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Composite traits and International genetic evaluation

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Abstract

Composites traits in MACE international evaluation have been discussed since the introduction of routine genetic evaluation for conformation trait. The issue is the decrease in efficiency of the MACE system when comparing traits that are heterogeneously defined across countries resulting in very low genetic correlations. The superiority of the use of single international, well defined and highly correlated traits, have been shown by several studies in ranking bulls within and across countries (Mattalia, 1998; Miglior,2005; Biffani, 2006). Several possible solutions have been presented and discussed at Interbull meetings including the possibility of not sending to Interbull data for composites by a group of countries (Rensing, 2005). Other possible solutions include recommendations from ICAR and Breed Associations on ”best practices” to be used.

Keywords: composite traits, international evaluation, conformation traits

Introduction

Multiple Across Country Evaluations is the system of choice for routine international evaluation of dairy bulls. The methodology was developed in 1994 by Larry Schaeffer and it treats estimated breeding values from different countries as different traits in a multiple country/trait evaluation system. Two parameters are needed for the evaluation: sire variance for each country/trait and genetic correlations across country/traits. The routine service is carried out at Interbull Centre four times per year for production, conformation, udder health, longevity and calving traits. Research is ongoing to develop a MACE multiple traits evaluation for fertility.

We define as linear all the traits that can be measured on a biological linear scale. In conformation in addition to linear traits also composites traits, or overall type traits more in general, are used to define Overall type, Overall udder and Feet & Legs functionality. Linear traits that do have the same definition have very high correlations across countries and the harmonisation process of traits definition across countries has greatly increased the genetic correlations since the first MACE evaluation for conformation (De Jong, 2004). Over time International Harmonisation groups for type traits have in fact greatly reduced the heterogeneity in the definition of the various linear traits for each breed and have made possible to compare bulls genetically evaluated in different countries.

Little work has been done to harmonize general characteristic (GT) because they have been always related to specific breeding goals in each country. In the last two World Classifiers Workshops (Canada, 2003 and The Netherlands, 2005) the final recommendation accepted by all Countries was to use four basic GT:
- Frame (including Rump), instead of Frame and Capacity;
- Dairy Strength (Instead of Dairy Character);

- Feet & Legs;
- Udder.

How these GT are calculated from linear traits and other extra information (i.e. defects) and how they are combined to obtain Final Score does vary across Countries. In some Countries the computer does the calculation (Denmark, Switzerland, Canada) while in others general characteristics are assigned subjectively by the classifier.

In some countries these GT are used for genetic evaluation. In other Countries composite indexes are calculated as a combination of different linear traits based on economic or otherwise defined weights. Composites having the same name can have very different weights across countries asnd include different traits. In the past the discussion on composite traits and on the efficiency of MACE in comparing bulls from different countries using these type of traits have been discussed extensively, especially for the Holstein breed. Some countries are planning not to send composites for international genetic evaluation anymore to Interbull, but the issue is quite controversial since some of those traits are included in selection indices all over the world (Rensing, 2004).

For international MACE evaluations, in the trait overall conformation some countries send EBV of GC and some others send a composite index calculated from linear traits EBV. A similar situation happens with EBV sent for traits overall udder and overall feet and legs. Problems appears depending on how countries uses MACE for overall traits. The problem may be specially relevant when Final Score EBV is included in TMI, as it happens, for example, with TPI in USA.

The objective of this study to review the present situation of composite traits issues and more in general of overall type traits and to suggest possible ways forward .

Composites in international evaluation

The first study on composites in MACE was done in France by Sophie Mattalia (1998) and presented at the Interbull workshop that focused on type trait international evaluation.
Her study showed that composite have very low and different genetic correlations across countries. Low genetic correlations across countries have two effects: 1) to favour domestic bulls or in general bulls that do have daughters measured in the country; 2) affect foreign bulls having daughters only outside of the country, the lowest the correlations the lowest their expected ranking.
Comparison of bull ranking based on composites showed a big impact if MACE composite (MTC) was used compared to a composite derive from MACE linear traits (ML).
She looked at correlations among proofs within country between the MTC and ML and the elementary international linear traits were much higher when the composite were derived from the linear for all bulls. Moreover it was very difficult to have bulls with at least 0.60 reliability from country were the composite definition was very far and different from the one used in France.
The recommendation that was derived from the study was that the ability of MACE to effectively compare traits with very different definitions as composites was reduced if compared with linear and well correlated traits, therefore it was much better to derive composites from individual linear traits.

In MACE today three composites are analysed: Overall score, Udder Score and Feet & legs score.

In Table 1 is the situation in the different countries participating to the evaluation as far as definition of the three overall type traits is concerned. The definition are very different, not all the countries do use composite traits and moreover when a composite is used its composition may vary related to the traits that are being used and which weight they are assigned in the computation.

