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Impact of Estimated Genetic Correlations on International Evaluations to Predict Milk Traits

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ABSTRACT

The Interbull procedure for combining dairy bull evaluations uses estimated genetic correlations between countries. It is important to know whether the resulting difficulties from differences in ranking in each country are justified by improved accuracy relative to a system assuming unity correlations. Data submitted for the May 2001 yield and somatic cell score (SCS) Interbull evaluations were processed once with the usual estimated genetic correlations (E01) and again assuming these correlations to be essentially unity (0.995; U01). The 2 sets of resulting evaluations were compared with August 2004 national evaluations (N04) for bulls not having local evaluations used in the 2001 evaluations. Thus, the examination was of Interbull evaluations from foreign data in predicting national evaluations. Countries in the study for yield were Australia, Canada, France, Germany, Great Britain, Ireland, Italy, The Netherlands, New Zealand, and the United States. Countries included for SCS were Canada, France, Germany, Great Britain, The Netherlands, and the United States. For most countries' evaluations, standard deviations of differences between E01 or U01 and N04 were smaller for E01 by about 5 to 7% and correlations between E01 and N04 were higher by 0.01 or the same as for U01 and N04. Although use of estimated correlations tended to improve prediction, the advantage was small. A previous study had concluded no difference in accuracy for yield but did not include Australia and New Zealand, countries with the lowest correlations with other countries. Excluding bulls from those countries produced results for the other 8 countries more like the previous study, but still favoring E01 slightly. Those 2 countries were not in the SCS data. Estimated genetic correlations improved the prediction of future national evaluations slightly in most countries but more substantially for the evaluations and bulls of Australia and New Zealand.

(**Key words:** bull evaluation, genetics, Interbull, international evaluation)

Abbreviation key: Interbull = International Bull Evaluation Service, **MACE** = multiple-trait across-country evaluation, **SD** = standard deviation.

INTRODUCTION

The genetic merit of dairy animals from other countries has become essential information for breeding selection since the widespread availability of frozen semen. Quality of bull information has evolved from daughter averages, to use of foreign evaluation data without factual information on how they related to local evaluations, to field trials, to conversion equations, and finally to the multiple-trait across-country evaluations (**MACE**; Schaeffer, 1994) provided by the International Bull Evaluation Service (**Interbull**) with the inclusion of estimated genetic correlations between countries. Even if accuracy in the resulting evaluations is not improved, the convenience of the Interbull service relative to the laborious processes of each country performing pairwise calculations of country-conversion equations should not be disregarded. However, investigation of MACE aspects such as the use of estimated genetic correlations is warranted. Genetic correlations between evaluations in different countries may be less than unity because of genotype-by-environment interaction (genes have different effects in different environments), differences in how traits are measured (e.g., inclusion of first lactations vs. all lactations), or evaluation model differences. The aim in estimating correlations for each country pair is to improve accuracy of evaluations across countries. One result is that bulls typically rank differently in different countries.

Studies have shown that the addition of foreign data to domestic data improves the prediction of subsequent national evaluations (Powell et al., 2000). Available national evaluations from all contributing countries are processed together by Interbull and evaluations are returned to each country on their own scale. Even when based entirely on foreign daughters, these evaluations have been shown to be good predictors of later domestic

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evaluations (Powell et al., 2004a). However, some studies have raised concern about whether use of the data is optimized across countries. Weigel and Powell (2000) found that MACE predictions were no more effective than former predictions based on pairwise conversion equations. Moreover, Powell and Norman (2000) showed that, for yield traits, the use of specific genetic correlations for each country pair was no more accurate than assuming that the genetic correlations were essentially unity (0.995). However, Australia and New Zealand, which have the lowest estimated correlations with most of the other countries, were not included in that study. These findings did not suggest that it was incorrect to use estimated genetic correlations; however, they raised the question of whether that use was justified without an improvement in accuracy. The considerable differences among countries in rankings of top bulls, which are a consequence of using estimated genetic correlations, lead to confusion in international marketing. Foreign evaluations for SCS have been shown to provide useful predictions of future national evaluations (Powell et al., 2004b), but the influence of genetic correlations on accuracy of predictions has not been studied.

