GENETICS AND BREEDING

Use of Multinational Data to Improve National Evaluations of Holstein Bulls

R. L. POWELL and H. D. NORMAN
Animal Improvement Programs Laboratory, Agricultural Research Service,
USDA, Beltsville, MD 20705-2350

ABSTRACT

The usefulness of multinational data for the improvement of national estimates of genetic merit of Holstein bulls was assessed. For 222 bulls, combined US-Canadian evaluations and evaluations from the US only from January 1993 for milk, fat, and protein yields were compared with their US only evaluations from August 1997. The correlations between the 1993 and 1997 evaluations and the standard deviations of differences in evaluations from added data favored the evaluations from the US only because of a part-whole relationship; often 1997 data were largely from US only data from 1993. However, the results for 35 bulls with reliability increases of >5% indicated that combining US and Canadian evaluations improved the prediction of future evaluations. The value of foreign data also was assessed from national and international evaluations on the scales of Canada, Germany, and the US. The changes from 1996 national evaluations to either 1996 international evaluations or 1997 national evaluations were compared to determine whether adding international data at the earlier time could provide a useful prediction of subsequent change in national evaluations. Although the degree of agreement among differences from added national and international data varied, international evaluations did provide useful information beyond the more limited national data available at the same time.
(**Key words**: genetic evaluation, multinational data, international evaluation)

Abbreviation key: **INTERBULL** = International Bull Evaluation Service.

INTRODUCTION

Much of the emphasis in animal breeding research is on making the best use of available data. Accounting for nongenetic effects through adjustment of data prior to analysis or accounting for those effects through the evaluation model are examples of this effort. The inclusion of data that previously were not used, such as records in progress (5) or data from unsupervised milk recording plans (8), is recognition that the addition of data that are properly weighted should improve estimates of true genetic merit. Countries historically have calculated genetic evaluations for bulls based solely on data from daughters in that country. A combination of national data with data from daughters from other countries might improve national evaluations. The use of multinational data by the International Bull Evaluation Service [**INTERBULL**; (1)] was designed to improve the prediction of the genetic merit of bulls for countries that had limited data or no data from daughters of the bull.

Prior to the release of INTERBULL evaluations, the Animal Improvement Programs Laboratory, (ARS, USDA, Beltsville, MD) combined bull evaluations from Canada and the US to produce US-Canadian evaluations (11). The national evaluations were combined by weighting daughter deviations on the US scale. Beginning in January 1993, combined US-Canadian evaluations were the official national evaluations in the US for bulls that were initially sampled in Canada. Canadian and US evaluations were combined after analysis of US data with the animal model. The US only evaluations that were included as data for calculation of US-Canadian evaluations were not released to the dairy industry but were required for the calculation of conversion equations (6). The evaluations based on US data only also were necessary as data for INTERBULL evaluations (7).

Conversion equations require evaluations on the scales of both countries for a number of bulls and permit estimates of genetic merit from one country to be expressed on the genetic scale of another country. However, conversion equations are calculated only between pairs of countries and force all converted evaluations to be on the prediction line. Because converted evaluations are rescaled original evaluations, bulls with converted evaluations are not reranked on the new scale.

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The system of across-country evaluation (7) used by the INTERBULL Centre (Uppsala, Sweden) considers all data simultaneously; therefore, merits of individual bulls should be more accurately represented. However, INTERBULL evaluations are not totally accepted among countries as being official. The term “official” may not have the same meaning in all countries but generally indicates that the evaluations can be used in marketing. Of the 19 countries with Holstein data used for August 1997 INTERBULL evaluations, none released all INTERBULL results (3) as official. Typically, countries accept the INTERBULL evaluations as official for all foreign bulls or for bulls that do not meet a minimum criterion for reliability based on local data only. As of February 1998, Italy and the United Kingdom had not accepted any INTERBULL Holstein evaluations as official. In the US, most dairy industry organizations consider INTERBULL results to be official for most foreign bulls and even for some US bulls; however, criteria for official status differ by breed (10).

The goal of the inclusion of additional data is the improvement of prediction of true genetic merit of a bull. The objective of this study was to evaluate the usefulness of including multinational data in combined US-Canadian evaluations and in INTERBULL evaluations for improving predictions of transmitting ability. The later national evaluations were assumed to be improved predictions of true genetic merit because of the additional data. The value of considering data from other countries that were available at the time of earlier national evaluation was assessed.

