Use of National and International EBVs of female fertility in Total Merit Index

Stéphanie Minery, Mickaël Brochard and Sophie Mattalia
Institut de l'Elevage, INRA-SGQA ,78352 Jouy en Josas, France
email: difindetr@dga.jouy.inra.fr

1. Introduction

Decrease in the fertility of dairy cows has been reported all around the world (Bousquet *et al.*, 2004), with important economic consequences (repeated inseminations, fertility treatments, prolonged lactation, involuntary culling). One of the reasons of this decrease is the negative genetic correlation with milk production. Until the nineties, selection focussed on production traits, without taking into account their negative effects on fertility, probably because of the complexity of the trait and the lack of complete and reliable insemination records (Jorjani, 2005). But progressively, countries developed national models of evaluation of fertility, and integrated it in their Total Merit Index (TMI). Recently (February 2007) Interbull implemented a routine international genetic evaluation of five fertility traits that allows better comparison of international bulls. This article compares the definition of fertility traits and their weight in TMI for nine countries. Then it considers how countries use international fertility estimated breeding values (EBVs) nationally with a focus on the French situation.

2. Relative emphasis on fertility in different Total Merit Indexes

We restrict the presentation to 9 important countries in terms of number and exchanges of bulls (Figure 1) in the Holstein breed: Canada (CAN), Denmark (DNK) (joint with Finland and Sweden (DFS)), France (FRA), Germany (DEU), Italy (ITA), Netherlands (NLD), New Zealand (NZL), United Kingdom (GBR) and USA. NLD put the largest weight on fertility in their TMI. They changed definition in 2007 and moved from DPS to NVI with a large emphasis on fertility (19% in 2008). GBR put also a large weight for fertility, with 18.5% in its TMI. FRA has a weight of 12.5% on fertility in ISU. CAN moved in January 2008 from 5% on fertility to 10% in LPI and DEU just passed from a weight of 1% to 10% on fertility in RZG in April 2008. With 9% on fertility we find DFS (S-Index), NZL (BW) and USA Net Merit (definition changed in 2006). USA TPI put 8% on fertility. ITA does not yet include fertility directly in its TMI.

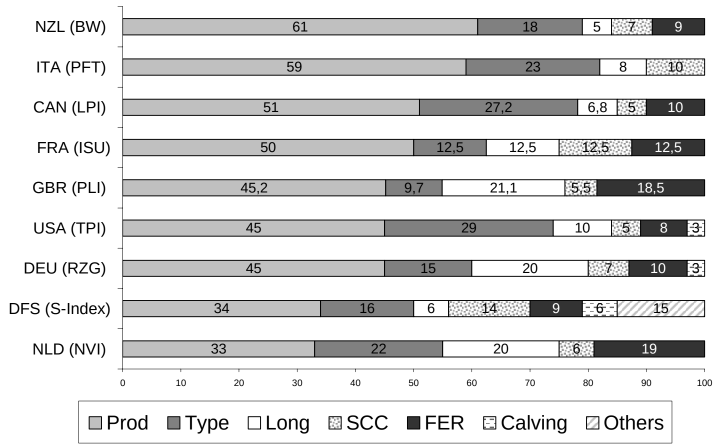

Figure 1. Composition of Total Merit Index in April 2008 (relative emphasis %).

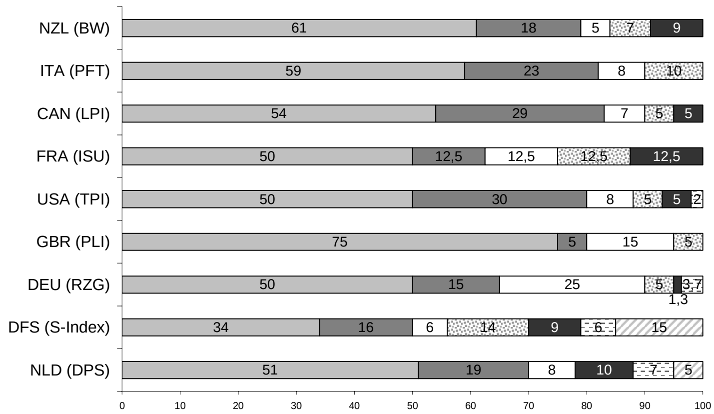

Figure 2. Composition of Total Merit Index in 2005 (relative emphasis %).

The comparison with the 2005 situation (Figure 2) illustrates general increase of weight on fertility in the recent years, associated with a decrease of emphasis on the production traits. For most of the countries in 2000, TMI were a combination of production and type traits, and only DNK and DEU had included fertility at that time. Note that the actual weight in TMI is underestimated when correlated traits also appear in TMI. This is the case for example for FRA where longevity also gets a weight of 12.5%, while longevity and fertility exhibit a large genetic correlation (0.48).

