Possible Global Scale for Ranking Dairy Bulls by Combining International Evaluations Expressed on National Scales

R.L. Powell, P.M. VanRaden
Animal Improvement Programs Laboratory, Agricultural Research Service, United States Department of Agriculture, Beltsville, MD, USA 20705-2350

Abstract

Genetic evaluations for Holstein bulls on a global scale were calculated by weighting May 2001 Interbull (International Bull Evaluation Service) evaluations expressed on 27 national scales. Interbull evaluations on national scales were weighted by the country's proportion of total daughters from all bulls (population size). Correlations within birth year between Interbull evaluations on national scales and evaluations on a global scale ranged from 0.961 to 0.998 (mean of 0.988). Number of top 100 bulls for protein yield that were in common between national and global scales ranged from 54 to 94 and was related significantly to mean genetic correlation used in the Interbull analysis between a country and all other countries. Weighting of Interbull evaluations on national scales was fairly robust; alternatives of equal weighting or weighting by inverse of population size produced practically the same group of top bulls as weighting by population size. Correlations among the three global scales within birth year were 0.999. Thus, the method for combining Interbull evaluations expressed on national scales had only minor impact and was much less important than use of all data.

Keywords: Genetic evaluation; International ranking; National scale; Dairy cattle

1. Introduction

The need for procedures to express genetic evaluations of dairy bulls across national borders has long been recognized. Groups meeting under auspices of the European Association for Animal Production and the International Dairy Federation date back to the early 1970s (Galliard et al., 1977). Their efforts resulted in the formation of Interbull in 1983. Discussions at early Interbull meetings often dealt with proposed improvements to methods for calculating equations to convert evaluations from one national scale to another and sharing of related experiences. Because conversion equations could be developed between only two countries at a time, their calculation and application were tedious. In addition, most of the dairy industry did not understand that equations between countries would not be reciprocal, which led to much confusion and mistrust.

Schaeffer (1985) proposed an approach that combined national evaluations by using male pedigree information to provide ties between countries. Interbull implemented this procedure in August 1994 with an assumed genetic correlation (r_g) of 1.0. Bull evaluations were presented on each national scale, and the ranking of bulls was the same in all countries. However, even before that time, it was recognized that rankings could and should differ among countries. Schaeffer (1994) provided a new method: multiple-trait, across-country evaluation, MACE, which uses estimates of r_g for each pair of countries and results in rankings that differ on each national scale. In February 1995, MACE was used with an r_g of 0.995 for all country pairs because an estimation method for r_g had not been developed. Because r_g 1, essentially the same ranking of bulls resulted for all national scales. In August 1995, estimated r_g were used for Interbull evaluations, and rankings again differed on each scale as they had with conversion equations.

Although variable rankings were seen as appropriate, considerable challenges resulted for non-participating countries and to a much lesser extent for international marketers. For the former, an assumption of r_g=1 allowed the use of any national scale for sire selection because bull rankings were the same regardless of country. With r_g 1, the scale of one participating country would have to be selected to ensure that all data were comparable. Although the goal is to use evaluations that best predict a bull's genetic merit in the local environment, criteria for selection of a national scale are not obvious. Familiarity, temperature, humidity, management techniques, evaluation system, and genetic similarity are all factors that could be used.

Selection on a global scale was suggested by van der Beek (1999). He investigated weighting Interbull evaluations by the largest eigenvector of the genetic correlation matrix. The result of this procedure was similar to a simple mean of national scales.

For marketers, the existence of a trait evaluation on more than two dozen national scales makes presentation of materials difficult, particularly for sales efforts in non-participating countries or that use magazines or other printed material that are distributed globally. For example, an advertisement for one bull included his protein ranking in nine countries (Holstein International, 2001).

The objective of this study was to examine methods for combining Interbull evaluations into a common global evaluation and to compare global and national scales.

2. Materials and Methods

Data were May 2001 Interbull yield evaluations for Holstein bulls (Interbull, 2001). The 65,472 bulls were born during 1984 or after; their Interbull evaluations included information from nearly 24 million daughters with milk, fat, and protein records. Bulls were required to have a protein evaluation, and only protein results are presented. Although data were from 24 countries, Denmark, France, and Switzerland have separate evaluations for red Holsteins, which results in 27 Holstein populations. For simplicity of presentation, the red Holstein populations are regarded as separate countries.

