Advantages of Using Multiple Country Converted Parent Averages in Mace

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Abstract

A method is presented that can be used to correct Mace for bulls without daughters in a country for biases in PA. The method uses a post-evaluation adjustment in which a weighted converted PA replaces the PA as used by Mace. As a result rankings become more consistent across countries.

Keywords: Mace, Parent Average, Conversion

Introduction

Mace allows producers to make comparisons among bulls across countries. This allows them to select the best bulls for their breeding programs. Even though they are aware that situations are different in different countries they expect a certain amount of consistency of bull rankings across countries. That is, they expect bulls with good genes in one production environment to perform well in each environment. When they observe large changes in rankings on some bulls they will get confused and start to mistrust the whole system. Recent popular press articles seem to bear this out (Holstein International, Jan-Feb 2003).

Re-rankings are usually attributed to the non-unity genetic correlations among countries. A number of reasons have been proposed for these lower correlations. Among them: 1) differences in trait definition, 2) differences in statistical models to analyze the data, 3) lack of genetic ties, 4) Non-randomness of bulls providing ties, and 5) genotype by environment interaction (e.g. Klei and Lawlor, 2001).

Bulls can also re-rank dramatically in an importing country because of biases in the parent average (PA) used in Mace for the importing country. These biases are not systematic but, in general, affect only direct descendants of a small number of parents. These re-rankings from country to country are unexpected and lead to reduced trust in Mace.

Parent averages in Mace are calculated from the evaluations on sires, maternal grandsires, and the phantom parent group assigned to the maternal granddam. Biases can occur due to 1) limited information in the importing country on any of the ancestors, 2) non-random use of the sire and maternal grandsire in the importing country, and 3) exclusion of data in Mace because of data edits imposed on Mace by Interbull.

Mace in its current form is working, as it was intended. Based on the model that is used and the assumptions that are made resulting evaluations can be explained. However, these explanations are not always intuitive.

As is shown in Table 1, Mace tends to favor data collected in the country of interest (importing country). A relative small number of daughters in this country will outweigh in importance a large number of daughters in other countries. When the information in the importing country is limited or inaccurate for the reasons mentioned in the previous paragraph, parent averages in Mace based on these will be inaccurate as well.

Table 1. The relative weight in Mace on daughter information from different countries for different combination of parameters (after Klei et al., 1999).

		Daughters		Relative weight on daughter information[2]	
Heritability[1]	Correlation	Importing	Exporting	Importing	Exporting
.35	.90	100	100	.662	.264
		100	1000	.571	.380
		100	10000	.558	.398
	.80	100	100	.745	.177
		100	1000	.709	.229
		100	10000	.704	.236
.25	.90	100	100	.606	.291
		100	1000	.487	.452
		100	10000	.468	.478
	.80	100	100	.685	.207
		100	1000	.631	.289
		100	10000	.624	.301

[1] Heritability is assumed to be the same in each country.
[2] Remainder of the weight is on parent averages in importing and exporting countries

This paper will attempt to address the issue of biased parent averages by proposing a post-adjustment to the Mace system. This should result in more consistent rankings of bulls across countries that are more in line with producer expectations. Thereby, reducing confusion about Mace and resulting in more trust in the Mace results.

The current Mace methodology can be viewed as a method that uses additional information to enhance genetic evaluations. The proposed method (Supplemental Mace, S-Mace) uses the international data as a supplemental source of information. This is can be compared to obtaining a second opinion on the genetic ability of the subject animal. This second opinion is only applied to parent averages used in calculating Mace. Therefore bulls are still expected to re-rank across countries but not to the extend to what has seen in the past.

Material and Methods

The method used in this study consists of the following four steps:

1) Calculate Mace.
2) Determine conversion equations for each country combination.
3) Calculate a weighted conversion for each bull based on the amount of information in each country.
4) Replace the PA in Mace with a weighted converted parent average (PA_{WC}).

