Optimum Use of MACE Information to Predict Composite Type Traits

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Introduction

Since August 1999, Interbull evaluations for conformation traits have been available for the Holstein breed and for other breeds in subsequent years. The current routine includes 16 linear traits and three composite traits (overall conformation, overall udder and overall feet & legs). Not all countries score the 16 'Interbull' linear traits and some countries score a higher number of type traits in their classification program. For example, the Canadian classification system scores 22 linear traits and five major scorecard traits (conformation, mammary system, feet and legs, rump and dairy strength), plus a series of defective characteristics. Countries differ also in the way they collect overall conformation. Some countries calculate overall conformation from the EBV of the linear traits, while others score overall conformation and estimate breeding values directly. As a consequence, countries also differ on how they publish MACE EBV for foreign bulls for overall conformation. Most countries predict the MACE EBV for conformation using the MACE EBV for the available linear traits, while others publish directly the EBV for overall conformation originating from MACE. Some European countries have challenged the latter practice, saying that their bulls were penalized (on those foreign scales where the MACE EBV was published directly) by this system. However, each country is responsible for the publication procedure of foreign bulls in their own scale. Thus, in the last few years some Interbull member countries have started to compute a second overall conformation with the objective of maximizing the genetic correlation with the United States. Since 2004, Canada has used a blending approach for MACE composite traits, which optimizes the use of all information from Interbull evaluations (Miglior *et al.*, 2004). The objective of this study was to illustrate the method when applied on country scales other than Canada and to compare it, in terms of average reliability, with using the MACE EBV or a Predicted EBV computed from linear traits.

Materials and Methods

All Interbull production evaluation summaries since May 2001 were used in order to observe the change in genetic correlations for overall conformation between some major dairy countries with US. Interbull EBV from August 2003 and May 2007 official runs were used for each country scale. On each country scale, only bulls with 1st crop daughters in that country were kept for the analysis to predict overall conformation using all available linear traits. Thus, all second crop bulls and dual-sampled bulls were excluded from this part of the analysis. This edit was performed in order to better approximate the domestic EBV on each country scale, which were input to the MACE evaluations.

Prediction equations were calculated within each country scale using multiple regression in SAS (PROC REG). Prediction equations were then applied to all foreign bulls on each country scale. Following Miglior *et al.* (2004), the reliability of the predicted overall conformation was calculated as the MACE reliability (on the local scale) of the linear traits used in the prediction equation weighted by the squared relative emphasis of each trait in the prediction equation. The reliability was then multiplied by the adjusted R-square obtained from the prediction of the multiple regressions (see Appendix). Reliabilities were then averaged within each country scale by country of origin of the bulls. Country of origin was assumed in this study as the country where the bull had the highest number of daughters.

Results and Discussion

Genetic Correlations: Figure 1 shows the genetic correlations over time for overall conformation between US and various countries. With the exception of Australia, genetic correlations have increased for every country (on average from 0.79 to 0.86). The largest changes between consecutive runs occurred for France (modified definition of overall conformation in November 2003) and Denmark. The drop in May 2005 for Denmark coincided with the start of the joint evaluation of Nordic countries (DFS) for conformation traits. The large increase for DFS in November 2006 was due to change in definition of overall conformation.

Multiple Regression: Figure 2 shows the adjusted R-square values within each country for the November 2003 and May 2007 runs. Values were as low as 0.78 for Australia in 2007 and as high as 0.9995 for Germany in 2007. The value of adjusted R-square helps to identify which countries use a prediction of EBV from linear traits to compute the EBV for overall conformation (e.g. Germany, Denmark, France and The Netherlands). A high value also indicates that MACE evaluations were available for most of the linear traits included in overall conformation for these countries. The countries with lowest adjusted R-square values (Australia, US, Canada and Italy) likely record scores for overall conformation and include overall conformation as a separate trait in their national genetic evaluations. A 'low' adjusted R-square also indicates that some of the linear traits included as part of the overall conformation score are not included in the Interbull MACE evaluations. For example, six linear traits that are not part of MACE evaluations are considered when assigning overall conformation scores in the Canadian classification system, namely Loin Strength, Udder Texture, Rear Attachment Width, Heel Depth, Bone Quality and Height at Front End, which represent approximately 28.5% of the overall Final Score.

