Survey on genetic evaluation procedures for functional traits in cattle in various countries

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Introduction

Current and future breeding programmes should be based on effective selection both nationally and internationally. Effective selection means identifying and selecting the best breeding animals to serve one's breeding goal. Breeding goals vary from country to country but in general consider various profitability related traits such as production, reproduction, health, management, and conformation.

Availability of tools to facilitate selection decisions for the above traits is pre-requisite for a successful breeding programme. National genetic evaluations provide the means for successful selection within a country's limits. International comparisons present the opportunities for across country selection.

Currently, international evaluations for dairy production (yield) traits are being computed at the Centre of the International Bull Evaluation Service (INTERBULL) on a routine basis. Such international evaluations are based on simultaneous analysis of national evaluation results from various countries

Expanding the international evaluation system to include economical important non-production (functional) traits would be desirable. The following factors, however, need to be taken into consideration:

1 Availability of information (records, genetic evaluations) on functional traits at national level in various countries.

2 Comparability of this type of information across different countries.

A survey was undertaken by the INTERBULL Centre to canvass the status of recording and genetic evaluation for functional traits in various countries. Responses to the survey are expected to provide useful indications regarding the feasibility of future international genetic comparisons for such traits.

This article briefly describes the survey, summarizes responses that have been received to this date, and speculates on future possibilities regarding international genetic evaluations for functional traits.

Survey description

All members of INTERBULL (presently 33 countries) were asked to provide facts on national genetic evaluation procedures applied to non-production traits in dairy and dual purpose cattle breeds. The questionnaire comprised several fields of information as follows:

- trait definition and unit of measurement
- method of measuring and collecting data (records)
- time period for data (records) inclusion in the national evaluation
- age groups of animals included in the national evaluation
- genetic parameters assumed in the national evaluation
- bull categories evaluated
- effects considered in the evaluation (including pre-adjustments, relationships etc)

- model of genetic evaluations and validation procedures
- expression of genetic proof (including reference base, criteria for publication etc)
- number and time of evaluations/publications

To this date twenty one (21) responses have been received. Table 1 shows the countries that have reported presence of national genetic evaluation system for some functional traits. Responses are classified by breed. Although more breeds mights have been reported by some countries, only those with international interest, i.e. with related populations in at least two countries, are included in Table 1.

Some responses have been provided collectively by a single reference body in an individual country while others have been sent separately from different agencies in the same country. In the latter case, the picture regarding breeds evaluated may not be complete, as some breed societies may have not provided all pertinent information yet.

Responses are still being collected and compiled. Upon completion of the process, all information will be analytically presented in an INTERBULL Bulletin, as an update of Bulletin No. 6 (1992).

Summary of results

Non-production traits included in the survey responses were classified according to the following categories:

1 Reproduction, including calving difficulty, stillbirth, and fertility
2 Health, including mastitis and somatic cell count
3 Milkability, including milking speed and udder conformation traits
4 Locomotion, including feet & leg conformation traits
5 A general category with traits not included in the first four, such as other body conformation traits, temperament, and longevity

A summary of information on the above categories follows.

Reproduction - calving difficulty

Twelve (12) countries have reported on their genetic evaluation systems of Holstein bulls for calving difficulty using BLUP: Australia, Austria, Canada, Denmark, Germany, Ireland, Israel, Italy, Netherlands, Slovenia, Sweden, and United States of America (USA). Calving difficulty evaluations in more than two countries are also available in the Ayrshire, Brown Swiss, and Simmental breeds. Table 2 summarizes some characteristics of the evaluation systems in these countries.

In almost all cases, records are being collected by farmers and then incorporated in the milk recording scheme. Records are basically subjective scores assessing the difficulty of delivery (in anywhere between 2 and 5 classes of difficulty) except in a couple of cases where percentage of "difficult" births is being recorded. There is no standardization of the definition of "difficult" across countries.

In most countries the maternal side of calving difficulty is also considered in the evaluation. Thus, bulls receive one evaluation for the direct effect (the difficulty of their progeny birth) and one for the maternal effect (the difficulty of their progeny delivery).

Records from different age groups of animals are considered in various countries. In some countries evaluations are based on performance of first calvers only, elsewhere on later calvers only, but in most countries records of both first and later calvers are considered in the genetic evaluation.

Most genetic evaluations are under a BLUP sire or sire-MGS model but some countries have already switched to animal models. When multiple calvings are considered, repeatability models are more popular while in only one country (Denmark) different calvings are considered different traits; in this country, the multi-trait evaluation model also considers calf vitality (stillbirth) and birth size. In the USA a non-linear threshold model is in place for calving difficulty evaluation of the Holstein breed.

Bull proofs in most countries are expressed in a standardized form and in few countries they are expressed in the trait unit (subjective score or % difficult births). Standardization results in either a normalized linear scale or in relative breeding values with a mean of 0 or 100 and standard

deviation ranging from 5 to 12 units.