Conversion Formulae

The slope of the regression formulae was determined from the sire genetic co-variance matrix used in Mace as:

$$b_{imp|exp} = g_{imp,exp} / g_{exp,exp}$$

where $g_{i,j}$ is the $(i,j)^{th}$ element of this matrix. The intercept $a_{imp|exp}$ is subsequently estimated from the average evaluation in importing and exporting country ($\bar{\mu}_{imp}$ and $\bar{\mu}_{imp}$) of those bulls that only have an evaluation in the exporting country as: $a_{imp|exp} = \bar{\mu}_{imp} - b_{imp|exp}\bar{\mu}_{exp}$.

Weights

To calculate the weighted conversion a method was developed that determines the amount of information on which the evaluation in each country was based. An obvious choice for the weights would have been the effective daughter contribution of each bull b in each country c ($EDC_{c,b}$). This does not take into account any sons with information that a bull might have in a country. Also, because of edits, a number of older bulls functioning as pedigree animals are not represented with an $EDC_{c,b}$ in Mace.

As a result the following algorithm was used to determine the weights ($WGH_{c,b}$) for each bull in each country. While processing the data from youngest to oldest calculate the following:

1) Add .5*$EDC_{c,b}$ to $WGH_{c,b}$.
2) Add .5* $WGH_{c,b}$ to $WGH_{c,sire}$.
3) Add .25* $WGH_{c,b}$ to $WGH_{c,mgs}$ and $WGH_{c,mgd}$.

In this algorithm the first step takes into account the influence of daughters in a country. The other two transfer this information to the ancestors.

Replacing Parent Averages

The final step of the process is to replace the PA in Mace with the PA_{WC} based on the weighted conversion of the evaluations on sire, maternal grandsire, and maternal granddam group. For each bull a small number of non-zero elements appear in the rows of the Mace equations that are attributed to him. These elements can be divided in four distinct categories based on their origin: a) own daughter performance (own), b) PA (pa), c) sons (sons), and d) maternal grandsons (grsn). With this in mind, a bulls Mace $\hat{u}_{bull}$ can be calculated as:

$$\hat{u}_{bull} = \left(W_{own} + W_{pa} + W_{sons} + W_{grsn}\right)^{-1} (W_{own}DPF_{own} + W_{pa}PA + W_{sons}DEV_{sons} + W_{grsn}DEV_{grsn})$$

where W_i is a matrix of weights given to each of the four components, DPF_{own} is the deviation of the bulls deregressed proof form the country mean , and DEV_{sons} and DEV_{grsn} are the sum of the deviations of the sons and grandsons from their other parents (mgs and granddam group, and sire and granddam group, respectively). For the purpose of replacing PA the only elements that are needed are $\hat{u}_{bull}$, PA, and W_i.

From Mace theory it can be determined that W_{own} is a diagonal matrix with the effective daughter contribution in country i (EDC_i) divided by the residual variance in country i (r_i) on the diagonal. For countries in which the bull does not have EDC the diagonal elements are 0. $W_{pa} = d_{bull}^{-1}G^{-1}$ where d_{bull}^{-1} = 16/11, 16/12, 16/15, or 16/16 depending on whether both sire and mgs are known, only the sire is known, only the mgs is known, or neither is known. G^{-1} is the inverse of the matrix of genetic (co)-variances among the countries used in Mace. Furthermore, $W_{sons} = .25 \times G^{-1}\sum_k d_k^{-1}$ is the sum over all k sons, and $W_{grns} = .0625 \times G^{-1}\sum_l d_l^{-1}$ is the sum over all l maternal grandsons.

The final step is to remove PA from the main equation in the following steps. Let W be the sum of all four W_i terms. Then:

1) Multiply left and right hand sides with W.
2) Subtract $W_{pa}PA$ from the right side.
3) Add $W_{pa}PA_{WC}$ to the right hand sides.
4) Multiply left and right hand sides with W^{-1}.

Data

Data used for this project consisted of the full set of solutions for the November 2002 official Mace for conformation. This included solutions for phantom parent groups as well as bulls without an official Mace that served as pedigree animals. Solutions were available for 64,664 bulls and 466 phantom parent groups for 20 populations and 18 traits.

Restrictions

Various strategies of using the data were explored. Differences between strategies were based on when to start using data from countries that did not progeny test the bull (second country proof). For animals functioning as pedigree animals as well as phantom parent groups information form all countries with $WGH_{i,bull} > 0$ was used.