MATERIALS AND METHODS

Combined Evaluations

Data from January 1993 USDA-DHIA genetic evaluations for Holstein milk, fat, and protein yields were available for combined US-Canadian evaluations and evaluations of bulls from US data only. Combined evaluations were computed only for Canadian bulls that had both Canadian and US evaluations (11). Equal weight was given to Canadian and US daughters (i.e., the genetic correlation between Canada and the US was assumed to be 1.0). The bulls that were selected had reliabilities of ≥75% for their US only evaluations for milk yield. For those 222 bulls, the portion of US daughters in the combined evaluations ranged from 1 to 95%; the median was 16%. The combined US-Canadian evaluations and evaluations from the US only from January 1993 were compared with evaluations from the US only for the same bulls from August 1997. In addition, a data set of evaluations was created that included all available August 1997 INTERBULL evaluations and US only evaluations for bulls without INTERBULL evaluations. This data set was designated as maximal because it contained evaluations based on the maximal amount of information available. Correlations were calculated between the 1993 and 1997 evaluations, and the standard deviations of differences between the 1993 and 1997 evaluations were computed. These two measures were chosen because they were unaffected by the change in the US genetic base in 1995 (9). The corresponding data for the 35 bulls with an increase in reliability of >5% from 1993 to 1997 for US only evaluations of milk yield also were examined. New adjustment procedures for age, parity, season, and days open during previous lactation were implemented in January 1995 with the establishment of the new genetic base (9). These adjustments could have reduced agreement between 1993 and 1997 evaluations but should have little impact on the comparison of US only and combined data.

INTERBULL Evaluations

For Canada, Germany, and the US, a data set that included the July 1996 national (i.e., local) evaluations that were data for INTERBULL test evaluations in October 1996, those INTERBULL test evaluations, and the August 1997 national evaluations was created for Holstein bulls. Evaluations in the data set of each country were on the scale of that country for evaluations of milk, fat, and protein yields. The INTERBULL test evaluations included Holstein data from 18 countries and were computed to assess the effect of the restriction of bulls to those born during 1980 or later, particularly on the estimation of sire variances. The birth year edit was accepted by INTERBULL; therefore, the 1996 test evaluations are the earliest evaluations that use the current INTERBULL evaluation procedure. Canadian and German data were chosen because genetic correlations with US evaluations in August 1997 for yield traits were high (0.95) and low (0.88 to 0.90), respectively, relative to those of other countries and because national evaluations from July 1996 were available. The 1997 Canadian evaluations were adjusted for the annual genetic base redefinition so that all evaluations in the Canadian data set were on a 1996 base (2). To be included in the data set of a country, a bull was required to have a national evaluation and data from at least one other country used as data for the INTERBULL evaluation. The Canadian, German,

TABLE 1. Correlations between January 1993 and August 1997 Holstein bull evaluations and standard deviations of evaluation differences.

Evaluations compared[1]	Correlations			Standard deviations of differences		
	Milk	Fat	Protein	Milk	Fat	Protein
				(kg)		
All bulls (222 bulls)						
1993 US only and 1997 US only	0.98	0.98	0.98	101	3.31	2.52
1993 Combined and 1997 US only	0.96	0.96	0.96	113	4.15	3.54
1993 US only and 1997 maximal	0.97	0.98	0.98	106	3.42	2.68
1993 Combined and 1997 maximal	0.97	0.97	0.96	104	3.74	3.28
Bulls with increased reliability of >5% for US only evaluation (35 bulls)						
1993 US only and 1997 US only	0.93	0.90	0.93	129	5.46	3.83
1993 Combined and 1997 US only	0.93	0.93	0.92	123	4.71	3.92
1993 US only and 1997 maximal	0.90	0.90	0.90	145	5.43	4.42
1993 Combined and 1997 maximal	0.93	0.95	0.92	120	3.77	3.90

[1]Evaluations based on data only from the US in January 1993 or August 1997, evaluations based on combined US-Canadian data in January 1993, and evaluations based on a maximal combination of multinational data and data from the US only in August 1997.

and US data sets included information for 577, 315, and 650 bulls, respectively.

The accuracy of INTERBULL evaluations relative to national evaluations is difficult to assess because of the recent initiation of current INTERBULL evaluation procedures in 1996. If the INTERBULL procedures had been in effect for 4 or 5 yr, national evaluations for some bulls could have increased in reliability to 99%, and those evaluations would have made a reasonable proxy for true genetic merit. Because no such standard is yet available, a less direct method was developed to assess the relative accuracy of INTERBULL and national evaluations. The 1996 INTERBULL evaluations and the 1997 national evaluations included the 1996 national data; the 1997 national evaluations also included an additional year of national data, and the 1996 INTERBULL evaluations included additional data from other countries. Therefore, the 1996 national evaluations were designated as the base data or starting point for each country.