Banos et al. (2001) found that the imposition, in one country, of cow paternity errors averaging 11% reduced estimated genetic correlations with other countries by about 5%. This portion of the difference from a unity genetic correlation is not due to biology, model, or trait definition; thus, the resulting estimated genetic correlations could be considered artificially low. The appropriate genetic correlation that would optimize prediction of bull genetic merit across countries may be at some point between the estimated genetic correlation and unity.

The merit of using estimated genetic correlations in the Interbull procedure can be investigated by comparing evaluations calculated using estimated correlations with evaluations calculated assuming unity correlations for accuracy of prediction of later national evaluations. The objective of this study was to investigate the appropriateness of the current system and the influence of estimated genetic correlations relative to unity correlations on evaluations in various countries.

MATERIALS AND METHODS

Data

Using all data submitted for May 2001 yield and SCS evaluations, the Interbull Center recalculated those evaluations, once including application of estimated genetic correlations between countries (**E01**), and once assuming unity (0.995) correlations (**U01**). These were matched with the national evaluations submitted to Interbull for August 2004 (**N04**) by 10 countries including Australia, Canada, France, Germany, Great Britain, Ireland, Italy, New Zealand, The Netherlands, and the United States. Of these countries, only Canada, France, Germany, Great Britain, The Netherlands, and the United States had participated in the Interbull SCS evaluation in 2001. The 2001 evaluations for Canada and France were adjusted to the August 2004 base by applying the accumulated annual base changes. The evaluations for other countries were not affected by scheduled base changes, which occur only every 5 yr (recently in 2000 and 2005). Estimated genetic correlations applied for E01 protein ranged from 0.87 to 0.95 among the 8 northern hemisphere countries. Estimated genetic correlations for those countries and Australia or New Zealand were 0.77 to 0.84 and between Australia and New Zealand, 0.90. Genetic correlations among the 6 countries with SCS data ranged from 0.87 to 0.96. An explanation of procedures for estimation of genetic correlations and correlations estimated for all country pairs in May 2001 are provided by Interbull (2001).

Bulls were selected to provide independent Interbull evaluations for comparison with the more recent national evaluations from each country (i.e., the 2001 Interbull evaluation and the 2004 national evaluation were from completely different contributing daughters). Bulls included in analysis for each country had N04 evaluations, but did not have national data from that country included in E01 and U01. For simplicity, these are referred to as foreign bulls, and for the vast majority, the daughters included in N04 were from imported semen.

During 2002, Austrian data were incorporated into the German evaluations and data from the Flemish part of Belgium were incorporated into The Netherlands' evaluations. To ensure the independence of daughters in 2001 and 2004 evaluations, bulls whose Austrian and Belgian daughters were included in the Interbull evaluations in May 2001 were considered to have had German and Dutch daughters, respectively. For example, a bull having Austrian but no German daughters in 2001 would still not be included in the German evaluation analysis, as the N04 evaluation would include the same Austrian daughters included in the Interbull 2001 evaluations.

Before November 2002, Holstein bulls used through imported semen needed to have at least 75 daughters in at least 50 herds to be included in the Interbull analysis. Since then, countries have been allowed more discretion. Although the requirements for mandatory inclusion increased to 150 daughters in 50 herds, bulls could be included with as few as 10 herds if the evaluations were considered official nationally (Interbull, 2002). Although some countries (New Zealand and the

United States) do not distinguish between imported-semen and other bulls when determining official status of national evaluations, most impose higher requirements than for domestic bulls, or consider such national evaluations as unofficial regardless of local data (France). These provisions are based on concern that evaluations of foreign bulls might be biased due to prior selection, differential use of semen, or preferential treatment of daughters. Evaluations were included in N04 data regardless of officiality; however, the subset of bulls having official national evaluations in August 2004 was also studied. Note that this discussion regards the status of the national evaluation only, as submitted to Interbull, not the determination of whether the national or the Interbull evaluation is the official one following the Interbull processing.