3. Fertility traits evaluated in different countries

Female fertility is a complex trait. A fertile cow should rapidly re-cycle after calving and should be pregnant quickly after the first artificial insemination (AI). Thus we usually distinguish traits that measure the animal's ability to re-cycle after calving (such as calving to first AI interval) from traits that measure the animal's ability to become pregnant (such as non return rate or conception rate). Some traits combine both abilities, such calving interval (Jorjani, 2005).

Measures and models of genetic evaluation of fertility depend on selection objectives of the country and its ability to collect complete AI data and calving dates. Calving interval corresponds to the objective of one calf per year and does not require AI information, but its evaluation arrives late and can be biased because cows culled for low fertility are not taken into account. Calving to first AI interval is available earlier, but it gives only an indication about the ability of the cow to re-cycle after calving. FRA chose to evaluate conception rate (success or failure after each AI) of heifers and of cows, as the most accurate indicator of the ability to conceive. Non return rate (usually at 56 days after first AI, NRR56) is obtained earlier, but it does not include all AI records. Interval measures generally have higher heritability than conception or non return rates.

Table 1 gives a description of the fertility traits evaluated in the 9 studied countries. Fertility traits measured on heifers are considered genetically different from fertility traits on cows, with a genetic correlation estimated at 0.52 (Boichard *et al.*, 2002), and some countries separate the two, namely CAN, DEU, DFS and FRA. Some other traits, such as milk production, conformation or body condition score are sometimes considered as predictors in the fertility genetic evaluation in order to increase reliabilities of the breeding values, especially for young bulls. FRA includes milk production, somatic cell count, longevity and conformation traits. ITA uses milk production and angularity. GBR, NZL and NLD include milk production and body condition score (NLD adds fat and protein yield). Since January 2008 CAN have evaluated 9 fertility traits together with calving traits. NZL has very specific fertility traits (PM21 and CR42, see definitions below table 1) adapted to their seasonal production system. Finally, countries with several fertility traits compute a Fertility Index (Table 1, in brackets).

4. International evaluation of fertility and use of Interbull EBVs

After the development of international genetic evaluations for production (1994), conformation (1999), udder health (2001) direct longevity (2004) and calving traits (2005), it appeared essential for Interbull to implement an evaluation of female fertility. A pilot study concluded to the feasibility of an international genetic evaluation of fertility (Jorjani, 2005) which began officially in February 2007, in the Holstein breed. In April 2008, 16 countries were participating, with the possibility to send 5 different traits per country. Even if it is relatively transparent to know what kind of data countries sent to Interbull (Table 2), it is not straightforward to know what International information is used and/or published for fertility by these countries. Many different alternatives could be chosen by the countries, as illustrated below.

Choice of traits and possible "post-processing" (Table 3)

DEU participates to all fertility trait groups and use all Interbull results to compute the RZR fertility index.

CAN also participates to the 5 trait groups, but uses only Interbull results for traits 2, 3 and 4 to compute the FF fertility index. DFS is in the same situation and computes fertility index from traits 2, 3 and 5. If only trait 3 or trait 5 is available a specific equation is developed.

Other countries do not send data for all 5 trait groups, and sometimes they send the same data for 2 trait groups. For example FRA sends conception rate for trait groups 3 and 4, USA sends daughter pregnancy rate (DPR) for trait groups 2, 3 and 4, NZL sends CR42 for groups 4 and 5 and ITA send calving interval for trait groups 4 and 5.

FRA and NZL chose to use Interbull results of only one group: trait 4 for FRA and trait 5 for NZL. FRA selects trait 4 because all the countries participate to this trait group and genetic correlations between FRA and the other countries for trait 3 are not better than for trait 4. Then FRA combines Interbull results with a predicted fertility computed from correlated traits (Table 4), using a selection index approach. The objective is to get combined EBVs the closest as possible to the national fertility EBVs which are obtained from an approximate mutiple trait animal model (Ducrocq *et al.*, 2001). NZL combines national and international EBVs in a "post processing" step.

Table 4. Correlated traits used by FRA to predict fertility (whether longevity is available or not).