Because of the larger number of countries (20) and traits (18) involved in the analyzes results will only be presented on for four countries and four traits. These were selected based on:

1. Range of correlations (.36 to .98).
2. Number of bulls (500 to 15,000).
3. Geographic location (different continents.
4. Genetic ties.

Results and Discussion

The method of replacing PA is appealing in that it only affects bulls that have none or few daughters in a country. Bulls with a sizable amount of information other than their parent average will see little change. As a result, for bulls that have received an evaluation in a country one expects the S-Mace to be close to the original Mace evaluation, even when they might be biased. However, the impact these bulls with biased evaluation have on their progeny evaluations will be greatly reduced. The same holds for biased phantom parent group solutions. This should lead to a more consistent ranking of bulls across countries. Especially, the large group of bulls that only has an evaluation in one country (approximately 90% of all bulls for this dataset).

The various restrictions were compared for correlation and rank correlation for all bulls and bulls that rank in the top 100. None of the strategies was optimal for all country and trait combinations. The various strategies tested can be found in the Appenix.. Results will be presented on the method which used converted information on a bull from countries in which he was progeny tested as well as all countries in which $WGH_{i,bull} \geq 150$. This restriction was chosen because of its intuitive appeal in that imported bulls need a sizeable amount of information to obtain an unbiased evaluation in a country.

Table 2. Estimated correlations for different methods and sets of bulls.

Country		Trait I					Trait II				
			Mace		S-Mace[1]			Mace		S-Mace	
		r_g[2]	All	Top[3]	All	Top	r_g	All	Top	All	Top
A	B	.93	.98	.77	.99[+]	.94	.85	.95	.59	.99	.77
	C	.88	.98	.73	.99[+]	.97	.72	.89	.30	.99	.62
	D	.94	.99	.78	.99[+]	.98	.44	.69	.11	.95	.39
B	C	.92	.99	.80	.99[+]	.96	.89	.95	.79	.99[+]	.94
	D	.95	.99	.84	.99[+]	.96	.36	.65	.24	.94	.49
C	D	.94	.99	.84	.99[+]	.99[+]	.49	.75	.53	.95	.63

Country		Trait III					Trait IV				
			Mace		S-Mace			Mace		S-Mace	
		r_g[2]	All	Top[3]	All	Top	r_g	All	Top	All	Top
A	B	.90	.97	.62	.99	.88	.80	.95	.57	.99	.83
	C	.80	.95	.48	.99	.86	.76	.94	.51	.99	.86
	D	.89	.98	.42	.99[+]	.83	.85	.98	.66	.99[+]	.75
B	C	.88	.98	.75	.99[+]	.97	.86	.97	.71	.99[+]	.94
	D	.85	.96	.45	.99[+]	.76	.79	.96	.74	.99	.84
C	D	.77	.95	.57	.99	.81	.68	.94	.56	.99	.76

[1] Supplemental Mace, Mace followed by the post-adjustment for multiple country converted parent average using Method 3.
[2] Genetic correlation used in Mace.
[3] Top 100 bulls in country A among the bulls that have an evaluation in only one country.
[+] Correlation ≥ .995.

Correlations are presented in Table 2. This table clearly shows that S-Mace is producing more consistent evaluations across countries. In all cases correlations for S-Mace are higher than those obtained for Mace. This is especially clear for Trait II, the trait with the lowest correlations. Because of the low correlation this trait relies more heavily on the parent average in the importing and any bias in them will be reflected in the progeny's evaluation. For traits with higher correlations this is much less of an issue (Trait I). Table 2 also shows that for the top bulls evaluations can become quite different across countries. Again, Trait II shows this most dramatic. For the top bulls S-Mace shows correlations closer to the correlation in the Mace evaluation.

To better understand the impact that using S-Mace has on the evaluations it is of interest to look at the average rankings of bulls the top 100 bulls. If bulls rank the same across countries one expect the average rank of the top 100 bulls to be 50 across all countries. Large deviations from 50 signify that dramatic re-rankings occur. For this analyses only bulls that have daughters in one country were used. Results are shown in Table 3.

