Expressing Female Fertility in the Walloon Region of Belgium: How to do?

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Abstract
Since September 2007, the Walloon Region of Belgium has used a genetic evaluation system for pregnancy rate in Holsteins and has participated in 3 of the 5 MACE trait INTERBULL runs for female fertility. In order to define general way of female fertility expression, a principal component analysis was carried out on six published foreign female fertility indexes. Results of were used to compute a direct female fertility index with the INTERBULL international female fertility proofs available on the Walloon scale. An indirect female fertility index was also developed in order to increase reliability of young bulls. Approximate procedure based on selection index was used to combine both indexes in an overall index called combined female fertility index. This index was highly correlated with the direct female fertility index (.96) and the first principal component (.85), therefore it was considered as good expression of female fertility. Moreover, this allowed recovering 4,019 INTERBULL bulls with a publishable female fertility index.

Keywords: female fertility, pregnancy rate, correlations

Introduction

Since September 2007, the Walloon Region of Belgium has used a genetic evaluation system for pregnancy rate (**PR**) in Holsteins and has participated at the INTERBULL international evaluations of female fertility. To evaluate the female fertility, the various populations participating to INTERBULL work with different female fertility traits. Therefore, in order to facilitate the evaluations, INTERBULL has grouped the traits in five groups and consequently does five evaluations (Jorjani, 2007). We participate in three of these five evaluations (groups 2, 4 and 5). Therefore, INTERBULL provides from one to three international proofs for bulls on the Walloon scale only for these three groups. When we have one, two or three international proofs for a bull, how could we to use these proofs to express female fertility of this bull in one value? People from the field considered proposed post-treatment of the three previous evaluations as suboptimal. This treatment consisted in averaging proofs to obtain one single value of PR. The main disadvantage of this method was that the rankings of bulls between populations could be greatly differed according to their participation in the INTERBULL runs. Therefore, the objective of this paper was to present an alternative method to use the INTERBULL international proofs of female fertility in order to express female fertility in the Walloon Region of Belgium. An additional objective was to study the use of other traits as predictors for fertility and the combination of direct and indirect values.

Materials and Methods

Female Fertility evaluation in the Walloon region

In this study, PR data from the April 2009 routine run for the Holstein evaluation were used (1,604,630 PR records on 606,328 cows). Proofs of 671 bulls were submitted to INTERBULL, and results obtained for 88,496 bulls.

Female Fertility indexes from foreign countries

Fertility traits definitions greatly differ across countries. Six countries (Canada (**CAN**), Germany (**DEU**), France (**FRA**), Italy (**ITA**), Netherlands (**NLD**), and **USA**) provided their own female fertility indexes for bulls published in the country. These countries were chosen as they represent major import countries of genetic materials for the Walloon Region of Belgium. Descriptive statistics for each index are given in Table 1; for all of these female fertility indexes higher values are desirable. These indexes were detailed by Minery and al. (2008) and Rensing and al. (2008). It is very important to notice that these are the published indexes, not the breeding values for the traits provided to INTERBULL.

Table 1 : Data description of female fertility indexes provided by the six countries

Country	Data		
	Bulls	Mean	Std Dev
CAN	86,027	101.35	4.13
DEU	27,707	106.52	10.70
FRA	11,162	0.30	0.74
ITA	6,195	101.77	5.64
NLD	104,094	100.51	4.08
USA	197,123	8.31	17.27
	Common data		
CAN	812	100.52	4.42
DEU	812	102.20	10.76
FRA	43	0.24	1.13
ITA	812	100.20	5.39
NLD	812	99.15	3.80
USA	812	-5.08	15.40

Principal Component Analysis (PCA)

In order to examine relationships among these female fertility indexes, a PCA was done on the common bulls between five of these six countries. The PRINCOMP procedure of Statistical Analysis System software was used to perform this analysis. Principal components will be named Prin1 to Prin5 with decreasing eigenvalues. Only female fertility indexes from five countries were used for this analysis in order to have a sufficient number of bulls in common, i.e. 812 bulls instead of 43 bulls if FRA index was not excluded (Table 1).