Methods

Analyses were conducted separately for each country's evaluations. Restricting the bulls to those with an N04 evaluation but without daughters from that country contributing to the E01 and U01 evaluations allowed comparison of E01 and U01 as predictors of a completely independent N04 (i.e., based on completely different daughters). Standard deviations (**SD**) of differences between E01 or U01 and N04 were calculated.

Pearson product-moment correlations (SAS Institute, 2003) were computed for E01 and U01 with N04 to provide an indication of whether estimated genetic correlations by country pair or the assumption of unity correlations most correctly ranked bulls relative to the national evaluation in 2004. Although correlations reflect ranking, SD of differences measure how close the prediction is to the actual EBV for local daughters. Thus, high correlations between subsequent evaluations for a subset of bulls (i.e., bulls rank the same within the subset) do not necessarily show high accuracy of the evaluations relative to the larger national population. Consideration of both criteria is needed to assess the quality of international predictions for future EBV. Besides the product-moment correlations, which measure agreement in proportional ranking, Lin's concordance coefficients (Lin, 1989), which also consider changes in mean values, were also computed (R Development Core Team, 2004).

In addition to the question of how application of genetic correlations affects the expression of international evaluations by country of evaluation is the question of how bulls from different countries fare in accuracy of their prediction across country scales. The correlations of E01 and U01 with each N04 were recalculated by home country (country of most daughters in May 2001) and country of evaluation. For each home country, the mean correlation across country scales was computed weighting each correlation by the number of contributing bulls. These weighted mean correlations describe the accuracy of evaluations by country of origin (home country) rather than country of evaluation.

To measure the applied impact of alternative approaches to genetic correlations, bulls were ranked on E01 and U01, and the top 100 bulls were compared. The number different among the top 100 was determined, and the N04 for bulls that differed were compared to see which approach gave the better predictor. Means of N04 for the 2 groups of top-100 bulls were computed to provide a measure of the impact on selection (a function of number of different bulls and the N04 for those bulls).

Table 1. Numbers of Holstein bulls with both an Interbull evaluation in May 2001, including no national[1] daughters, and a national evaluation submitted to Interbull in August 2004, and the subset of bulls with those national evaluations designated as official (official bulls), with median numbers of daughters in the national 2004 evaluation, by national evaluation scale.

	All bulls		Official bulls	
National scale	Bulls (no.)	Daughters (median)	Bulls (no.)	Daughters (median)
	Yield			
Australia	374	77	160	171
Canada	324	65	127	144
France	601	101	16	107
Germany	467	67	305	107
Great Britain	728	81	273	272
Ireland	389	67	146	199
Italy	322	87	250	132
New Zealand	331	70	331	70
The Netherlands	425	69	268	134
United States	253	55	253	55
	SCS			
Canada	316	63	122	142
France	390	59	26	114
Germany	449	65	311	102
Great Britain	635	71	338	166
The Netherlands	586	101	384	125
United States	208	55	208	55

[1]National daughters are daughters in the country of the national scale being considered.

RESULTS AND DISCUSSION

For the 10 national evaluations considered, numbers of bulls without local daughters in the May 2001 Interbull evaluation but having an available or official national evaluation for August 2004 are shown in Table 1. Due to the United States' recent history as an exporter rather than an importer of bull semen, the numbers of bulls available for study were fewest for the United States. For yield, numbers of bulls ranged from 253 for the US analysis to 728 for the British. Numbers

of bulls were generally less for SCS evaluations, and 4 countries were not participants in the earlier SCS analysis by Interbull. Median number of daughters in N04 ranged from 55 to 101.

