Relationship Between United States and Canadian Genetic Evaluations of Longevity and Somatic Cell Score

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ABSTRACT

Canadian and US evaluations of Holstein bulls were compared for longevity measures (433 bulls) and somatic cell score (354 bulls). Bulls were required to have a birth year of ≥1975, daughter information from ≥20 herds, and a reliability of ≥50% in both Canada and the US. The number of bulls with longevity evaluations was greater for early years because longevity information was available from lactation data and daughters were required to be ≥3 yr of age for US evaluations; evaluations for somatic cell score required additional collection of data and did not have corresponding numbers of bulls until the 1980s. Correlation between longevity measures in the US (productive life) and Canada (herd life) was 0.60. This low correlation was expected because US productive life includes yield information, but yield is excluded from Canadian herd life. For evaluations for somatic cell score, the correlation between the two countries was 0.82. Genetic correlations with productive life were estimated to be 0.69 for herd life and 0.81 for herd life combined with protein yield. Conversion equations were developed to predict a US evaluation for somatic cell score from a Canadian evaluation for somatic cell score and to predict a US evaluation for productive life from Canadian evaluations for herd life and yield.
(**Key words**: genetic evaluation, longevity, somatic cell score)

Abbreviation key: **HL** = herd life, **PL** = productive life, **SCS_{CAN}** = Canadian SCS, **SCS_{US}** = US SCS.

INTRODUCTION

Mastitis and involuntary culling are two major costs to dairy producers. Although both are influenced by management and chance, genetics also has a role. National US genetic evaluations for SCS and for longevity began in January 1994 (13). The US SCS (**SCS_{US}**) evaluations are calculated as has been described by Schutz (12). Productive life (**PL**), the US longevity measure, initially was a single-trait, direct measure of months of lactation and was limited to 10 mo per lactation (14). Since July 1994, PL for Holsteins has included a contribution from linear type traits as provided by Holstein Association USA, Inc. (Brattleboro, VT).

Net merit dollars, a US economic index that includes yield, PL, and SCS evaluations with weights of 10:4:–1, was distributed with USDA bull evaluations beginning in January 1994 (13). Although USDA bull evaluations for yield traits have included combined (or converted) evaluations for Canadian bulls since January 1993 (15), those bulls often had few or no US daughters and no Canadian evaluation corresponding to PL or SCS. Therefore, net merit dollars assigned for those bulls were not as accurate as those for US bulls.

Beginning in January 1996, Canadian evaluations included SCS (**SCS_{CAN}**) (10) and herd life (**HL**) (7). For SCS_{CAN}, test day SCS are used directly in a model that includes DIM and thus are adjusted for stage of lactation; for SCS_{US}, the dependent variable is the mean of test day SCS, which is then adjusted for lactation length (12). For SCS evaluations in both countries, mean values are added to the intermediate solutions after values for the genetic base animals are set to 0 (10, 12). Both PL and HL are expressed as transmitting abilities and are enhanced by considering type traits as indirect measures; PL is a deviation in months (0 is the mean for base animals), and HL is expressed as number of parities. Although HL and PL are both measures of longevity, they are not directly comparable because HL is adjusted for fat and protein yields, but PL is a measure of actual longevity. Ducrocq et al. (2) defined and distinguished between true stayability and functional stayability. Similarly, PL is true stayability and reflects whatever attributes daughter groups have that result in their surviving for longer or shorter times. The HL is functional stayability and measures attributes other than yield, the primary reason for decisions to

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cull or to keep cows. Advocates of functional stayability characteristics promote it as indicating all of the other characteristics that daughter groups exhibit beyond yield. Proponents of true stayability point out that longer life without additional yield is a net loss and that breeders could make serious mistakes in selection by choosing bulls on functional stayability alone. Bulls with functional stayability below the population mean could be outstanding for functional stay-ability, and, in such cases, true stayability could be misleading to some users. If the information is combined appropriately, the same selection decisions would result from indexes using either trait definition, but a different set of economic weights would be necessary (14).

Heritabilities for Canadian HL are 0.03 for parities 1 through 3, and genetic correlations are 0.62, 0.57, and 0.75 between parities 1 and 2, 1 and 3, and 2 and 3, respectively (6, 7). For SCS_{CAN}, heritabilities are 0.09 for parity 1, 0.09 for parity 2, and 0.11 for parity 3; corresponding genetic correlations were 0.79, 0.75, and 0.95 (6, 9). In the US, heritabilities are 0.085 for PL (6, 14) and 0.10 for SCS_{US} (6, 12).