Reliability of Predicted vs. MACE EBV: Table 1 summarizes the differences between Predicted and MACE reliability values for foreign bulls (by country of origin) for 10 country scales for the August 2003 run. A positive value means that the reliability of predicted overall conformation was greater than the reliability of the MACE overall conformation. In four countries, the average reliability of the predicted overall conformation was higher than MACE reliability for all bulls (Denmark) or for most bulls (Germany, France and The Netherlands). In the other six countries (Australia, Canada, Great Britain, Italy, New Zealand and United States), the average reliability from MACE was mostly higher than the predicted. Apart from the scale of Denmark, where the average reliability was consistently higher from predicted than from MACE for all bulls, regardless of country of origin, different groups of bulls were penalized on every other country scale if using either the MACE overall value or the Predicted EBV. Table 2 shows the same summary as Table 1, but using the May 2007 Interbull run. In 2007, the differences in reliabilities between Predicted and MACE seemed even more dependant on country of origin. Thus, whatever methodology each country uses to publish overall conformation for foreign bulls (Predicted or MACE EBV), large groups of bulls are penalized depending on their country of origin.

The blending approach: The blending approach has been shown already in 2004 by Miglior *et al.* (2004). Since then, very few countries have adopted this blending methodology and the discussion has been focusing again on using the MACE evaluation of the composite trait or using the Prediction approach based on MACE evaluations of the linear traits in the composite. Thus, the blending approach has been largely ignored. In this study, the blending approach was applied to all countries and results are summarized in Table 3 by country scale. The table shows quite clearly how the average reliability of the blending approach is always greater than the average reliability of the Predicted or MACE overall conformation. Because the blending approach uses all available information (all relevant linear traits and the overall conformation MACE EBV), weighted by their estimated reliability, the average reliability is always higher or equal to the highest reliability obtained either by using the Predicted EBV or the MACE EBV. Thus, there is no penalization for bulls because of their country of origin. Miglior *et al.* (2004) have shown that differences in country of origin and breeds between MACE and predicted reliabilities were largely affected by genetic correlations within breed-country-trait combinations. Other

potential differences are how overall conformation is calculated within each country and if linear traits not included in MACE evaluations are part of the overall conformation in a given country.

Conclusion

Each country is responsible for their policies of EBV publication for foreign bulls. Some countries use a prediction of linear traits to compute the overall conformation, while others use directly the MACE evaluation for overall conformation. Choosing one approach over the other usually means more accurate EBV for some countries, but less accurate EBV for others. However, it should be the duty of each country to treat fairly all bulls independent of their country of origin. The blending approach serves this objective well since it maximizes the use of all available information weighted by their estimated reliability. With blending, the maximum accuracy is achieved in all cases. The blending approach should be recommended by Interbull as the methodology to use for any composite trait.

References

Miglior, F., Sullivan, P.G. & Van Doormaal, B.J. 2004. Accuracy of MACE evaluation for composite type traits compared to prediction based on linear traits. *Interbull Bulletin 32*, 41-45.

Appendix – The blending approach

1. Use your national EBV to compute prediction equation for a given composite.
2. Include in the analysis only the traits that are evaluated in MACE. Some traits may also be included as squared terms (i.e., rump angle, udder depth, stature, etc.).
3. Use multiple regression to maximize the adjusted R-square.
4. The level of significance of each factor included in the analysis must be examined, in order to obtain the best prediction in terms of the highest level of adjusted R-square and removal of nuisance variables.
5. Reliability of the predicted composite trait is calculated as the MACE reliability of the linear traits used in the prediction equation weighted by the squared relative emphasis of each trait in the prediction equation.
6. The reliability is then multiplied by the R-square obtained from the prediction of the multiple regression for that specific composite trait.
7. A blended EBV is calculated as follows:

   $EBV_{blended} = (w_1 EBV_{MACE} + w_2 EBV_{Pred}) / (w_1 + w_2)$

   where w_i = $reliability_i$ / (1-$reliability_i$), with i=1 for MACE reliability, and i=2 for predicted reliability.
8. The reliability of the blended EBV is conservatively (under)estimated as the highest value between the MACE and predicted reliability.

Figure 1. Genetic correlations over time for overall conformation between US and various countries.