The difference between the numbers of bulls available for yield or SCS varied considerably across countries, apparently due to relative completeness of SCS data in the population and differences between requirements for release of SCS or yield evaluations within countries. For example, The Netherlands had more qualifying bulls for SCS than for yield. This can be explained by a higher requirement on number of daughters for SCS. Bulls with official national yield evaluations in 2001 (thus having national data included in 2001 Interbull evaluations, excluding the bull from analysis for yield) might not have had enough daughters for official national SCS evaluations in 2001 (i.e., providing no national data for use in 2001 Interbull evaluations). If they met the national SCS daughter requirement by 2004, they were eligible for the SCS study, assuming daughters from some other country had provided data for the 2001 Interbull evaluations.

The proportion of qualifying foreign bulls that had official national evaluations in 2004 differed widely. All bulls for the New Zealand and US evaluations were official; whereas on the other extreme, very few were official for France (only simultaneously sampled bulls, not imported-semen bulls). In between were the countries that have higher national officiality requirements for imported-semen bulls than for domestic bulls. For evaluations designated as official, median number of daughters ranged from 55 to 272 (yield) or 166 (SCS).

The SD of change from May 2001 Interbull evaluations to the November 2004 national evaluation (E01 – N04 and U01 – N04) are in Table 2. When considering bulls regardless of officiality of the national 2004 evaluation, the SD of change was smaller for 2001 Interbull evaluations calculated with estimated genetic correlations between countries in all cases. Typically, the reduction in SD of differences by using estimated genetic correlations was about 7%, but for Australia it was about 10% and for New Zealand, 15 to 18%. If bulls from Australia and New Zealand were excluded, the reduction in SD of differences was only about 4% for all other countries. Ireland is often considered along with Australia and New Zealand as a grazing country, for example, in the current procedures for estimation of genetic correlations (Interbull, 2004). The disparity between SD of differences for E01 and U01 (SD lower for E01) was greater than for other northern hemisphere countries, similar to that for Australia, but not as extreme as for New Zealand.

When considering only bulls with national evaluations designated official in August 2004, the SD of change were usually the same or lower than for all bulls. That was expected because most countries have higher requirements for official status than the 10 herds required for submission to Interbull. The exception is France where there were very few foreign bulls with official evaluations, and the SD of change were larger. The ratios of SD for the subset of official bulls were similar to those for all bulls. Many differences in national systems affect the magnitude and SD of change between the E01 or U01 and N04 evaluations such that comparisons across countries are not appropriate. However, these factors would be the same within country for E01 and U01 as the same bulls and data are included.

Correlations of E01 and U01 with N04 are in Table 3. In all cases, the correlations were the same or favored E01. However, as with SD of differences, there was seldom a substantial discrepancy; the most frequent difference was 0.01. Exceptions were for Australia and New Zealand where correlations for yield were higher by 0.02 to 0.05 for E01. For comparison, results from major changes in evaluation systems are often correlated with previous results by 0.99 or more. Differences in correlations for Ireland did not exceed 0.01. Exclusion of bulls from Australia and New Zealand reduced the difference in correlations in nearly all cases, but usually by less that 0.01 (data not shown). Concordance coefficients were similar to product-moment correlations and again favored E01; however, differences between concordances for E01 and U01 were slightly higher than for correlations in many cases.

Similar calculations to those presented in Table 3 but limited to bulls with official N04 evaluations yielded very similar results except for France where the small number of bulls having official evaluations had correlations higher for U01 than E01 by 0.03 to 0.09 for yield traits. Correlations for E01 and U01 were essentially the same for Australian bulls on the New Zealand scale and vice versa (data not shown). For the 6 countries with SCS data, differences in correlations were not more than 0.01.

Whereas Table 3 presents the comparisons of correlations based on country of evaluation, Table 4 shows the results for yield by home country of bulls. A similar pattern emerged for home country as for country of evaluation; correlations for E01 were the same or higher than for U01 and differences were generally very small. Exceptions were for New Zealand bulls, with correlations that differed by 0.04 to 0.11 and, to a much lesser extent, bulls from Australia (fat and protein), Belgium and Denmark (milk and protein), and Germany (fat). Table 5 shows corresponding figures for SCS. Again, correlations were the same or higher for E01 than for U01. The largest difference was 0.02 (Denmark) but others were 0.00 or 0.01.