Other calving performance related traits, such as gestation length and size of the calf, are evaluated in very few countries (gestation length in Holsteins in Ireland and Netherlands and birth size/weight in Holsteins in Denmark and Netherlands).

Reproduction - stillbirth

Only four (4) countries have reported genetic evaluation systems of Holstein bulls for stillbirth using BLUP: Denmark, Germany, Israel, and Sweden. One more country (Finland) evaluates for stillbirth using selection index. Table 3 summarizes some characteristics of the evaluation systems in these countries. Coloured breed evaluations are also available in Norway (Ayrshire) and Switzerland (Brown Swiss and Simmental).

Records are normally being collected by farmers and then incorporated in the milk recording scheme. Records are either 0/1 scores (indicating alive/dead calf) or percentage of calves born dead or dying within 24 hours. In all countries the maternal side of stillbirth is also considered in the evaluation. In half of the countries only first calving records are included in the evaluation and in the other half first and later calving records are considered simultaneously.

Almost everywhere genetic evaluation systems are based on BLUP sire or sire-MGS models but one country (Germany) has switched to the animal model. One country (Denmark) considers different calvings as different traits; in this country, the multi-trait evaluation model also considers calving difficulty and birth size.

Bull proofs in all but one countries are expressed in a standardized form. Standardization here results in relative breeding values with a mean of 0 or 100 and standard deviation ranging from 5 to 12 units.

Reproduction - female fertility

The picture is much more complicated in this case. Eight (8) countries have reported presence of genetic evaluation systems of Holstein bulls for some female fertility trait using BLUP: Austria, Denmark, Finland, Germany, Israel, Netherlands, Slovenia, and Sweden. Genetic evaluations for fertility traits in more than two countries are also available in the Ayrshire, and Brown Swiss breeds. Table 4 summarizes some characteristics of the evaluation systems in these countries.

As can been concluded from Table 4, there is no real standardization in female fertility trait definition across countries. There are non-return related traits spanning different time periods (from 56 to 90 days) in a few countries; there are also some interval traits, such as days from calving to first insemination, from first to last insemination, and from calving to calving as well as days open; finally there are traits related to number of inseminations per conception and strength of heat signs. Some survey responses have reported variable genetic correlation estimates among some of these traits within country, ranging from .10 to .85. It would be interesting to estimate such correlations across countries, but they are not expected to be higher than within country.

In half of the countries genetic evaluations are based on BLUP sire or sire-MGS models and the other half have switched to animal models. In some cases, heifers and cows are evaluated separately.

Bull proofs are expressed in a standardized form in as many countries as in the trait unit. Standardization here also results in relative breeding values with a mean of 0 or 100 and standard deviation ranging from 5 to 12 units.

Health - Somatic cell count and mastitis

Clinical mastitis is only being evaluated for in four Nordic countries: Denmark (Holstein), Finland (Holstein and Ayrshire), Norway (Ayrshire), and Sweden (Holstein and Ayrshire). Records in these countries are associated with veterinary treatments for the disease.

Somatic cell count (SCC) as an indicator trait of mastitis incidence is recorded and evaluated for in more countries. Canada, Denmark, Finland, Germany (regional at the moment), Israel, Sweden, and the USA have routine evaluations for the Holstein breed. Ayrshire and Brown Swiss are also being evaluated in more than two countries. Table 5 summarizes some characteristics of the evaluation systems in these countries.

The trait is mostly defined as logarithmically transformed somatic cell concentration in milk. In most cases a lactation mean is produced, except in Canada where the individual test-day observation is considered. In this country, a multi-trait test-day animal model is used for genetic evaluation. In all other cases single trait sire or animal models are used to analyze the lactation score.

The objective nature of the SCC definition (basically number of cells per ml of milk) reduces the need for across country standardization and makes it simpler to incorporate in an international evaluation scheme. Of course differences across countries exist including the number of lactations considered in the evaluation, the period within lactation when tests are taken, and the age groups of evaluated animals. Fikse (1995) computed genetic correlations between SCC in three countries (Denmark, Finland, USA) and his estimates ranged from .60 to .85.

Milkability - milking speed

Twelve (12) countries have reported genetic evaluation systems of Holstein bulls for milking speed using BLUP: Australia, Canada, Denmark, Finland, France, Ireland, Italy, Netherlands, New Zealand, Slovenia, Sweden, and the United Kingdom. Two more countries (the Czech Republic and Germany-regional) evaluate milking speed with Contemporary Comparison methods. Milking speed evaluations in more than two countries are also available in the Ayrshire, and Brown Swiss breeds. Table 6 summarizes some characteristics of the evaluation systems in these countries.

