from 0.015 to 0.040; $P < 0.01$.

Table 2. Phenotypic and genetic correlations of Brown Swiss mobility with 16 linear type traits and final score

Trait	Phenotypic correlation[1]	Genetic correlation[2]
Stature	0.14	0.17
Strength	0.14	0.22
Dairy form	0.13	0.40
Foot angle	0.30	0.47
Rear legs (side view)	−0.10	−0.10
Body depth	0.20	0.34
Rump angle	−0.07	−0.13
Rump width	0.12	0.20
Fore udder attachment	0.19	0.31
Rear udder height	0.23	0.46
Rear udder width	0.24	0.51
Udder depth	0.02	−0.01
Udder cleft	0.09	0.23
Front teat placement	0.10	0.18
Teat length	0.01	0.03
Rear legs (rear view)	0.38	0.72
Final score	0.63	0.78

[1]SE of phenotypic correlation ranged from 0.003 to 0.005; $P < 0.01$.
[2]SE of genetic correlation ranged from 0.009 to 0.056; $P < 0.05$.

and 0.05, respectively (Boelling et al., 2007). Heritability estimates for Brown Swiss linear traits ranged from 0.06 to 0.37, similar to those reported by Wiggans et al. (2006) and differing on average by 0.03 from that study. The heritability estimate for final score was 0.33, which is close to the 0.29 used in national evaluations for Brown Swiss (Animal Improvement Programs Laboratory, 2012). Repeatability for mobility was 0.46, which indicates consistency in later scores. Repeatability for other linear traits ranged from 0.13 for rear legs (rear view) to 0.57 for stature. Final scores are seldom lowered for individual animals; therefore, its high repeatability (0.74) was not surprising; Wiggans et al. (2004) reported a repeatability of 0.60 for their final score.

Genetic and phenotypic correlations of mobility with other type traits generally were similar (Table 2); standard errors of the genetic correlations (not given) averaged 0.034, ranging from 0.009 to 0.056. Traits most highly correlated with mobility were: final score (0.63, phenotypic; 0.78, genetic), rear legs (rear view; 0.38; 0.72), foot angle (0.30; 0.47), rear udder width (0.24; 0.51), and rear udder height (0.23; 0.46). The higher correlations with rear legs (rear view) and foot angle are expected, as both are considered in assigning mobility score. Likewise, final score is affected by mobility score; therefore, higher correlations are not unexpected. For the first 4 parities of British and Irish Holstein-Friesians, Boelling and Pollott (1998) reported genetic correlations of locomotion with foot angle and total score that were moderate to high (−0.34 to −0.96); correlations were negative because locomotion was scored from best (lowest score) to worst (highest score). van der Waaij et al. (2005) reported genetic correlations with locomotion of 0.70 for rear legs (rear view) and 0.47 for foot angle for Dutch Holstein-Friesians. The genetic correlation of −0.10 in this study (Table 2) between locomotion and rear legs (side view) was also similar to the correlation of −0.14 reported by van der Waaij et al. (2005); however, Boelling and Pollott (1998) reported a much stronger genetic relationship (0.33–0.78) between locomotion and rear legs (side view). The moderately high genetic correlations between mobility and udder cleft (0.23), fore udder attachment (0.31), rear udder height (0.46), and rear udder width (0.51) indicate that cows with poorly attached, extremely low or wide udders may experience difficulty in ease of movement.

Statistics for PTA for mobility are shown in Table 3 for bulls and cows. The PTA were expressed relative to a base population of cows born in 2005. Mean PTA for all evaluated bulls was −0.1 with an SD of 0.5 and a range of −1.8 to 1.6, whereas mean cow PTA was 0.0 with an SD of 0.5 and a range of −4.0 to 1.6. Correlations between August 2011 evaluations for mobility and official US national evaluations for production and fitness traits are shown in Table 4. The PTA for mobility had a moderate, positive correlation with yield, productive life, and net merit (0.31–0.41), which indicates that selection for mobility should complement selection for those traits. A positive genetic relationship between milk yield and locomotion for Canadian Holsteins was also reported by Van Dorp et al. (2004). The negative relationship between mobility and reproduction was unexpected; most Holstein studies (Weigel, 2004; Bicalho et al., 2007; Zink et al., 2011) have concluded that unimpaired mobility is beneficial for reproductive

Table 3. Descriptive statistics for Brown Swiss PTA for mobility

Population	Animals (no.)	PTA				Mean reliability (%)
		Mean	SD	Minimum	Maximum	
All bulls	1,868	−0.1	0.48	−1.8	1.6	30
Bulls with >1 daughter	840	0.0	0.48	−1.8	1.6	46
Bulls with >10 daughters	331	0.1	0.48	−1.8	1.6	59
Bulls with >50 daughters	70	0.2	0.46	−1.1	1.2	96
All cows	19,450	0.0	0.48	−4.0	1.6	66

Table 4. Correlations of August 2011 PTA for mobility with official US national PTA for yield and fitness traits for Brown Swiss bulls with official evaluations in August 2011

PTA trait	Correlation
Milk	0.41***
Fat	0.36***
Fat percentage	−0.17***
Protein	0.40***
Protein percentage	−0.12***
SCS	−0.07**
Productive life	0.31***
Daughter pregnancy rate	−0.27***
Cow conception rate	−0.09***
Heifer conception rate	−0.02
Net merit	0.39***

**$P < 0.01$; ***$P < 0.001$.

performance. However, Zink et al. (2011) also reported a positive association between poorer locomotion and greater days from first to last insemination.

Mobility can be a useful trait for increasing the accuracy of determining which animals are most likely to remain in the herd and be profitable for breeders. Heritability estimates for mobility were somewhat higher than past estimates for locomotion and lameness but were still similar, as were genetic correlations with other type traits. The American Milking Shorthorn Society and BSCBA share appraisal personnel, and a similar study with Milking Shorthorn data (J. R. Wright, unpublished data) had similar results; mobility heritability was estimated to be 0.18. National evaluations for mobility in Brown Swiss were officially released for the first time in August 2012. Because of the higher heritability for mobility (0.21) and its higher genetic correlation with productive life (0.31) compared with FLC (heritability of 0.15 and genetic correlation of 0.19), BSCBA replaced FLC with mobility in its Progressive Performance Ranking (Brown Swiss Cattle Breeders' Association of the USA, 2012a).

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