Table 2. Standard deviation (SD) of change from May 2001 Interbull EBV, calculated with genetic correlations estimated between countries (E01) or assumed 0.995 (U01), and corresponding August 2004 EBV (N04) and ratios of these SD, for Holstein bulls having no national[1] daughters in the 2001 EBV and the subset of bulls with those national evaluations designated as official (official bulls), by national scale, for yield traits and SCS.

	All bulls			Official bulls		
	SD of change[2]		Ratio[3]	SD of change[2]		Ratio[3]
National scale	E01 – N04	U01 – N04	of SD	E01 – N04	U01 – N04	of SD
	Milk					
Australia	281	312	0.90	262	273	0.96
Canada	436	453	0.96	409	428	0.96
France	338	361	0.94	604	618	0.98
Germany[2]	382	396	0.97	359	376	0.96
Great Britain	296	311	0.95	305	311	0.98
Ireland	204	222	0.92	179	194	0.92
Italy	335	348	0.96	307	317	0.97
New Zealand	197	237	0.83	197	237	0.83
The Netherlands	364	380	0.96	349	366	0.95
United States	363	385	0.94	363	385	0.94
	Fat					
Australia	12.0	13.4	0.90	11.4	12.0	0.95
Canada	17.7	18.2	0.97	15.4	16.1	0.96
France	13.8	14.5	0.95	20.8	20.3	1.03
Germany[2]	14.3	15.0	0.95	13.2	13.8	0.95
Great Britain	11.6	12.6	0.92	10.8	11.5	0.94
Ireland	7.7	8.4	0.92	6.8	7.2	0.95
Italy	13.0	13.6	0.95	12.8	13.2	0.97
New Zealand	8.1	9.5	0.85	8.1	9.5	0.85
The Netherlands	14.6	15.2	0.96	14.2	14.9	0.95
United States	15.1	16.0	0.95	15.1	16.0	0.95
	Protein					
Australia	7.1	8.1	0.88	6.5	7.2	0.91
Canada	13.0	13.3	0.97	12.5	12.9	0.97
France	9.6	10.0	0.96	15.4	14.9	1.03
Germany[2]	11.6	11.9	0.97	11.0	11.5	0.96
Great Britain	8.5	9.1	0.94	8.4	8.8	0.96
Ireland	6.0	6.6	0.91	5.6	6.0	0.93
Italy	9.8	10.3	0.95	9.0	9.3	0.97
New Zealand	6.4	7.8	0.82	6.4	7.8	0.82
The Netherlands	10.7	11.3	0.95	10.3	11.0	0.94
United States	10.1	11.0	0.92	10.1	11.0	0.92
	SCS					
Canada	0.31	0.32	0.98	0.29	0.29	0.99
France	0.64	0.67	0.96	0.89	0.88	1.02
Germany[2]	0.30	0.29	0.95	0.28	0.29	0.95
Great Britain[3]	13.71	14.48	0.95	13.52	14.35	0.94
The Netherlands[3]	5.67	6.09	0.93	5.46	5.85	0.93
United States	0.29	0.30	0.97	0.29	0.30	0.97

[1]National daughters are daughters in the country of the national scale being considered.

[2]Change is E01 – N04 or U01 – N04.

[3]Ratio is $SD_{(E01 - N04)}/SD_{(U01 - N04)}$.