The impact of added data through later national evaluations or from other countries was assessed in two ways. First, a measure of consistency defined as the percentage of bulls that had 1997 national and 1996 INTERBULL evaluations that changed in the same direction (both evaluations increased or both evaluations decreased) from the 1996 national evaluations was determined for each country. Second, the correlations between the change from the 1996 national evaluation to the 1997 national evaluation and the change from the 1996 national evaluation to the 1996 INTERBULL evaluation were computed for each country. Those correlations were a second measure of the relationship between the two sources of added information.

Because the quantity of added data affects evaluation accuracy, consistency percentages and correlations between evaluation changes also were calculated for three levels (low, medium, and high) of relative increases in the number of daughters since the 1996 national evaluations for each country. In addition, consistency percentages and correlations between evaluation changes were computed for bulls with increases in reliability of ≥3% or ≥5% for both the 1997 national and 1996 INTERBULL evaluations for milk yield.

RESULTS

Combined Evaluations

Combined US-Canadian evaluations in 1993 were generally not as closely related to 1997 evaluations as were 1993 evaluations from US data only (Table 1). However, relative differences would be small between evaluations from the US only if records from only a few daughters were added. About 85% (187) of the bulls increased ≤5% in the reliability of the US only evaluations from 1993 to 1997. For the 35 bulls that increased >5% in reliability, correlations between the 1993 and 1997 evaluations generally were higher for the combined evaluations than for the evaluations from the US only, and standard deviations of differences were lower. This finding suggests that the addition of Canadian data was useful in increasing the evaluation accuracy and that the combined Canadian-US evaluations were better predictors of genetic merit of Holstein bulls than were the evaluations from the US only. The 35 bulls with reliability increases of >5% had larger standard deviations and smaller correlations than were found for all 222 bulls, which was a reflection of the addition of more new daughters between 1993 and 1997 for those 35 bulls.

INTERBULL Evaluations

Consistency percentages and correlations of evaluation changes are in Tables 2, 3, and 4 for Canadian, German, and US evaluations, respectively. If no relationship existed between changes in evaluations because of additional data from later national evaluations or from multinational evaluations, consistency would be 50%, and correlations would be 0. If changes were positively related (i.e., evaluations with added data tended toward the same assumed true value), consistency would be >50%, and correlations would be positive. Conversely, if changes were negatively related (i.e., evaluations with added data tended toward different true values), consistency would be <50%, and correlations would be negative.

For the full Canadian data set (Table 2), consistency was slightly >50% for all yield traits, and correlations were small but positive (0.08 for milk and protein; 0.07 for fat) and significant ($P \le 0.05$ for milk and protein; $P \le 0.10$ for fat). Consistency percentages and correlations for the nine data subsets were varied and difficult to assess based on increases in the number of daughters relative to 1996 national evaluations. Consistency generally was higher for subsets with more added data. Although most correlations were not significant ($P > 0.1$), they tended to be higher and positive for the subsets that had more added data. The correlations were significant and negative for the subset with the least added data for milk (–0.14, $P \le 0.1$) and for protein (–0.17, $P \le 0.05$). For bulls with increased reliability, consistency was around 60% (62% for all traits with a reliability increase of ≥3% for milk yield, 61% for milk and fat yields, and 56% for protein yield with a reliability

TABLE 2. The consistency of evaluation change from the addition of national or multinational data to July 1996 Canadian national evaluations and the correlations of those changes.

Evaluations compared	Increase in the number of daughters relative to 1996 national evaluations: National[1]	Multinational[2]	Bulls	Consistency[3]: Milk	Fat	Protein	Correlation[4]: Milk	Fat	Protein
	(%)		(no.)	(%)					
All bulls	1.4[5]	180[5]	577	51	51	53	0.08*	0.07†	0.08*
	<1.5	<150	151	44	49	48	–0.14†	–0.08	–0.17*
		150 to 1299	108	51	52	48	0.06	0.00	0.01
		>1300	36	56	42	56	0.13	–0.29†	0.02
	1.5 to 9.5	<150	69	52	48	49	0.14	0.18	0.20†
		150 to 1299	46	48	61	63	–0.10	–0.02	–0.20
		>1300	30	60	43	70	–0.13	–0.19	–0.27
	>9.5	<150	46	59	63	54	–0.05	–0.02	–0.04
		150 to 1299	42	57	69	62	0.31*	0.36*	0.31*
		>1300	49	55	35	53	0.36**	0.21	0.45**
Bulls with reliability increase[6] of ≥3%	71.7[5]	975[5]	34	62	62	62	0.30†	0.16	0.23
Bulls with reliability increase[6] of ≥5%	84.6[5]	1092[5]	18	61	61	56	0.26	0.14	0.17

[1]August 1997.