Objectives of this study were to determine the relationships between US and Canadian Holstein bull evaluations for longevity (PL and HL) for SCS. In addition, conversion equations for these traits were developed to provide guidance for breeders who want to estimate net merit dollars for Canadian bulls.

MATERIALS AND METHODS

January 1996 genetic evaluations for longevity and SCS were matched for Holstein bulls in the US and in Canada. For each trait, daughter information from ≥20 herds and a reliability of ≥50% in each country were required for a bull to be in the study. Only bulls born in 1975 or later were accepted.

Data included evaluations from 433 bulls for longevity and 354 bulls for SCS; Table 1 shows the numbers of bulls by birth year for each trait. Because longevity information was available from lactation records and did not require additional data collection, numbers of bulls were higher during the early years. In contrast, the SCS data were collected more recently. More bulls qualified for SCS evaluations in recent years, partly because PL evaluations are not computed until bull daughters are 3 yr of age. Thus, in the US, younger bulls can receive SCS evaluations before PL evaluations. A contributing factor to the larger number of bulls with SCS evaluations in recent years is that the heritabilities for SCS are higher than for longevity, especially HL. Therefore, many more daughters were needed for longevity traits than for SCS to reach the reliability of ≥50% that was required for this study. Despite the low heritabilities for longevity and SCS, reliabilities reached 99% for bulls with many daughters.

TABLE 1. Numbers of bulls included in analyses of longevity and SCS evaluations by birth year of bull.

Birth year of bull	Bulls included in analyses	
	Longevity	SCS
	(no.)	
1975	32	10
1976	31	8
1977	28	12
1978	31	11
1979	36	23
1980	51	25
1981	57	44
1982	38	35
1983	36	38
1984	31	34
1985	30	51
1986	16	32
1987	7	7
1988	7	6
1989	2	14
1990	0	4

Correlations were calculated between US and Canadian evaluations for longevity (PL and HL) and milk yield and also between US and Canadian evaluations for SCS (SCS_{US} and SCS_{CAN}) and milk yield. The method of Calo et al. (1) was used to estimate genetic correlations. The recency of evaluations for SCS and longevity suggests that genetic trend would be small; product-moment correlations between national evaluations were computed from residuals after birth year was accounted for to adjust for any trend.

For calculation of conversion equations, only bulls that had US yield evaluations from combined US and Canadian data (15) were accepted. The presence of combined data meant that a bull had been used initially in the exporting country (Canada), which is a recommendation of INTERBULL (International Bull Evaluation Service, Uppsala, Sweden) for calculation of conversion equations. Although recommendations for developing conversion equations for yield traits are for use of evaluations from only the most recent 10 birth years for bulls with a reliability of ≥75%, bulls with a birth year of ≥1975 and a reliability of ≥50% were included because heritabilities for longevity and SCS traits were lower than those for yield

TABLE 2. Evaluations[1] for bulls with birth year of ≥1975, daughter information from ≥20 herds, and reliability of ≥50% and the subset of bulls that was initially sampled in Canada and that contributed information for calculation of conversion equations for longevity[1] and SCS.

Trait	Evaluations of bulls included in longevity study				Evaluations of bulls included in SCS study			
	All data (n = 433)		Conversion subset (n = 258)		All data (n = 354)		Conversion subset (n = 182)	
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
Milk (kg)								
US	–138	429	–292	367	38	367	–143	347
Canada	155	940	–263	852	528	893	64	822
Protein								
US	–4.3	11.8	–8.3	11.3	...	...	...	...
Canada	3.2	28.7	–7.9	27.2	...	...	...	...
Longevity[2]								
US (mo)	–0.05	1.37	–0.24	1.37	...	...	...	...
Canada (parities)	2.988	0.154	2.985	0.163	...	...	...	...
SCS								
US	...	...	...	...	3.17	0.19	3.14	0.18
Canada	...	...	...	...	3.01	0.19	2.99	0.18

[1]Canadian evaluations for milk and protein yields are expressed as breeding values; all other evaluations are expressed as transmitting abilities.

[2]Productive life for US evaluations; herd life for Canadian evaluations.