To investigate the practical implications of selecting bulls based on evaluations calculated using estimated genetic correlations between countries, the 2004 national evaluations of the top 100 bulls in corresponding E01 and U01 data were compared. Mean N04 evaluations for both groups of 100 bulls are in Table 6. Differences generally favored bulls selected from evaluations calculated with estimated genetic correlations, but the magnitude of mean differences was small. The majority of bulls in either top 100 were common for both selection criteria. The unique bulls on each list give a practical indication of how selection might differ using either method. The number of unique bulls and mean difference in N04 for these bulls are also in Table 6. For US evaluations, the 4 bulls in the E01 top 100 only (i.e., not in the U01 top 100) had mean EBV milk 189 kg higher than their counterparts (in the U01 top 100 only) did. However, when averaged with the 96 bulls in com-

Table 3. Correlations and concordance coefficients of national EBV in August 2004 (N04) with corresponding Interbull EBV from May 2001 calculated with genetic correlations either estimated between countries (E01) or assumed 0.995 (U01), by national scale, for Holstein bulls having no national[1] daughters in the 2001 EBV.

National scale	Correlations with N04		Difference[2] in correlation	Concordance with N04		Difference[2] in concordance
	E01	U01		E01	U01	
			Milk			
Australia	0.80	0.77	0.03	0.77	0.72	0.05
Canada	0.86	0.85	0.01	0.85	0.84	0.01
France	0.87	0.86	0.01	0.86	0.85	0.01
Germany	0.83	0.83	0.00	0.77	0.73	0.04
Great Britain	0.85	0.85	0.01	0.85	0.84	0.01
Ireland	0.86	0.86	0.01	0.86	0.84	0.02
Italy	0.84	0.83	0.01	0.83	0.82	0.01
New Zealand	0.71	0.65	0.05	0.70	0.63	0.07
The Netherlands	0.83	0.82	0.01	0.82	0.81	0.01
United States	0.90	0.89	0.01	0.88	0.87	0.01
			Fat			
Australia	0.71	0.68	0.02	0.68	0.65	0.03
Canada	0.82	0.81	0.01	0.80	0.80	0.01
France	0.84	0.83	0.01	0.83	0.81	0.02
Germany	0.80	0.79	0.01	0.72	0.69	0.03
Great Britain	0.74	0.71	0.02	0.68	0.64	0.04
Ireland	0.80	0.79	0.01	0.79	0.78	0.01
Italy	0.80	0.79	0.01	0.75	0.73	0.02
New Zealand	0.69	0.65	0.05	0.67	0.60	0.07
The Netherlands	0.80	0.79	0.02	0.77	0.76	0.01
United States	0.81	0.80	0.01	0.80	0.78	0.02
			Protein			
Australia	0.77	0.74	0.03	0.75	0.70	0.05
Canada	0.88	0.87	0.01	0.88	0.87	0.00
France	0.88	0.87	0.01	0.88	0.87	0.01
Germany	0.83	0.82	0.01	0.79	0.76	0.03
Great Britain	0.84	0.83	0.01	0.83	0.82	0.02
Ireland	0.84	0.84	0.00	0.84	0.83	0.01
Italy	0.81	0.79	0.02	0.78	0.76	0.02
New Zealand	0.69	0.66	0.03	0.67	0.60	0.07
The Netherlands	0.84	0.82	0.02	0.81	0.79	0.02
United States	0.90	0.88	0.02	0.89	0.86	0.02
			SCS			
Canada	0.71	0.71	0.00	0.70	0.70	0.00
France	0.76	0.75	0.01	0.45	0.44	0.01
Germany	0.73	0.72	0.00	0.72	0.72	0.01
Great Britain	0.76	0.75	0.01	0.76	0.75	0.01
The Netherlands	0.74	0.72	0.01	0.73	0.71	0.02
United States	0.69	0.68	0.01	0.69	0.68	0.01

[1]National daughters are daughters in the country of the national scale being considered. Foreign daughters are from countries other than the country of national scale.

[2]Differences (E01:N04 – U01:N04) calculated before rounding.

mon (zero difference), the mean advantage for the E01 list was only 12 kg. Although a few individual bulls will differ in true merit as represented by N04, differences are small when selecting a larger group of bulls. As expected, Australia and New Zealand generally had the most different bulls in their top 100 lists, but the difference in the N04 merit of the different bulls was not unusual.