Table 1. Definition of overall type traits (February 2006 Interbull run)

Country	Overall conformation score	Overall Udder score	Overall Feet & Legs score
AUS	General appearance	Mammary system	Side view foot diagonal
BEL	Overall conformation score	Overall udder score	Overall F&L score
CAN	Final score (individual trait)	Mammary system	F&L (individual trait)
CHE	Final score (composite trait)	Overall udder (composite)	Overall F&L (composite)
CHR	Overall score (composite)	Composite score for udder	Composite score for F&L
CZE	Overall conformation score	Overall udder score	Overall F&L score
DEU	Relative breeding value conformation (RZE)	Overall udder (composite)	Overall F&L (composite)
DFS	Overall conformation(composite)	Mammary (composite)	F&L (composite)
DNK	Overall conformation(composite)	Mammary (composite)	F&L (composite)
ESP	Overall conformation(composite)	Overall udder (composite)	F&L (individual trait)
FRA	Overall score (composite)	Udder score (composite)	Locomotion
GBR	Overall conformation (composite)	Overall udder (composite)	Overall F&L (composite)
HUN	Overall conformation	Overall udder	Overall F&L
ITA	Final score (individual trait)	Overall udder (composite)	Functionality of F&L (individual trait)
JPN	Overall conformation (composite)	Overall udder score (individual trait)	Overall F&L (individual trait)
NLD	Overall conformation(composite)	Qualification of total udder (individual traits)	Functionality of F&L (individual trait)
NOR	Overall conformation	Udder index	Leg index
NZL	Overall conformation (composite)	All traits of the udder	-
POL	Overall conformation score	Overall udder score	Overall F&L score
USA	Overall conformation (individual trait)	Overall udder (composite)	F&L (composite)

A strategic question

In principle what we are assuming when we use MACE type composite to derive our own composite is more or less equivalent to assuming that PFT can be used to best predict LPI, or PLI, or TPI, and vice versa. (Rensing, 2004).Why we do it for composites in type traits and not for selection index? Perhaps it is because we think that there are better ways to properly rank domestic and foreign bull in our country i.e. compute the composite using the single elements that do compose them instead of assuming that they are somehow related at genetic level, which is certainly true also for each of the selection index that defines bull ranking all over the world.
In type traits we do otherwise because we think that:

A) there are no other options that can be used instead;
B) it is the simplest solution.

These composites are used in some of the aggregate indexes in the world and do affect rankings all over the world.

Originally the reason why Overall type traits were included in international evaluations for type was that there was a demand on it by some countries (USA, Canada and some other countries, for example Spain because they were running until January 2001 genetic evaluations for GT and had them included in our Total Merit Index).

The main objective of the international evaluation is to predict the future breeding value of a bull when daughters will be performing in the country, using information measured on daughters outside of the country as soon as the bull gets an official proof anywhere. The key question is if overall composites very heterogeneously defined across the different Countries are the best predictor of the

corresponding EBVs for composites or individual traits once they will be computed based on daughters record within any specific country.

A small study was done in Italy trying to assess the predictive ability of international breeding values. Interbull results from February 2002 run were used and compared to February 2006 results. Foreign bulls that now have an official proof in Italy based on Italian daughters were selected and their Italian final score proof in 2006 was compared with the Overall score computed and distributed in February 2002 (OS) by Interbull and with a Final score recomputed using Interbull individual linear traits (LTFS) for all bulls that at that time (2002) did not have daughters classified in Italy. Average differences and simple and rank correlations were computed for all bulls and by country of origin of bulls. Table 2 reports a summary of the findings. In all cases the average difference between Final score computed on real Italian daughters and Final Score derived from linear traits were smaller. If we look at all bulls the situation in terms of correlations seems to be the same for the two proofs but if we stratify bulls by origin the situation looks quite different. With the exception of Canada and The Netherlands for all countries and especially for those who have a very different definition of Final Score, like France and Denmark, it is clear that Final Score derived from Linear Traits ranks bulls much better that the composite computed by MACE. The superiority of LTFS is confirmed also for US bull although the MACE correlation between USA and Italy is greater than 0.85.

Table 2. Average difference and SD of differences between estimated breeding value based on Italian daughters and MACE Overall Score (OS) and Final Score derived from MACE linear traits (LTFS) overall and by Country of origin of the bulls.