	Longevity (R^2=22%)	No longevity (R^2=13%)
Milk	26% (-)	
Protein Yield		36.3% (-)
SCC		26.5%
Longevity	45.6%	
Rump Width	2%	
Rump Angle	17%	29.1%
Angularity	4.8% (-)	
Body Depth	4.5% (-)	8% (-)

Some countries chose among several trait groups, values with highest reliability. NLD uses Interbull results of trait 3 and EBV with highest reliability among trait 4 or 5 for calving interval. ITA has the same strategy, and adds traits 2. Then ITA combines fertility EBVs with angularity and milk production. USA also selects EBV with highest reliability among traits 2, 4 or 5 (only if reliability is above 40%).

GBR uses Interbull fertility results of trait 3 and trait 4. They use trait 2 when trait 4 is missing or trait 5 if traits 2 and 4 are missing.

If missing trait or missing country (Table 5)

Countries try to use the maximum available information for other countries that do not send data for a required trait group, or when the country does not participate at all to the fertility international evaluations.

Some of them compute parent average EBVs (NZL, GBR), some others calculate prediction from correlated traits (USA, ITA). DEU and FRA use both options, depending on availability of parents average EBVs. CAN computes a prediction from available fertility traits. NLD combines parents average EBVs with mendelian sampling terms from available fertility and milk production, using genetic correlations between traits.

These procedures allow computation of fertility index and TMI for most of the international bulls. Sometimes these values calculated for missing traits are also published.

Criteria for publication (Table 6)

Some countries prefer to publish national fertility EBVs for foreign bulls having daughters in the country. FRA publishes combined Interbull fertility for foreign bulls when the reliability is at least 50% and if trait 4 is available. For bulls progeny tested in FRA, national fertility EBVs replace Interbull EBVs as soon as their national reliability reaches 50%. ITA, DFS and CAN publish Interbull fertility index until national fertility index becomes official (reliability at least 50% for ITA and DFS and for CAN at least 20 daughters in 10 herds for NRR56, with reliability above 45%). For NLD, national fertility EBVs are published if the reliability is above 90%, otherwise Interbull EBV is official (if reliability is above 35%). When the fertility index is official, both elementary traits proofs become official.

Other countries choose to publish Interbull fertility results instead of national EBVs, when they are available. This is the case for GBR (when the reliability is at least 20%), DEU (when the reliability of fertility index is at least 30% with at least 10 daughters for NRR56 or calving to first AI interval) and USA (as soon as they have 10 daughters).

NZL publishes EBVs blending national and Interbull EBVs for all bulls enrolled in the genetic evaluation system.

5. Future evolutions in France

FRA plan to evaluate calving to first AI interval to completely cover female fertility abilities. A fertility index will be defined to integrate the different fertility traits. The definition of French TMI (ISU) will be modified in order to put more emphasis on fertility.

Moreover FRA will study the possibility to evaluate NRR56, as an early predictor of conception rate. As most of the countries send NRR56 for ability to conceive, FRA will assess the benefit to send NRR56 to Interbull to improve genetic correlations with other countries.

6. Conclusion

The variety of traits considered in national fertility evaluation is continuously increasing. In recent years, fertility has regularly increased in Total Merit Indexes. International genetic evaluation began in February 2007, with the possibility to send 1 heifer trait and 4 cow traits. The use of fertility Interbull results is very variable between countries, in the way to select traits (some countries select the value with highest reliability among 2 or 3 traits, some others choose one specific trait), in the way to "fill up" missing values (predicted fertility from correlated traits, parents average EBVs…), and in the way to combine or not international EBVs with other EBVs. In some cases, there is a risk of double counting, as countries could send the same data into different trait groups.

As fertility is presently often one of the major traits in TMI, it is important first to work on the harmonisation of traits definition, but also to help the users in understanding the results. At this level, it would be necessary to have a clear description of the procedures used by the countries to derive the published "Interbull" fertility EBVs from national and international EBVs. Some recommendations on these procedures would help to harmonise and to clarify the situation.

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Table 1. Different fertility traits evaluated in 9 countries (in brackets weight in % in Fertility Index).

	FRA	USA	DFS	DEU	ITA	GBR	NZL	NLD	CAN
	Ability to recycle after calving								
Calving-first AI interval			Cow (54%)	Cow (25%)	Cow	Cow		Cow	Cow (15%)
Age at first AI									Heifer (10%)
PM21							Cow		
	Ability to become pregnant								
Non Return Rate at 56 days			Heifer Cow	Heifer (12.5%) Cow (25%)	Cow	Cow (83%)		Cow	Heifer Cow (50%)
AI number						Cow			Heifer Cow
Conception rate	Heifer Cow								
First-last AI interval			Heifer (10%) Cow (36%)						
First AI - conception				Heifer(12.5%) Cow(25%)					Heifer Cow (25%)
	Combination of the 2 abilities								
Calving Interval					Cow	Cow (17%)		Cow	
Days Open				Cow*					Cow*
Daughters pregnancy rate		Cow							
CR42							Cow		

* computed from "calving to first AI interval" and "first AI to conception interval"
Days Open (DO) = calving to conception interval
Daughters pregnancy rate=21/(DO – voluntary waiting period + 11)
PM21 = cow presented/or not for mating in the first 21 days after the planned start of mating
CR42 = calving/or not in the first 42 days after planned start of calving

Table 2. Data sent to International Fertility Genetic Evaluation in the Holstein breed (April 2008).