Combining international proofs to direct female fertility (DFF)

The first principal component, obtained during the first phase, was regressed on the International proofs. The regressions coefficients found for each case (one, two or three international proofs available) were used to estimate one unique value of female fertility, calling direct female fertility (**DFF**), for bulls sent back by INTERBULL. Reliability of DFF was computed using an approach similar to the one proposed by VanRaden (2006a) however the three traits were considered completed independent. This was necessary as the theoretical correlations between the three traits were 1, the observed nearly 1.

Female fertility index for Walloon Region of Belgium

For young bulls, only information of daughter fertility through the first lactation is available which limits the accuracy of DFF. For such animals, the use of correlated traits (e.g., production traits, conformations traits) to estimate an indirect female fertility (**IFF**) may be as accurate as, or more accurate than, the DFF estimated from daughter information in first lactation.

Furthermore, there are also bulls without international proofs for each of the three groups in which we participate but having international proofs in the two others (groups 1 and 3). In such case, prediction of IFF could be also a good solution to provide an indication about the female fertility of these bulls.

A multiple regression method, using as weight the reliability of DFF, was used to find traits (evaluated in the Walloon Region) being the best predictors of female fertility (represented by Prin1) in order to develop IFF. Based on selection index theory, DFF and IFF were combined afterwards in a global index called combined female fertility index (**CFF**). Reliabilities of CFF were estimated according VanRaden (2006a).

Results and Discussion

Principal Component Analysis (PCA)

Table 2 shows eigenvalues and eigenvectors from the PCA. The first component (**Prin1**) explained about 80 percents of the total variance and showed approximately equal coefficients on all foreign indexes. Therefore, a compromise on female fertility expression was given by Prin1, which can be represented as a linear combination of the five foreign indexes.

Table 2: Eigenvalues and eigenvectors from the PCA

	Prin1	Prin2	Prin3	Prin4	Prin5
Eigenvalues	4.039	.365	.291	.186	.118
CAN	.442	-.585	.048	.658	.162
DEU	.470	-.205	.061	-.305	-.801
ITA	.430	.613	-.580	.315	-.068
NLD	.460	-.215	-.282	-.612	.537
USA	.433	.441	.761	-.004	.200

Correlations of the six foreign indexes with Prin1 are showed in Table 3. A posteriori, the exclusion of FRA index could be considered as not a major problem given its correlation with Prin1, which was equal to the correlation with ITA index. The highest correlation was observed for DEU index followed by NLD index; also reflected by the values of coefficient contained in the first eigenvector.

Table 3: Correlation of Prin1 with the 6 countries

	CAN	DEU	FRA	ITA	NLD	USA
Prin1	.89	.94	.86	.86	.93	.87

Combining international proofs to direct female fertility (DFF)

The standardized international proofs are combined, in function of their availability, to DFF using as weights coefficients of regression of Prin1 on the international proofs (see Table 4). As expected, the best R^2 was observed when the three international proofs were available. Some regression coefficients were negative as observed for T2 with T4 and/or T5. This can be interpreted as compensation between highly correlated traits (Table 3).

Table 4: R-square and coefficients of regression of Prin1

	Bulls	R^2	Regression coeff		
			T2	T4	T5
T2	791	.525	.399		
T4	811	.684		.454	
T5	790	.682			.445
T2-T4	790	.703	-.283	.714	
T2-T5	790	.683	-.407		.825
T4-T5	790	.729		.133	.315
T2-T4-T5	790	.730	-.407	.138	.691

Correlations of DFF with the other traits for publishable bulls in the Walloon Region of Belgium are presented in Table 5.
DFF showed positive correlations with only six other traits; the highest was with BCS followed by percent of fat and percent of protein. These results seemed consistent with results found in literature (VanRaden, 2006b). They simplified the search of good predictors of the female fertility.

Combined female fertility index (CFF) for the Walloon Region of Belgium

An index to predict female fertility of bulls based on official Walloon bull proofs for ten traits was derived using milk yield, fat percent, protein, SCS, stature, body depth, overall udder score, overall feet and legs score, final conformation score and BCS .