[2]October 1996 test evaluations from the International Bull Evaluation Service (INTERBULL, Uppsala, Sweden).

[3]Percentage of bulls that had 1997 national and 1996 INTERBULL evaluations change in the same direction (both increase or both decrease) from 1996 national evaluations.

[4]Correlation between the change from the 1996 national evaluation to the 1997 national evaluation and the change from the 1996 national evaluation to the 1996 INTERBULL evaluation.

[5]Median.

[6]Increase in reliability of both national and multinational evaluations for milk yield.

†$P \le 0.10$.

*$P \le 0.05$.

**$P \le 0.01$.

increase of ≥5% for milk yield). Although correlations for bulls with increased reliability were not significant ($P > 0.05$), those correlations were positive (0.14 to 0.30) and larger than correlations for all bulls. The numbers of Canadian bulls that had increased reliability from the 1996 national evaluations were lower because of a change in the procedure for calculating Canadian reliability in 1997 (4) that generally lowered reliability; however, this decrease in reliability was slight for the subsets of bulls with international evaluations and, therefore, high national reliabilities.

For the full German data set (Table 3), consistency was around 60% for fat and protein yields but 50% for milk yield; the correlations were small and positive (0.03 to 0.08) although not significant ($P > 0.1$). No pattern in consistency or correlation was apparent for the nine subsets based on increases in daughter numbers. Although the correlations were higher, positive, and significant (0.40 to 0.48; $P \le 0.05$) for the subset with the greatest relative increase in daughter numbers, the correlations for the subset with moderate relative increases in daughter numbers were negative and significant (–0.44 to –0.66; $P \le 0.1$). For bulls with increased reliability of ≥3% or ≥5%, consistency was 49% for milk yield and from 54 to 59% for component yields; the correlations were all positive (0.14 to 0.27) and were larger than the correlations for all bulls but generally were not significant ($P > 0.1$).

For the full US data set (Table 4), consistency was 46% for milk yield, 61% for fat yield, and 63% for protein yield, which indicated that changes from added data from national and multinational sources were negatively related for milk yield and positively related for component yields. The relationship was similar for bulls with reliability increases of ≥3%, but consistency was >50% for all yield traits for bulls with reliability increases of ≥5% and ranged from 51 to 56%. The correlations were close to 0 and not significant ($P > 0.1$). For the nine data subsets that were based on relative increases in daughter numbers, con-

TABLE 3. The consistency of evaluation change from the addition of national or multinational data to July 1996 German national evaluations and the correlations of those changes.

Evaluations compared	Increase in the number of daughters relative to 1996 national evaluations			Consistency[3]			Correlation[4]		
	National[1]	Multinational[2]	Bulls	Milk	Fat	Protein	Milk	Fat	Protein
	(%)		(no.)	(%)					
All bulls	2.0[5]	207[5]	315	50	62	60	0.03	0.08	0.05
	<0.5	<300	79	51	70	63	–0.15	0.12	–0.08
		300 to 1199	27	56	70	59	0.16	0.40*	0.29
		>1200	10	90	30	80	0.68*	–0.14	0.42
	0.5 to 9.5	<300	49	35	55	53	–0.09	0.15	–0.10
		300 to 1199	20	50	45	60	–0.66**	–0.44†	–0.44*
		>1200	29	52	48	62	0.06	0.38*	0.13
	>9.5	<300	42	40	74	64	0.17	0.12	0.19
		300 to 1199	27	52	67	48	0.11	0.15	0.18
		>1200	32	62	59	62	0.46**	0.48**	0.40*
Bulls with reliability increase[6] of ≥3%	23.0[5]	622[5]	69	49	59	54	0.14	0.27*	0.17
Bulls with reliability increase[6] of ≥5%	44.3[5]	563[5]	45	49	56	58	0.16	0.23	0.22

[1]August 1997.

[2]October 1996 test evaluations from the International Bull Evaluation Service (INTERBULL, Uppsala, Sweden).

[3]Percentage of bulls that had 1997 national and 1996 INTERBULL evaluations change in the same direction (both increase or both decrease) from 1996 national evaluations.