As in the previous table this table shows that rankings across countries are more consistent with S-Mace than when using Mace. As an example, the top 100 bulls in country D for trait IV rank on average 86, 109, and 259 in the other three countries when using Mace. These rankings are 66, 67, and 70 when they are based on S-Mace.

Table 3. Average rank of the Top 100 bulls in each country.

Trait	Top 100 from	Mace				S-Mace			
	Country	A	B	C	D	A	B	C	D
I	A	50	69	76	65	50	54	52	52
II	B	147	50	116	2621	91	50	57	315
III	C	120	95	48	170	82	59	48	87
IV	D	86	109	259	50	66	69	70	50

Top 100 determined among those bulls with only country with an evaluation.

Table 4. Example for Trait I.

		Country			
		A	**B**	**C**	**D**
Parent Average	**Mace**	**.75**	**.47**	**.54**	**.22**
	S-Mace	**.76**	**.59**	**.82**	**.48**
Sire	*Mace*	*1.53*	*1.55*	*.98*	*.96*
	S-Mace	*1.60*	*1.40*	*1.23*	*1.21*
MGS	*Mace*	*.04*	*-.24*	*.33*	*-.25*
	S-Mace	*-.05*	*-.16*	*.43*	*-.21*
P-MGD	*Mace*	*.04*	*-.98*	*-.12*	*-.79*
	S-Mace	*-.13*	*-.28*	*.38*	*-.31*
Bull	**Mace**	**3.17**	**2.67**	**1.68**	**2.29**
	S-Mace	**3.17**	**2.78**	**1.96**	**2.54**
Ranking	**Mace**	**64**	**113**	**374**	**186**
	S-Mace	**51**	**77**	**71**	**66**

As in Table 2, results in this table also show that Mace shows large re-rakings in cases where correlations are low. The correlation used in the Mace evaluation used for trait II was .36 between countries B and D. Using the logic as presented by Klei et al. (1999), it can easily be shown that for this trait where the heritabilities in country B and D are .14 and .11, respectively, a bull with 100 daughters in country B still derives 59.1% of his evaluation in country D from the PA in country D. Any bias in the PA will greatly affect the rankings for this bull.

Examples for each of the four traits on how evaluations based on S-Mace are different from the Mace ones are shown at the end of the paper. In all these examples bulls had only daughters in country A.

The example for trait I (Table 4) shows that difference seen at the bull level can directly be attributed to differences in PA. Evaluations used for the maternal grandsire (mgs) are similar for both methods. Differences in PA are mainly due to differences in the evaluations used for sire and phantom group for maternal granddam (P-MGD).

A similar situation is illustrated in the example for Trait II (Table 5). This example illustrates that relative small changes in an evaluation, .23 for country D, can have a large impact on the ranking of a bull (1586 to 81). This example also shows that a change for one of the parents can be offset by a change in the other direction of another parent (e.g. sire and P-MGD for country A and B).

The example for Trait III (Table 6) shows another interesting feature of S-Mace. Even though the PA for this bull for country B went down, the bull's own evaluation went up. An explanation for this is that the parent average in country A, the country where the daughters are, actually went down. As a result the mendelian sampling (MS) for this country increased. This translated in a larger MS used for country B. This increase was enough to offset the reduction in PA for country B. This effect can also be seen for countries C and D, where the drop was smaller than expected based on the change in PA for country C while the increase was larger than expected in country D.

Table 5. Example for Trait II.

		Country			
		A	B	C	D
Parent Average	**Mace**	**.70**	**.20**	**.02**	**-.12**
	S-Mace	**.53**	**.24**	**.16**	**.08**
Sire	*Mace*	*1.27*	*.44*	*.02*	*.15*
	S-Mace	*1.07*	*.60*	*.26*	*.23*
MGS	*Mace*	*-.05*	*-.32*	*.00*	*-.28*
	S-Mace	*-.19*	*-.29*	*.02*	*-.13*
P-MGD	*Mace*	*.31*	*.25*	*.05*	*-.51*
	S-Mace	*.18*	*.04*	*.09*	*-.01*
Bull	**Mace**	**4.31**	**3.03**	**.66**	**.79**
	S-Mace	**4.25**	**3.23**	**.81**	**1.02**
Ranking	**Mace**	**3**	**29**	**266**	**1586**
	S-Mace	**3**	**11**	**24**	**81**

Table 6. Example for Trait III.