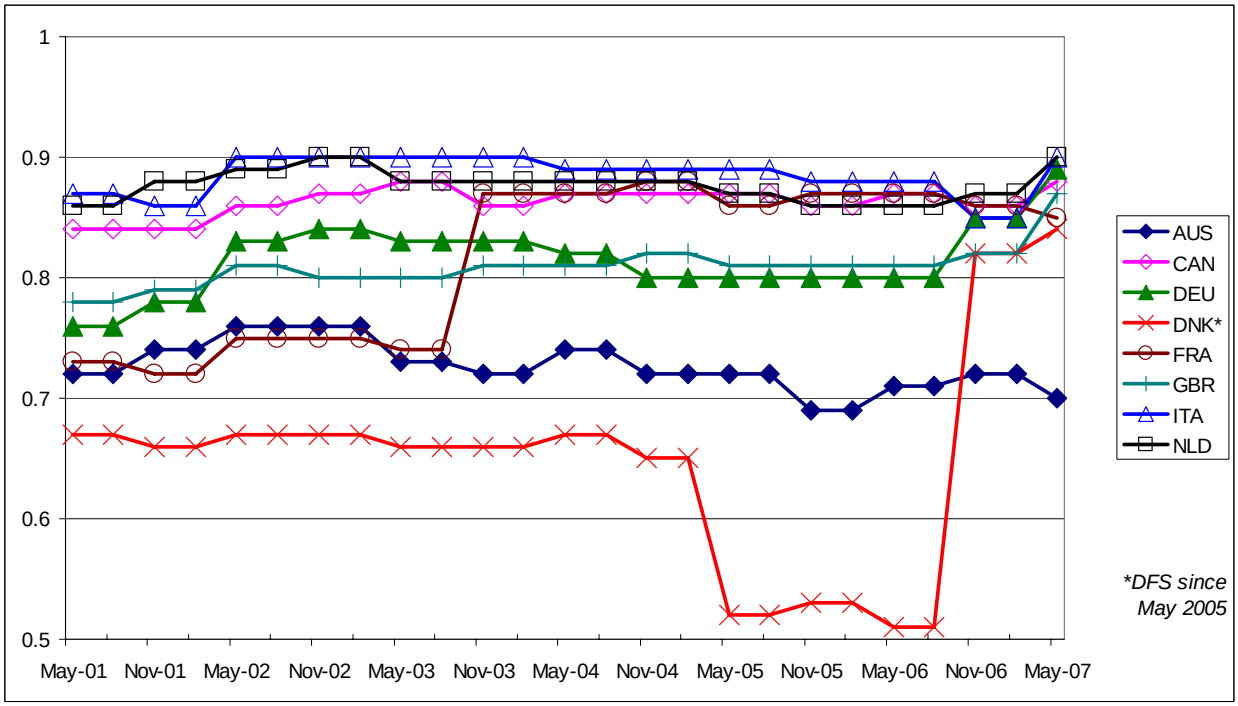

Figure 2. Values of adjusted R-square within each country for the August 2003 and May 2007 runs.

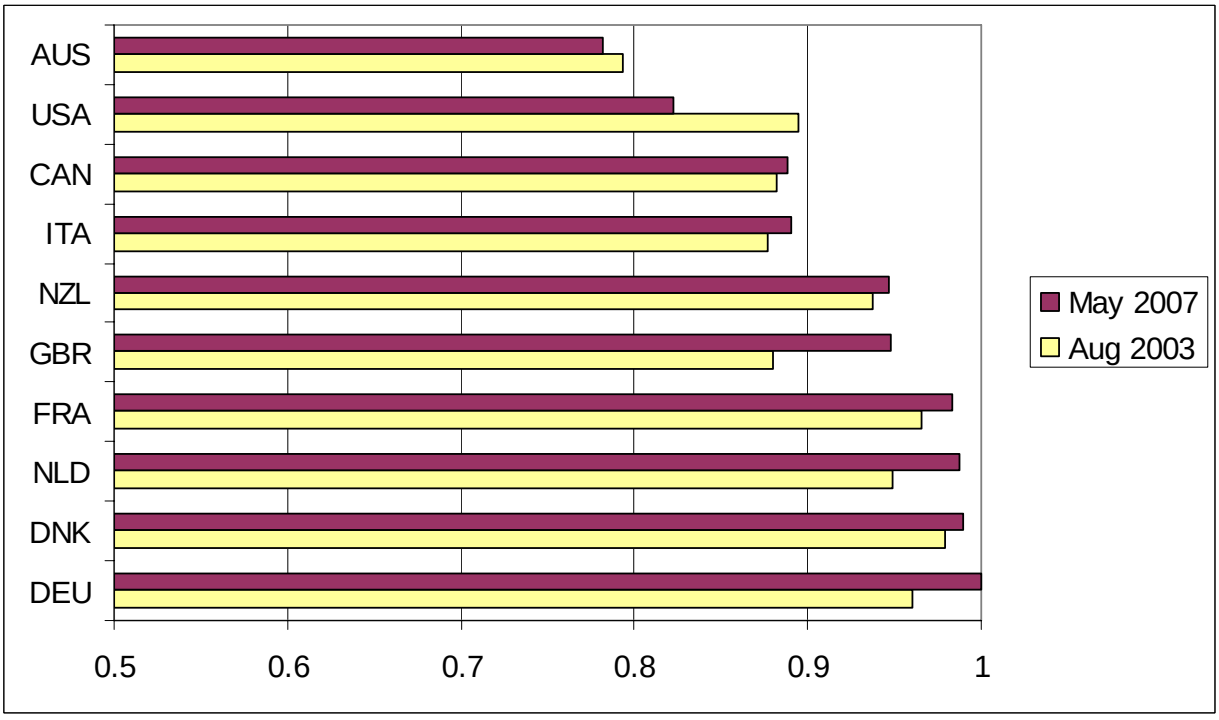

Table 1. Difference in average reliability for overall conformation (Predicted - MACE) from August 2003 Interbull run.