[4]Correlation between the change from the 1996 national evaluation to the 1997 national evaluation and the change from the 1996 national evaluation to the 1996 INTERBULL evaluation.

[5]Median.

[6]Increase in reliability of both national and multinational evaluations for milk yield.

†$P \le 0.10$.

*$P \le 0.05$.

**$P \le 0.01$.

sistency generally was <50% for milk yield and >50% for component yields, except for subsets that had an increase of >7.5% in daughter numbers for national evaluations. For those subsets, consistency was around 50% for milk yield for low to medium increases of multinational data and 29% for large increases; for component yields, consistency was >50% for low to medium increases of multinational data and <50% for large increases. Correlations for data subsets based on relative increases in daughter numbers generally were low (absolute value ≤0.15) and nonsignificant ($P > 0.1$). The only significant ($P \le 0.01$) correlation was 0.38 for fat yield for the subset with increases of 5.0 to 7.5% in daughter numbers for national data and <35% for multinational data.

Differences in results among the national data sets could be affected by the amount of US data included in the October 1996 INTERBULL evaluations; 44, 43, and 75% of the data used in the INTERBULL evaluations for Canada, Germany, and the US, respectively, were from US daughters. National daughters were only 25 and 23% of INTERBULL data for Canada and Germany. This difference in the amount of US data included in October 1996 INTERBULL evaluations also was reflected in the definition of high relative increases in daughter numbers for multinational data: >1300% for Canada (Table 2), >1200% for Germany (Table 3), but only >130% for the US.

CONCLUSIONS

The combined US-Canadian evaluations were improved predictors of genetic merit compared with the evaluations from the US only. However, this improvement was apparent only for bulls with large increases in added daughter data because of the part-whole relationship between 1993 and 1997 evaluations from the US only; 1997 data were largely from US only data from 1993.

The INTERBULL evaluations on Canadian, German, and US scales appeared to provide useful information beyond that found in the particular national evaluation. This conclusion was based on the relationship of the INTERBULL evaluations to national evaluations that included added information. Although this relationship does not indicate that the

TABLE 4. The consistency of evaluation change from the addition of national or multinational data to July 1996 US national evaluations and the correlations of those changes.

Evaluations compared	Increase in the number of daughters relative to 1996 national evaluations			Consistency[3]			Correlation[4]		
	National[1]	Multinational[2]	Bulls	Milk	Fat	Protein	Milk	Fat	Protein
	(%)		(no.)	(%)					
All bulls	1.0[5]	66[5]	650	46	61	63	0.02	0.02	–0.01
	<0.5	<35	84	44	74	70	0.09	0.15	0.12
		35 to 129	81	49	64	65	0.03	0.00	0.06
		>130	117	47	59	61	0.02	0.09	–0.01
	0.5 to 7.5	<35	67	43	67	75	0.18	0.38**	0.13
		35 to 129	88	40	47	60	0.06	–0.05	0.15
		>130	71	46	58	63	–0.01	0.06	–0.06
	>7.5	<35	74	50	68	62	0.03	0.14	0.08
		35 to 129	47	51	62	53	0.00	0.05	–0.09
		>130	21	29	48	38	0.13	–0.27	–0.03
Bulls with reliability increase[6] of ≥3%	1.8[5]	152[5]	161	45	53	56	0.02	0.02	–0.01
Bulls with reliability increase[6] of ≥5%	9.8[5]	117[5]	45	51	56	53	0.05	–0.01	–0.02

[1]August 1997.

[2]October 1996 test evaluations from the International Bull Evaluation Service (INTERBULL, Uppsala, Sweden).

[3]Percentage of bulls that had 1997 national and 1996 INTERBULL evaluations change in the same direction (both increase or both decrease) from 1996 national evaluations.

[4]Correlation between the change from the 1996 national evaluation to the 1997 national evaluation and the change from the 1996 national evaluation to the 1996 INTERBULL evaluation.

[5]Median.

[6]Increase in reliability of both national and multinational evaluations for milk yield.

$^{**}P \le 0.01$.

INTERBULL procedure was optimal, the INTERBULL evaluations probably are more accurate, especially when they contain considerably more data. The usefulness of the added data in INTERBULL evaluations was most apparent for data subsets with the most added information. However, bulls with limited new information over the period studied can mask or dilute the overall impact of added information on evaluations. Therefore, editing or analyzing subsets of evaluations may be necessary to assess appropriately the differences in evaluation accuracy, especially for brief intervals.

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