Table 5: Correlations of traits with DFF for publishable bulls in the Walloon Region of Belgium

Trait	Correlation
Milk	-.53
Fat	-.41
Protein	-.50
%Fat	.19
%Protein	.17
SCS	-.15
Longevity	.13
BCS	.40
Stature [I]	-.31
Chest width [I]	.10
Body depth [I]	-.24
Chest depth	-.26
Loin strength	-.04
Rump length	-.24
Rump angle [I]	.09
Hips width	-.16
Rump width [I]	-.10
Foot angle [I]	-.09
Rear leg set [I]	-.08
Bone quality	-.28
Rear leg rear view [I]	-.01
Udder balance	-.23
Udder depth [I]	-.05
Teat placement side	-.15
Udder support [I]	-.26
Udder texture	-.43
Fore udder [I]	-.17
Front teat placement [I]	-.24
Teat length [I]	-.01
Rear udder height [I]	-.33
Rear udder width	-.36
Rear teat placement [I]	-.33
Angularity [I]	-.49
Overall development	-.21
Overall rump	-.21
Overall Feet and legs [I]	-.16
Overall udder score [I]	-.23
Overall fore udder	-.18
Overall rear udder	-.25
Dairy character	-.41
Final conformation [I]	-.33

[I] INTERBULL type trait

However, BCS is only recorded in Walloon Region for a few years, as in several countries. Not all bulls have a proof for BCS consequently a second index was developed. This index was composed by the same traits as the first index but BCS was replaced by angularity, which presented also a high but negative correlation with DFF (see Table 5). The first index was called IFF_{BCS} and the second called $IFF_{ANG.}$

Correlations between international proofs and DFF and the two IFF are showed in Table 6. Considering that high correlation between T4 and T5, same range of correlations with DFF and IFF were not surprising. Correlation between both IFF was close to unity, so IFF_{BCS} and IFF_{ANG} can be considered very similar (see Table 6).

Table 6: Correlations between female fertility proofs and indexes for publishable bulls in Walloon Region

	T2	T4	T5	DFF	IFF_{BCS}	IFF_{ANG}
T4	.90					
T5	.95	.97				
DFF	.83	.97	.96			
IFF_{BCS}	.42	.48	.50	.51		
IFF_{ANG}	.51	.57	.58	.59	.99	
CFF	.80	.92	.93	.96	.76	.82

Besides, both indexes have the same range of correlations with T2, T4, T5 and DFF but, as expected, slightly higher for IFF_{ANG}. Also correlations with T2 were lower with all traits.
Coefficients to combine DFF with IFF into CFF obtained were, if BCS is available:

$$CFF= .751 * DFF + .381 * IFF_{BCS}$$

Otherwise, as:

$$CFF= .763 * DFF + .373 * IFF_{ANG}$$

Correlation between Prin1 and CFF (.86) was very close of the one with DFF (.85). Therefore, there was no loss of information to combine DFF with IFF into CFF. Furthermore, these correlations were comparable to those previously observed between Prin1 and the six foreign indexes in Table 3.

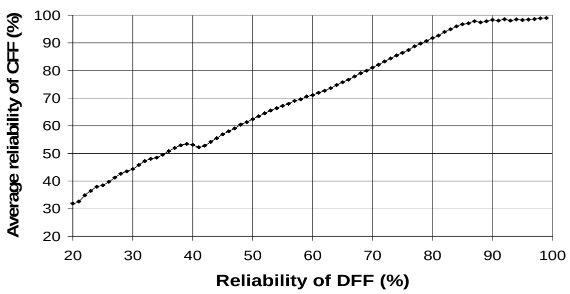

Figure 1: Average reliability of CFF as a function of reliability of DFF (N = 88,496 bulls)

Moreover, as illustrated in Figure 1, CFF presented, in average, higher reliabilities than DFF principally for bulls having a reliability of DFF below 80%.
On the 88,496 sires from INTERBULL, 82,757 bulls had a reliability of DFF > 34% (rule of publication) and 86,776 had a reliability of CFF > 34% which leads to extra 4,019 bulls with publishable female fertility information.

Conclusion

This research has permitted to develop an alternative method to the previous post-treatment of the international female fertility proofs; but also to add indirect information thanks to the combination of DFF and IFF into CFF.
According to correlations of CFF with DFF and Prin1, CFF could be considered as a pretty good expression of female fertility with a better accuracy for young bulls. For bulls without international proofs, CFF provide a useful first indication of female fertility potentiality.
This new female fertility index will be presented to our breeders in a couple of months and we hope that it will be a helpful tool to manage fertility of their herds.
The next step will be to integrate CFF into the Walloon economic index system and therefore to improve our global economic index.

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