International trait		CAN	DEU	DNK	FRA	NLD	USA	ALL
OS	Mean	0.36	0.69	-0.03	0.40	0.54	0.60	0.53
	SD	0.52	0.39	0.80	0.52	0.56	0.52	0.54
	Simple correlation	0.90	0.90	-0.26	0.83	0.66	0.79	0.80
	Rank correlation	0.90	0.79	-0.42	0.68	0.66	0.80	0.79
LTFS	Mean	0.20	0.37	0.09	0.30	0.50	0.54	0.46
	SD	0.57	0.35	0.47	0.55	0.57	0.53	0.55
	Simple correlation	0.86	0.89	0.44	0.82	0.59	0.78	0.79
	Rank correlation	0.86	0.81	0.50	0.75	0.57	0.81	0.79

In the study of Miglior et al. (2004) the index for Overall Score predicted from linear traits showed that the predicted correlations where higher than the genetic correlations for Canada with all the countries with the exception of Switzerland and Belgium.
The only limiting factor in the derivation or prediction approach are the linear traits available. The derived index is more accurate than the composites when all the elements that are needed to compute it i.e. the single linear traits are all available at international level. If one or two components are missing then the superiority of the derived or predicted index compared to the composite is not so high or may be even not superior anymore.

How to derive composites from linear traits

Several approaches has been suggested and used to derive the weights to be assigned to each of the linear traits to estimate Overall score. Here we report the systems used in Italy and other countries as and example and a proposal that was presented at the Interbull meeting by Miglior et al. (2004) and that now it is officially used in Canada.

In Italy overall conformation score provided by Interbull is not used anymore. Genetic evaluation results for type traits were used to choose the linear traits to be used for the composite and their relative weight. Only national bull proofs were used to assess the relationship between Final Score results analysed as an individual trait and the other single traits, trying to identify the best estimators for the unknown Final Score of future daughters in the country.
A stepwise regression was used to identify the traits that significantly affected final score proofs. The R-square of the model was around 0.88.
Te final equation to derive final score was:

Final Score = -0.05 + 0.14*stature+0.16* angularity –0.01* rump angle
+0.03*rump width –0.04* rear leg side view+0.08*foot angle
+0.19*fore udder+0.08*rear udder height+0.09* udder support
-0.04*udder depth+0.09* teat position

In France Final Score is composed by three breakdowns that are estimated from linear traits: Body capacity, Udder and Feet & Legs. In the final composition of Final score Udder weights 60%, Body capacity and Feet & Legs 20% each. The same formula applies for French bulls and for imported bulls using international proofs computed by Interbull for the linear traits.

In the Netherlands Final Score is composed by three general traits: Frame, Udder and Feet & Legs. These three general traits receive a breeding value based on scores for these three traits. For foreign bulls frame is derived from the linear traits and Udder and Feet & Legs are taken from the MACE evaluation. For Final scores the same formula is used as for bulls being tested in the Netherlands, so a derivation based on Frame, Udder and Feet & Legs.
Formula for deriving Final Score is: .3*Frame + .4*Udder + .3*Feet & Legs.

In Denmark, Finland and Sweden the Index body (Overall conformation) includes only linear traits related to Body (not including feet & legs). The index is calculated using linear regression coefficients, determined using the same approach previously described for Italy, with an R-square of 0.88.
The formula to compute Body is the following:

Body = 103.9 + 0.7428×stature –0.0289×stature2 + 0.0355×chest width
-0.0012×chest width2 + 0.0143×body depth –0.0118×body depth2
+0.1168×rump angle –0.0119×rump angle2 +0.0011×rump width
-0.88×rump width2

The published overall conformation for bulls (and cows) is a composite (RZE = Relative Breeding value Exterior) derived from the published composites for Dairy Type, Body, Feet & Legs and Udder. Each of this 4 composites includes linear traits (75-50% relative weight) and the score (25-50% weight). The same formula are used for domestic and foreign bulls except for Dairy Type and Body. Because no IB figures are available for these scores the Dairy Type and Body composite of foreign bulls consist of only (MACE) linear traits, but in the same proportions than for the domestic bulls.
The Interbull figures for Overall Conformation are not used.

In Spain only MACE for linear traits and MACE for overall feet and legs are official and published. Udder composite and overall conformation composite are calculated from MACE for linear traits applying the same formulas than for national evaluations. Feet and Legs composite is calculated from MACE for linear traits and MACE for overall feet and legs, again using the same formula than for national evaluations.

At the Interbull meeting in Sousse (2004) Miglior presented results from a study that compared composites predicted from linear traits and composites computed by MACE and a blended index combining the two sources (MACE and predicted) of information, that is the . The blended index showed the best correlation and the highest reliability of the three and was proposed as a possible

solution to the composites problem. This is the method now applied in Canada for all three composite traits. Reliability of the predicted composite traits are calculated as the MACE reliability (on the Canadian scale) of the linear traits used in the prediction equation weighted by the squared relative emphasis of each trait in the prediction equation.

In the United States Holstein USA uses MACE overall score as it is computed by Interbull. According to a survey done within World Holstein Friesian Federation members they are the only country still using Overall type traits as provided by the International evaluation service.