Global evaluations were calculated by weighting standardized Interbull yield (milk, fat, and protein) evaluations expressed on national scales. To standardize an Interbull evaluation, national mean for the yield trait was subtracted from the evaluation, and the result was divided by national standard deviation (SD) for the trait, which had been computed from the country's evaluations. Sire SD from Interbull were not used because those SD units differed from evaluation units for Nordic countries. Weights for standardized evaluations were the proportion of a given country's daughters to total daughters from all countries (Table 1) and represented market share among participating countries. The weighted evaluations were on an SD basis and could be re-scaled if desired. To determine the impact of the weighting scheme, simple mean of standardized evaluations (equal weighting) was examined as well as application of reciprocals (inverses) of weights divided by sum of reciprocals.

Correlations were computed between Interbull evaluations on each national scale as well as with global evaluations. Computation of correlations was within birth year (i.e., from residuals after fitting birth year) so that genetic trend would not increase correlations inappropriately. Top 100 bulls on each national scale were compared with top 100 bulls on the global scale to determine number of bulls in common. Characteristics of countries with more or fewer bulls in common were examined.

3. Results and Discussion

Correlations among Interbull evaluations on national scales ranged from 0.915 to 0.995 (mean of 0.976). Correlations of evaluations on national scales with the global scale (Table 1) ranged from 0.961 to 0.998 (mean of 0.988).

The number of top 100 bulls for protein yield that were in common between national and global scales ranged from 54 to 94 and was significantly (P<0.001) related to mean r_g between a country and all other countries. Not surprisingly, countries with the lowest mean r_g with other countries (Australia and New Zealand) had the fewest top bulls in common with the global scale. However, that relationship was not significant for the other 25 Holstein populations. Number of top bulls in common was highly and significantly (P<0 .001) correlated with correlation of national and global scales for all countries.

Table 1. Proportion of bull daughters by country, correlations between national and global scales, numbers of bulls in common between top 100 on the national and global scales, and mean r_g with other countries

Country	Proportion of daughters (%)	Correlation with global evaluation	No. of top bulls in common	Mean r_g
USA	17.4	0.988	78	0.89
Germany	15.3	0.991	76	0.87
France	12.3	0.994	82	0.88
New Zealand	10.6	0.961	56	0.79
Netherlands	9.3	0.995	81	0.90
Canada	4.7	0.991	77	0.89
UK	4.7	0.989	80	0.89
Australia	4.5	0.961	54	0.80
Italy	4.3	0.989	81	0.87
Denmark	4.1	0.995	87	0.89
Poland	1.6	0.986	83	0.87
Sweden	1.5	0.991	84	0.88
Spain	1.2	0.994	93	0.88
Czech Republic	1.2	0.965	67	0.86
Belgium	1.2	0.995	86	0.89
Ireland	1.1	0.978	67	0.88
Hungary	1.0	0.990	79	0.87
Israel	0.9	0.988	81	0.86
Switzerland (Red)	0.8	0.993	84	0.88
Finland	0.8	0.991	80	0.88
Switzerland	0.4	0.990	77	0.88
South Africa	0.3	0.993	86	0.86
Estonia	0.3	0.993	91	0.86
Slovenia	0.1	0.997	91	0.86
Austria	0.1	0.988	85	0.86
Denmark (Red)	0.1	0.993	88	0.87
France (Red)	0.1	0.998	94	0.88

Other explanations for country differences in the number of top bulls in common with the top bulls globally failed statistical tests. Estonia, France (Red), and Slovenia were among countries with the highest numbers (>90) of top bulls in common. Their smaller populations (<1% of total daughters) might suggest difficulty in estimation of r_g and, therefore, use of less scientifically based r_g (Interbull, 2001). However, Israel, South Africa, and Switzerland (Red), which had as many or more estimation difficulties (Interbull, 2001), had modest numbers (81-86) of bulls in common with the global top 100. Variation in r_g with other countries was thought to be related inversely to number of top bulls in common. A country that has similar r_g with other countries already has somewhat of a global evaluation, which might explain why the USA had the highest variation in r_g, and its number of top bulls in common with the global top bulls (78) was below mean (80). However, the correlation was not significant between number of top bulls in common and variation in r_g with other countries. A country with many of its own bulls among top bulls on its national scale (such as the USA and Netherlands) also may have fewer bulls on a global scale. Although the correlation between number of domestic bulls among top bulls on national and global scales was negative, it was not significant. Because only 27 Holstein populations were involved, some true relationships could have been masked by conflicting effects. Multiple regression to predict number of common top bulls from mean r_g, SD of r_g, and numbers of domestic bulls on national and global scales showed that only effect of mean r_g was significant ($P<0.05$), and that significance disappeared in a re-analysis without Oceania.