(0.25 for the US and 0.33 for Canada) (5). Conversions were computed using information from 258 bulls for longevity and from 182 bulls for SCS.

As has been the practice in the US for yield traits, the Goddard method was used to develop conversion equations (3, 8); that is, the daughter deviation in the importing country was regressed on the point estimate in the exporting country. Although adjustment of HL for fat and protein yields, which is based on cow phenotype, cannot be fully represented with evaluation data, Canadian yield evaluations as well as HL were considered in predicting PL because HL is adjusted for yield and PL is not. A multiple regression approach was used, and four models to predict PL were examined: 1) HL, milk, fat, and protein; 2) HL, milk, and protein; 3) HL and milk; and 4) HL and protein. According to INTERBULL guidelines, only the importing country has the right to establish official conversion equations. Therefore, conversions from the US to Canada were not suggested.

RESULTS

Means and standard deviations of evaluations are in Table 2 for bulls that qualified for the study and for the subset of bulls that were used for developing conversion equations. For all traits, mean estimated genetic merit was lower for the subset than for all qualifying bulls; corresponding standard deviations generally were lower.

Correlations between US and Canadian evaluations are in Table 3 for longevity and milk yield and in Table 4 for SCS and milk yield for bulls qualifying for the study and for the subset of bulls that were used for developing conversion equations. Correlations between SCS evaluations (Table 4) were higher (0.82 for all bulls and 0.77 for the conversion subset) than between PL and HL evaluations (Table 3; 0.60 for all bulls and 0.64 for the conversion subset), partly because SCS_{US} and SCS_{CAN} are more similarly defined than are PL and HL; PL is true stayability and includes contribution of yield, but HL is functional stayability and is adjusted for yield. This difference in definition was further illustrated by correlations of longevity with milk yield evaluations for all bulls (Table 3), which were higher for PL (0.45 with US yield and 0.34 with Canadian yield) than for HL (0.09 with US yield and 0.05 with Canadian yield). The latter correlations were not significantly different ($P < 0.05$) from 0, which was as intended for functional stayability. As expected, PL was positively correlated with both US and Canadian milk yields because PL was partially influenced by milk yield. The correlation is higher for evaluations of PL and US milk yield (0.45) than for PL and Canadian milk yield (0.34) because PL is the US measure and because evaluations for US and Canadian milk yield are not perfectly correlated (0.95).

Both SCS_{US} and SCS_{CAN} evaluations were positively correlated with evaluations for milk yield (Ta-

TABLE 3. Correlations and mean reliabilities of US and Canadian evaluations for longevity[1] and milk yield for 433 bulls (above diagonal) with birth year of ≥1975, daughter information from ≥20 herds, and reliability of ≥50% and for the subset of 258 bulls (below diagonal) that was initially sampled in Canada and that contributed information for calculation of conversion equations.

		US		Canadian		
Country	Trait	Productive life	Milk	Herd life	Milk	Mean reliability
US	Productive life		0.45**	0.60**	0.34**	0.84
	Milk	0.45**		0.09	0.95**	0.98
Canada	Herd life	0.64**	0.14*		0.05	0.90
	Milk	0.35**	0.94**	0.11		0.97

[1]Productive life for US evaluations; herd life for Canadian evaluations.

*$P < 0.05$.

**$P < 0.01$.

ble 4) for all bulls; correlations for SCS_{US} were more highly related to yield (0.22 to 0.24) than were correlations for SCS_{CAN} (0.15 to 0.17). These positive correlations reflect a small negative genetic relationship between yield and udder health. The correlation within birth year of 0.83 between SCS_{US} and SCS_{CAN} evaluations suggests that these evaluations measure nearly the same trait.

The genetic correlation between SCS_{US} and SCS_{CAN} that was estimated by the method of Calo et al. (1) was 0.93; the corresponding estimate for milk yield was 0.99. In contrast, the estimated genetic correlation between PL and HL was only 0.67 because of the difference in trait definition. Rogers et al. (11) estimated genetic correlations with SCS_{US} to be –0.87 for Danish SCC, –0.99 for Swedish SCC, –0.66 for Danish clinical mastitis, and –0.49 for Swedish clinical mastitis; in Denmark and Sweden, higher numbers are preferred.