CONCLUSIONS

Increasing international distribution of semen has created the opportunity to use hundreds of 2004 national evaluations of foreign bulls to assess the predictive quality of Interbull evaluations when the evaluations included completely independent daughters. Most SD of differences and correlations favored the use

Table 4. Weighted mean correlations of national EBV milk, fat, and protein in November 2004 (N04) with corresponding Interbull EBV from May 2001 calculated with genetic correlations either estimated between countries (E01) or assumed 0.995 (U01), by country of most daughters in the 2001 EBV (home country), and total contributions of home country bulls across national scales, for Holstein bulls having no national[1] daughters in the 2001 EBV.

		Weighted mean correlation with N04 and differences in correlations								
		Milk			Fat			Protein		
Home country	Bull contributions	E01	U01	Difference[2]	E01	U01	Difference[2]	E01	U01	Difference[2]
Australia	74	0.79	0.78	0.00	0.73	0.71	0.02	0.76	0.74	0.02
Belgium	20	0.68	0.66	0.03	0.69	0.67	0.01	0.44	0.41	0.03
Canada	730	0.80	0.78	0.01	0.74	0.73	0.01	0.79	0.78	0.01
Czech Republic	16	0.88	0.88	0.00	0.95	0.93	0.01	0.82	0.81	0.01
Denmark	56	0.73	0.69	0.04	0.78	0.76	0.02	0.72	0.67	0.05
France	370	0.80	0.80	0.00	0.69	0.69	0.01	0.79	0.79	0.00
Germany	120	0.84	0.84	0.00	0.75	0.72	0.03	0.79	0.78	0.01
Great Britain	121	0.89	0.88	0.01	0.81	0.81	0.00	0.84	0.82	0.02
Ireland	6	0.88	0.87	0.01	0.94	0.93	0.01	0.91	0.90	0.01
Italy	216	0.75	0.75	0.00	0.75	0.75	0.00	0.73	0.72	0.00
New Zealand	162	0.85	0.75	0.11	0.64	0.60	0.04	0.82	0.74	0.09
Swiss Red Holstein	39	0.65	0.65	0.00	0.61	0.61	0.00	0.69	0.69	–0.01
The Netherlands	530	0.86	0.88	0.00	0.81	0.81	0.00	0.81	0.81	0.00
United States	1716	0.81	0.79	0.02	0.75	0.74	0.02	0.81	0.79	0.01
All	4214	0.84	0.82	0.01	0.78	0.76	0.02	0.83	0.82	0.01

[1]National daughters are daughters in the country of the national scale being considered. Foreign daughters are from countries other than the country of national scale.

[2]Differences (E01:N04 – U01:N04) calculated before rounding.

of estimated genetic correlations over assuming unity correlations. The advantages were minor except for scales and bulls from Australia and New Zealand. The results for most of the countries supported the conclusions of Powell and Norman (2000), who reported that there was essentially no difference in accuracy of prediction between estimated and unity genetic correlations. However, the typically modest differences (0.01 for correlations and 5 to 7% reduction for SD of differences) favored the estimated correlation approach in this study, whereas the results were mixed in the earlier study. This study was motivated by the question of how conclusions might differ with the inclusion of Australia and New Zealand, whose participation in Interbull evaluation was too recent to have been included in that earlier report. Excluding those countries from the analysis decreased the minor advantages of E01 over U01.

Accuracy of predictions of future, independent national evaluations for Australia and especially New Zealand were improved considerably with the application of estimated genetic correlation in the Interbull process. Interbull evaluations for New Zealand bulls

Table 5. Weighted mean correlations of national EBV SCS in November 2004 (N04) with corresponding Interbull EBV from May 2001 calculated with genetic correlations either estimated between countries (E01) or assumed 0.995 (U01), by country of most daughters in May 2001 (home country), and total contributions of home country bulls across national scales, for Holstein bulls having no national[1] daughters in the 2001 EBV.