		Country			
		A	B	C	D
Parent Average	**Mace**	**1.60**	**1.20**	**.94**	**1.02**
	S-Mace	**1.41**	**1.14**	**.78**	**1.07**
Sire	*Mace*	*2.66*	*2.99*	*1.67*	*2.09*
	S-Mace	*2.55*	*2.21*	*1.12*	*1.91*
MGS	*Mace*	*-.21*	*-.71*	*.20*	*-.27*
	S-Mace	*-.26*	*-.42*	*.30*	*-.14*
P-MGD	*Mace*	*1.30*	*-.46*	*.23*	*.17*
	S-Mace	*.80*	*.54*	*.59*	*.58*
Bull	**Mace**	**3.44**	**2.81**	**1.42**	**2.23**
	S-Mace	**3.38**	**2.86**	**1.29**	**2.36**
Ranking	**Mace**	**31**	**98**	**47**	**239**
	S-Mace	**39**	**58**	**60**	**65**

Finally, Trait IV (Table 7) shows similar patterns as seen before. Changes in PA are reflected in differences between Mace and S-Mace. In this example, country B, shows again that the change in one parent is partially offset by the change in the other parents.

The bottom line of these examples is that in all cases a more consistent ranking across countries is obtained when using S-Mace instead of Mace.

Table 7. Example for Trait IV.

		Country			
		A	B	C	D
Parent Average	**Mace**	**.35**	**.25**	**.38**	**104.8**
	S-Mace	**.26**	**.06**	**.74**	**101.4**
Sire	*Mace*	*.21*	*1.01*	*.36*	*108.4*
	S-Mace	*.20*	*.01*	*.71*	*100.8*
MGS	*Mace*	*.52*	*.50*	*.58*	*106.2*
	S-Mace	*.47*	*.30*	*.87*	*103.9*
P-MGD	*Mace*	*.44*	*-1.52*	*.23*	*96.2*
	S-Mace	*.18*	*-.09*	*.68*	*100.3*
Bull	**Mace**	**2.65**	**2.90**	**1.81**	**132.2**
	S-Mace	**2.63**	**2.79**	**2.21**	**129.7**
Ranking	**Mace**	**9**	**14**	**287**	**11**
	S-Mace	**10**	**26**	**20**	**34**

Conclusions

Results in this paper show that PA can have a large impact on evaluations in importing countries. The method presented in this paper shows that one can correct PA in importing countries for potential biases. These biases can be due to limited information, editing of the data in Mace, and/or due to biases in parent evaluations. As a result S-Mace gives a more consistent ranking of sons across countries.

In countries where bulls have evaluations based on actual daughter information evaluations will only differ slightly from current Mace.

Recommendations

It is strongly recommended that Interbull take a closer look at S-Mace to alleviate some of the issues that occur because of spurious PA in importing countries.

To improve the credibility and believability it is recommended that Interbull use S-Mace as an integral part of the routine Interbull services in the near future.

Literature Cited

Klei, B., Weigel, K. & Lawlor, T. 1999. Mace, the relative importance of information sources. *Interbull Bulletin 22,* 9-13.

Klei, B. & Lawlor, T. 2001. Mace for Conformation. Ayrshire. *Interbull Bulletin 27,* 51-55.

Appendix

Tested Conversion Strategies.

1) Single country conversion based on initial progeny test country. Initial progeny test country was determined as the country in which the bull was coded as progeny tested. In the case of multiple progeny test countries the country with the highest info was chosen.
2) Weighted average of converted evaluations from all countries in which a bull was progeny tested. Weights were the values of info.
3) Weighted average of converted evaluations from all progeny test countries as well as those from countries in which the bull was imported $WGH_{i,bull} \geq 150$.
4) As 3) but $WGH_{i,bull} \geq 75$.
5) Weighted average of converted evaluations all countries in which the bull was used (progeny tested or imported).
6) Weighted average of converted evaluations from all countries.
7) Un-weighted average of converted evaluations from all countries.