For the subset of bull evaluations that was used for developing conversion equations, corresponding correlations generally were similar to those for all bulls. For HL evaluations, correlations with other traits were slightly higher than for all bulls. For the SCS analysis, all correlations were slightly less for the conversion subset than for all bulls.

Results from the four multiple regression models to predict PL evaluations from Canadian HL and yield evaluations are in Table 5. Inclusion of the Canadian evaluation for fat yield (Model [1]) was not a significant ($P = 0.38$) benefit, and inclusion of milk as the only yield variable (Model [3]) had the lowest accuracy. Of the other two models, Model [4] is recommended because both coefficients were highly significant ($P < 0.01$), one fewer variable was needed, and no negative coefficients were present. Also, HL was computed using adjustments for fat and protein yields but not for milk yield.

The conversion equation of Model [4] was applied to the Canadian data for all 433 bulls. The product-moment correlation between PL and predicted PL was 0.71. Mean reliability of the predicted index

TABLE 4. Correlations and mean reliabilities of US and Canadian evaluations for SCS and milk yield for 354 bulls (above diagonal) with birth year of ≥1975, daughter information from ≥20 herds, and reliability of ≥50% and for the subset of 182 bulls (below diagonal) that was initially sampled in Canada and that contributed information for calculation of conversion equations.

		US		Canadian		
Country	Trait	SCS	Milk	SCS	Milk	Mean reliability
US	SCS		0.22**	0.82**	0.24**	0.89
	Milk	0.17*		0.15**	0.94**	0.98
Canada	SCS	0.77**	0.06		0.17**	0.89
	Milk	0.18*	0.93**	0.07		0.96

*$P < 0.05$.

**$P < 0.01$.

TABLE 5. Intercepts and partial regression coefficients from various models for predicting US productive life from Canadian herd life and yield evaluations.

Model	Intercept	Regression coefficient for Canadian EBV: Herd life	Milk	Fat	Protein	R^2
	(mo)	(mo/no. of parities)	(mo/kg)	(mo/kg)	(mo/kg)	
1	–20.4	6.79** (0.59)[1]	–0.0006* (0.0002)	–0.0039 (0.0044)	0.0409** (0.0092)	0.421
2	–20.2	6.73** (0.58)	–0.0005* (0.0002)		0.0362** (0.0075)	0.420
3	–20.0	6.65** (0.61)	0.0005** (0.0001)			0.367
4	–19.9	6.63** (0.59)			0.0212** (0.0035)	0.408

[1]Standard errors in parentheses.

*$P < 0.05$.

**$P < 0.01$.

(true stayability) was estimated as 0.91. The genetic correlation between true stayability in the US and Canada was estimated to be 0.81. The INTERBULL (4) recommendation for estimation of reliability of a converted evaluation is multiplication of the reliability of the evaluation from the exporting country by the square of the genetic correlation between the exporting and importing countries. Calculation of actual reliability for predicted PL would require computation of reliability for HL combined with yield. However, the square of the genetic correlation between the US and Canada is only 0.66 for longevity evaluations (PL and predicted PL, respectively). Therefore, the mean of reliabilities for HL and protein yield was considered to be a suitable estimator of the actual reliability for predicted PL.

The conversion equation for an SCS_{US} evaluation from a SCS_{CAN} evaluation was 0.64 + 0.836(SCS_{CAN} evaluation). The standard error of the regression was 0.054. Reliability of the converted evaluation would be the SCS_{CAN} reliability times the genetic correlation (0.93) squared.

CONCLUSIONS

Many Holstein bulls have evaluations for longevity and SCS in both the US and Canada, which makes possible the calculation of conversion equations by traditional methods and supports the combining of data for yield as is done by INTERBULL. The genetic correlation was only 0.69 between PL and HL evaluations but increased to 0.81 for PL and a function of HL and protein yield evaluations. The genetic correlation of 0.93 for SCS_{US} and SCS_{CAN} evaluations suggests that SCS evaluations are estimates of the same trait in the two countries and could be effectively combined.

The genetic correlations can be accounted for in combining evaluations across countries. For longevity, differing trait definitions (PL vs. HL) must be considered, and yield information would need to be included in multiple-country evaluations. Until multiple-country evaluations are developed, conversion equations can be used to estimate PL evaluations from HL and Canadian yield evaluations and SCS_{US} evaluations from SCS_{CAN} evaluations.

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