The three overall type traits

In MACE today there are three different overall scores each with a different degree of complexity. The overall type trait that shows the lowest genetic correlation is Overall conformation Score because is the traits that has the highest variability in terms of definition and of traits used to compute it (table 1). Overall conformation score is also the trait for which all the component elements (the linear traits that are evaluated in the same round of classification) are all available and thus it is possible to derive or predict it from linear traits with a high R-square.
Overall Udder score is defined by different traits in every country but the traits used are strongly correlated with each other thus the difference has a low impact on the final composite.
Overall Feet & Legs score have an additional problem that is the trait that if the most important in determining the composite i.e. locomotion is not a trait considered in the international evaluation yet, so that the composite is the best option compared to an index that can be derived only partially from all the traits that are needed.

The “international predictor”

In the meantime few countries have started to send to Interbull not the official Overall Score Composite that is computed for their national bulls but what is called and “international predictor” of overall score that is a composite derived at national level that maximize the correlation between the overall score of the country and the overall score of US bulls which are the majority of bulls in the international evaluation and that are the bulls that are defining the genetic links across all countries. As a final results of this practice what today is included in MACE evaluation for Overall Score composite is quite undefined, less transparent and various than ever!

The reason for this practice is that by doing so bulls having daughters only in these countries are more fairly ranked in USA for Final Score and, the most important, in Top TPI lists. This practice would not be necessary if Holstein USA followed Interbull recommendation about how to derive proofs for overall conformation blending information from MACE for linear traits and MACE for overall conformation. In fact, a questionnaire circulated among WHFF members shows there is only one country (USA) that uses MACE Overall Conformation score and this index is included in it’s total merit index (TPI) with 13% relative weight.

The impact on the genetic progress

If the ability of the international evaluation to predict the future breeding value of a bull is reduced by the use of composites by 1-2%, the expected effect on the genetic progress will be comparable to a reduction of the average reliability of the breeding values with a corresponding decrease in the realized progress.

Interbull recommendation

At the last Interbull meeting in Uppsala in 2005, Interbull has recommended the method developed by Miglior and Sullivan (2004) for computing overall conformation from MACE evaluations from linear traits and GT.

An additional problem may arise when countries compute genetic evaluation for a GT but use a separate formula for calculating EBV for bulls without national proof. Because of being an estimate, the predicted proof for foreign bulls will be less variable and top foreign bulls will be underestimated. Estimating overall conformation EBV exactly in the same way, (i.e. with the same formula) both for national an international evaluation would help in more fair comparison of bulls with or without daughters in the country.

The choice of not sending the data to Interbull

Not sending data for Overall Composite will create a situation in which countries will receive Interbull results that for the bulls that do have daughters only in countries that are not sending data will not have an international evaluation. It is then up to the Country receiving the data to decide what to do for those bulls with no proofs. Several options are available.
They can:

- leave the bulls with no proof
- compute a pedigree index
- derive the composite or the overall trait from linear traits.

There are no clear defined rules on how to proceed in this case.
In the last meeting of the World Holstein Friesian Federation Board the following statement was approved: “For the past 15 years WHFF has successfully harmonised linear traits. Thus, correlations of many linear traits between countries are higher than correlations of production traits. WHFF believe in using mainly linear traits for conversion in MACE evaluation. WHFF-Council recommend to its members that: Countries which do not submit a Final Score to Interbull will assign a Final Score using the converted traits based on the composites formula applied in that country.” Again the statement does not clearly say what Countries not receiving data should do. Therefore the question remains an open issue, the biggest risk being that the bulls of a Country not sending overall score to Interbull may not necessarily have an international proofs for Overall Score derived from linear traits as that Country would hope.

Interbull position regarding this practice is clearly defined in a chairman letter of December 2005 as not to stop sending overall conformation proofs for MACE evaluations, as that may drive to a worst situation than the present because there is no evidence that foreign bulls will be more fairly ranked for overall conformation in those countries using now the proof just as Interbull sends it.

Conclusive remarks

From the literature and from the generic correlations for composites and in general for overall type traits, usually lower than the genetic correlations of the corresponding linear trait for the same Country, it is quite clear that the efficiency of MACE when composites defined in different ways across countries are involved is reduced.
There is a variety of methodologies that have been proposed and are actually used by many different countries already in place. There are thus options available to minimize the risk of incorrectly ranking bulls and therefore decrease the efficiency of the selection improvement of the breed and those should be adopted by all countries.

Since there are cases in which composites may still remain the best option available it sounds not reasonable to ask Interbull not to compute them.
It will be very important that the Breed Associations decide together which policy to suggest to their members in order to maximize the genetic progress and for traits for which the overall trait or the composite is never the best option available to use decide that that is not a trait to be evaluated internationally for the breed. ICAR may also be involved and play a role in establishing or recommending “best practice” procedures for countries to adopt.

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