Country of Origin	Country Scales									
	AUS	CAN	DEU	DNK	FRA	GBR	ITA	NLD	NZL	USA
AUS		-2.2	9.5	19.5	17.5	-13.9	-6.7	9.9	-6.1	-6.7
CAN	-0.6		6.6	29.2	9.2	-2.4	-8.4	8.3	-10.6	-9.4
CHE	1.0	-12.3	10.0	16.2	11.6	-3.6	-6.0	8.1	-2.4	-6.1
DEU	-0.5	-6.5		32.0	13.0	-6.1	-12.3	6.4	-4.1	-7.5
DNK	2.9	9.1	24.5		24.9	9.2	5.5	17.0	8.8	4.8
ESP	-5.0	-0.7	8.5	28.5	24.8	-7.1	-13.4	7.0	-9.0	-7.1
FRA	-7.6	-22.5	3.7	13.8		-22.6	-21.8	4.4	-15.7	-21.5
GBR	-3.1	7.4	8.1	29.5	27.9		1.5	14.0	0.6	5.8
ITA	-3.6	-1.4	3.6	27.1	22.8	1.9		9.4	-3.8	-2.2
JPN	-4.3	-10.3	9.5	17.2	16.9	-8.2	-10.3	6.2	-4.2	-6.7
NLD	-7.8	-14.1	8.9	17.4	15.6	-22.9	-24.3		-14.8	-26.1
NZL	-16.2	-21.3	-15.2	25.5	-17.8	-36.2	-18.3	-37.9	0.0	-21.6
POL	4.2	9.5	15.1	19.6	29.5	-9.5	-0.7	11.1	12.1	5.6
SWE	4.2	8.8	19.6	37.0	17.2	13.0	8.0	23.7	-3.3	9.4
USA	-6.4	-5.2	7.1	21.2	16.3	-1.5	-7.2	0.4	-10.0	
Other	10.3	5.0	25.2	28.9	25.6	3.2	5.5	20.4	6.5	6.5

Table 2. Difference in average reliability for overall conformation (Predicted - MACE) from May 2007 Interbull run.

Country of Origin	Country Scales									
	AUS	CAN	DEU	DNK	FRA	GBR	ITA	NLD	NZL	USA
AUS		2.2	1.6	11.3	2.1	-7.0	-1.3	6.0	-8.6	-8.0
CAN	3.7		7.1	23.9	3.0	2.8	-7.4	13.3	-8.3	-11.8
CHE	6.1	-13.7	2.2	28.8	5.3	-2.9	-8.7	4.3	-11.3	-12.0
DEU	-5.5	-2.7		13.5	0.0	-6.0	-10.2	0.7	-8.5	-15.7
DNK	-5.1	7.1	5.6		9.5	2.8	1.1	13.6	-10.4	-12.7
ESP	-0.5	3.0	-0.2	23.5	6.2	-2.4	-6.6	10.2	-5.7	-12.1
FRA	13.7	12.0	16.4	40.7		5.5	4.9	19.3	5.4	7.1
GBR	-5.5	2.3	1.6	16.4	8.2		-5.5	5.6	-2.4	-11.8
ITA	0.6	-1.5	4.2	22.0	6.8	3.3		10.4	-3.3	-8.2
JPN	2.0	-7.4	5.3	21.2	3.2	-1.8	-9.8	6.7	-3.7	-9.1
NLD	-2.9	-6.8	-11.8	14.1	-5.1	-19.0	-18.0		-16.9	-26.2
NZL	-10.8	-16.9	-4.2	-33.7	-20.6	-19.0	-8.5	-25.6		-7.9
POL	8.6	10.3	11.0	28.4	3.7	-1.4	-4.8	10.3	13.2	-2.0
SWE	-2.3	9.8	8.6		9.1	5.2	2.1	13.3	-9.9	-10.2
USA	-3.9	-5.5	-2.4	11.1	1.9	-4.2	-8.3	-2.9	-8.8	
Other	3.1	-3.4	3.4	21.6	3.0	-5.8	-6.0	3.8	-8.4	-8.2

Table 3. Average reliability by country scale.

	Predicted	% Increase with Blending	MACE	% Increase with Blending
Australia	41.2	11%	43.4	5%
Canada	48.8	14%	52.6	6%
Denmark	65.4	0%	41.2	59%
France	62.7	2%	45.7	40%
Germany	61.8	2%	52.2	21%
Great Britain	45.2	21%	52.3	4%
Italy	47.0	20%	54.3	4%
The Netherlands	59.8	4%	52.5	19%
New Zealand	38.4	16%	42.1	5%
United States	48.1	17%	53.6	5%