	Trait 1	Trait 2	Trait 3	Trait 4	Trait 5
April08	**Heifer ability to conceive**	**Cows ability to re-cycle after calving**	**Cows ability to conceive (rate trait)**	**Cows ability to conceive 2 (interval trait)**	**Interval Measures**
Belgium		Pregnancy rate		Pregnancy rate	Pregnancy rate
Canada	NRR56	Calving- first AI	NRR56	First AI-conception	Days Open
Switzerland		Calving- first AI	NRR56	NRR56	
Switzerland Red		Calving- first AI	NRR56	NRR56	
Czech Rep.	Conception rate		Conception rate	Conception rate	
Germany	NRR56	Calving- first AI	NRR56	First-last AI	Days Open
Denmark, Finland, Sweden	NRR56	Calving- first AI	NRR56	First-last AI	Days Open
Spain		Days Open		Days Open	Days Open
France	Conception rate		Conception rate	Conception rate	
United Kingdom		1st-2nd calving	NRR56, L1	1st-2nd calving	1st-2nd calving
Ireland		Calving interval		Calving interval	Calving interval
Israel			NAI to conception	NAI to conception	
Italy		Calving- first AI	NRR56	Calving interval	Calving interval
Netherlands		Calving- first AI	NRR56	Calving interval	Calving interval
New Zealand		PM21		CR42	CR42
USA		Pregnancy rate		Pregnancy rate	Pregnancy rate

NRR56 = Non Return Rate at 56 days
NAI = Number of Artificial Inseminations
PM21 = cow presented/or not for mating in the 21 first days after the planned start of mating
CR42 = calving/or not in the 42 first days after planned start of calving

Table 3. Choice of traits and possible post processing.

	Interbull fertility results used at the national level	Post processing
CAN	Traits 2, 3 and 4, or any combination including 4	
DEU	Traits 1, 2, 3, 4 and 5	
DFS	Traits 2, 3 and 5	
FRA	Trait 4	Blended with fertility predicted from correlated traits
GBR	Trait 3 and Trait 4 (or 2 if 4 is missing, or 5 if 2 and 4 are missing)	
ITA	Traits 2, 3 and Traits 4 or 5 (highest reliability)	Blended with milk production and angularity
NLD	Trait 3 and Trait 4 or 5 (highest reliability)	
NZL	Trait 5	Blended with national fertility EBVs
USA	Trait 2 or 4 or 5 (highest reliability)	

Table 5. Procedure in case of missing trait.

	Replacing missing traits
CAN	Prediction from available fertility traits
DEU	Parent average EBVs, if available Otherwise prediction from correlated traits
DFS	-
FRA	Parent average EBVs, if available Otherwise prediction from correlated traits
GBR	Parent average EBVs
ITA	Prediction from correlated traits
NLD	Parents average and mendelian sampling terms of available fertility and milk production, using genetic correlations
NZL	Parent average EBVs
USA	Prediction from correlated traits

Table 6. Publication.

	Criteria of publication	Foreign bulls having daughters in the country
CAN	Reliability at least 45% with at least 20 daughters in 10 herds for cow NRR56. For Interbull, only fertility index is published	National EBVs replace Interbull EBVs
DEU	Reliability at least 30% with at least 10 daughters for NRR56 or calving-first AI interval	Interbull EBVs replace National EBVs
DFS	Reliability if fertility index at least 50%, with 30 daughters	National Fertility Index replace Interbull Fertility Index
FRA	Reliability at least 50%	National EBVs replace Interbull EBVs when bulls are progeny tested in FRA
GBR	Reliability at least 20% (and 30% for fertility index with a national and/or a Interbull EBVs)	Interbull EBVs replace National EBVs
ITA	Reliability at least 50% For Interbull, only fertility index is published	National EBVs replace Interbull EBVs
NLD	Reliability at least 35%	National EBVs replace Interbull EBVs if national reliability is above 90%
NZL	All bulls enrolled in the evaluation system	National EBVs and Interbull EBVs are blended
USA	All bulls with at least 10 daughters	Interbull EBVs replace National EBVs