Applying equal weights to standardized Interbull evaluations on national scales did not result in important changes in top bulls (Table 2). Correlation within birth year between equal weighting and weighting by population size for global ranking was 0.9994. Correlations of Interbull evaluations on national scales with global evaluations based on equal country weighting were slightly higher than those with global evaluations weighted by population size and ranged from 0.967 to 0.998 (mean of 0.989). Of the top 100 bulls on global scales that were equally weighted or weighted by population size, 97 were in common. Because a fractional unit difference can change a bull's inclusion on either global ranking of top bulls, differences in the two weighting methods had essentially no impact on ranking of top bulls and, therefore, the countries represented among those bulls.

Using inverse weighting to combine Interbull evaluations on national scales to a global ranking resulted in exactly the same mean number of top bulls in common between national and global scales as was found with the original weighting by population size. Mean correlation between In terbull evaluations on national scales and the inversely weighted global scale was 0.988. Correlations among the three global scales are in Table 2, which also shows the numbers of bulls in common among the top 100. Although all weighting methods were highly related, the original weighting by population size and its inverse weighting were related the least as expected.

Table 2. Correlations[1] between global bull evaluations based on various weightings of Interbull evaluations expressed on national scales (above diagonal) and numbers of bulls in common among top 100 bulls for protein yield (below diagonal).

[1]Computed within birth year (i.e., from residuals after fitting birth year).

Weighting method	Weighted by national number of daughters	Equal weighting	Inverse weighting
Weighted by national number of daughters		0.9994	0.9989
Equal weighting	97		0.9997
Inverse weighting	95	97	

4. Conclusions

Evaluations on a global scale were calculated by weighting of standardized Interbull evaluations on 27 national scales. Weighting of evaluations was fairly robust in that weighting by number of contributing daughters, inverse of those weights, or equal weights for each country produced practically the same group of top bulls. Correlations within birth year among the three global scales were 0.999. Thus, the method for combining Interbull evaluations on national scales had only minor impact. This finding supports the conclusion results of others that the relevant issue is that all data are used rather than how data are combined. Powell and Norman (2000) showed that use of estimated r_g does not produce more accurate MACE evaluations than if r_g is assumed to be 1, which produces a global evaluation. Weigel and Powell (2000) demonstrated that the MACE approach to combining national evaluations was not more accurate than using. conversion equations.

Although all global scales were highly correlated, the top 100 bulls globally sometimes differed substantially from the top bulls on national scales. Although a global scale would be useful for marketing and support of reasonable selection decisions in countries that do not participate in Interbull, defining groups of countries that have highly related evaluations and developing subglobal scales could be useful. Then non-participating countries could select an appropriate scale based on countries with similar climate, feeding and management practices, and evaluation system.

References

Gaillard, C., Dommerholt, J., Fimland, E., Gol-Christensen, L., Lederer, J., McClintock, A.E. Mocquot, J.C. & Philipsson, J. 1977. A.I. bull evaluation standard for dairy and dual purpose breeds. *Livest. Prod. Sci. 4,* 115–128.

Holstein International. 2001. Sersia France advertisement. *Holstein Int. 8(6),* inside front cover.

International Bull Evaluation Service. 2001. *INTERBULL routine genetic evaluation for dairy production traits, May 2001.* http://www-interbull.slu.se/ eval/may01.html. Accessed July, 11, 2001.

Powell, R.L. & Norman, H.D. 2000. Impact of genetic correlations on accuracy of future evaluations. *J. Dairy Sci. 83 (July),* http://www.adsa.org/jds/ papers/ 2000/online/jul1552.htm. Accessed July 24, 2001. (Abstract: *J. Dairy Sci. 83,* 1552).

Schaeffer, L.R. 1985. Model for international evaluation of dairy sires. *Livest. Prod. Sci. 12,* 105–115.

Schaeffer, L.R. 1994. Multiple-country comparison of dairy sires. *J. Dairy Sci. 77,* 2671–2678.

Van der Beek, S. 1999. Exploring the (inverse of the) international genetic correlation matrix. *Interbull Bulletin 22,* 14-20.

Weigel, K.A. & Powell, R.L. 2000. Retrospective analysis of the accuracy of conversion equations and multiple-trait, across-country evaluations of Holstein bulls used internationally. *J. Dairy Sci. 83,* 1081–1088.