		Mean correlation with N04		Difference[2] in correlations
Home country	Bull contributions	E01	U01	
Canada	534	0.71	0.70	0.01
Denmark	42	0.74	0.72	0.02
France	256	0.78	0.78	0.00
Germany	89	0.77	0.77	0.00
Great Britain	29	0.78	0.77	0.00
The Netherlands	312	0.77	0.76	0.00
United States	1315	0.72	0.71	0.01
All	2584	0.71	0.70	0.01

[1]National daughters are daughters in the country of the national scale being considered. Foreign daughters are from countries other than the country of national scale.

[2]Differences (E01:N04 – U01:N04) calculated before rounding.

Table 6. Mean August 2004 national EBV (N04) for bulls having the top 100 May 2001 Interbull evaluations calculated with genetic correlations either estimated between countries (E100) or assumed 0.995 (U100), by national scale, for Holstein bulls having no national[1] daughters in the 2001 EBV, and numbers of different bulls between E100 and U100.

Trait	National scale	Unique bulls in E100 or U100, no.	N04		Difference[2] in N04 for unique bulls
			E100	U100	
Milk, kg					
	Australia	14	745	733	85
	Canada	6	1785	1794	–151
	France	8	720	706	173
	Germany	11	1630	1613	159
	Great Britain	6	1466	1476	–169
	Ireland	7	897	902	–66
	Italy	6	1466	1486	–334
	New Zealand	17	1430	1412	103
	The Netherlands	4	1169	1168	27
	United States	4	971	963	189
Fat, kg					
	Australia	14	19.3	18.9	2.8
	Canada	5	49.8	50.6	–14.8
	France	10	23.7	23.3	4.1
	Germany	10	46.8	46.6	2.0
	Great Britain	7	30.6	30.1	7.1
	Ireland	14	24.7	24.7	–0.1
	Italy	7	54.8	53.9	13.6
	New Zealand	13	34.2	33.0	9.1
	The Netherlands	14	24.7	22.8	13.4
	United States	5	35.0	35.6	–12.7
Protein, kg					
	Australia	22	19.2	18.6	2.6
	Canada	8	55.5	55.8	–3.1
	France	8	17.8	17.1	9.0
	Germany	7	49.6	48.9	10.1
	Great Britain	7	40.2	40.2	–0.2
	Ireland	10	24.5	24.4	0.2
	Italy	5	47.3	47.2	1.8
	New Zealand	15	39.9	39.6	1.7
	The Netherlands	9	27.0	27.1	–0.8
	United States	6	32.8	31.9	14.1
SCS[3]					
	Canada	6	6.37	6.36	0.16
	France	5	0.52	0.50	0.16
	Germany	8	0.99	0.98	0.25
	Great Britain	9	30.92	31.30	–4.32
	The Netherlands	6	209.72	209.66	0.87
	United States	6	6.49	6.48	0.19

[1]National daughters are daughters in the country of the national scale being considered. Foreign daughters are from countries other than the country of national scale.

[2]Differences ($N04_{(E100)} - N04_{(U100)}$) calculated before rounding.

[3]Higher values are preferable (i.e., indicate lower SCC) on the SCS scales for France and The Netherlands, whereas lower values indicate superior merit on the other SCS scales presented.

were also more highly correlated with their evaluations on other national scales when estimated genetic correlation were applied to the earlier data. Australian and New Zealand bulls were predicted about equally as well on the other's scale by either E01 or U01. Thus, E01 was not superior between Australia and New Zealand, or to an important degree among the other countries, but was useful between the country groups. This supports the suggestion of H. Wilmink (personal communication, 2002) that certain blocks of countries could be considered as having unity correlation within the block and nonunity correlations only between blocks. A minor loss of precision in the estimates for foreign bulls would be outweighed by the advantage of nearly identical rankings of bulls within countries in a block, which would reduce confusion and increase credibility.

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