In almost all cases, records reflect the farmer's assessment of the milking speed. Scores are classified in up to 9 categories from slow to fast (or vice versa) but there is no standardization of the definition of "fast" across countries. In a couple of countries, alternative measures such as output per minute are considered.

In most countries only first lactation cows are being assessed. Most evaluations are single trait except in France where milking speed is evaluated for together with udder conformation and Denmark where first and second lactation scores are considered different traits. In the majority of countries, bull proofs are expressed in a standardized scale with standard deviation ranging from 1 to 12 units.

Milkability - udder conformation traits

A plethora of udder conformation traits is available in most of the countries shown in Table 1. The most frequently evaluated for traits are fore udder attachment, udder depth, rear udder height and width, teat length and placement, and suspensory ligament as well as overall udder score. Table 7 summarizes some characteristics of the evaluation systems for such traits. Regarding standardization of definitions across countries, some European countries have adopted the guidelines of the European Confederation of Black and White Breed Societies (Diers, 1993).

In most countries single observations from animals up to two (2) years of age are considered; some countries, however, consider multiple records per animal. Most evaluations are based on single trait models except in France and the USA where several udder conformation traits are evaluated for simultaneously and Denmark where first and second lactation scores are considered different traits. In the majority of countries, bull proofs are expressed in a standardized scale with standard deviation ranging from 1 to 12 units.

Correlations of udder conformation traits across countries have been estimated by Fikse (1995) in a three-country scenario including Canada, Denmark, and the USA and were between .77 and .95. While estimates among other countries are needed, these preliminary figures hint to the feasibility of meaningful international genetic evaluations for such traits.

Udder conformation traits are not only associated with the animals' milking ability but may also reflect their udder health status. This is especially important when international comparisons for udder health are desirable but data are not available in many countries. Estimating the expected daughter resistance to mastitis in one country based on udder conformation evaluation in another becomes then quite interesting. The magnitude of the appropriate genetic correlations among traits across countries would be the decisive factor; preliminary results of a research study show correlations between some udder conformation traits in the USA and clinical

mastitis in Denmark of up to .45-.50 (Gary Rogers, personal communication).

Locomotion

Almost all countries compute genetic evaluations for traits related to the animal's moving ability. Most frequently evaluated for traits are rear leg set and foot angle as well as overall feet and leg score. Table 7 summarizes some characteristics of the evaluation systems for such traits.

Trait definition, age groups included in the evaluation, method of evaluation, and bull proof expression are similar to the udder conformation traits discussed above. Genetic correlations among Canada, Denmark, and USA for these traits were also estimated in the study by Fikse (1995) and were between .79 and .94 except for foot where correlations were lower; the latter is defined differently in these three countries.

Temperament

Eight (8) countries have reported existence of genetic evaluation systems of Holstein bulls for temperament using BLUP: Australia, Denmark, Finland, Ireland, Netherlands, New Zealand, Sweden, and the United Kingdom. Table 8 summarizes some characteristics of the evaluation systems in these countries.

In almost all cases, records reflect the farmer's assessment of the animal's temperament, frequently while milking. Scores are classified in up to 9 categories from placid to nervous (or vice versa) but there is no standardization of the definition of "placid" across countries.

In most countries only first lactation cows are assessed. Most evaluations are single trait and bull proofs are expressed in a standardized scale with standard deviation ranging from 1 to 12 units.

Feasibility of international evaluations for functional traits

There has been an increasing number of countries establishing genetic evaluation systems for several functional traits compared to a similar survey conducted a few years ago (INTERBULL Bulletin No. 6, 1992). This indicates the increasingly important role such traits are assuming in determining the animal's profitability. It also means that availability of such data in making international genetic comparisons is less of a concern than before. How well do such data relate to each other across countries remains to be seen. The flexibility of current methodology (Schaeffer, 1994; Sigurdsson and Banos, 1995) would enable incorporation in an international evaluation scheme of traits that are not exactly the same across countries. The question of the minimum genetic correlation among countries needed for such international evaluations to make sense has not been answered yet.

Some additional technical issues may also arise. International evaluation results with the current methodology are only as good as national evaluation results that are used as input. Methods to validate national genetic evaluation systems for dairy production traits regarding estimation of the genetic trend have been developed (Bonaiti et al, 1994). For non-production traits most countries perform certain quality control and follow some protocol on model selection but only 4-5 countries actually implement standard genetic trend estimation tests.

Another problem that will arise is utilization of national evaluation results based on a multi-trait model. On several occasions functional traits are simultaneously evaluated for (e.g. conformation traits in France and the USA, SCC and mastitis resistance in Denmark, direct and maternal calving performance and stillbirth traits in several countries etc). The existing methods that prepare data for the international evaluation (proof de-regression, genetic parameter estimation) operate on a single-trait mode. Research is needed to determine whether modification of the procedure to account for multi-trait national evaluation results is necessary.

Conclusions

Several functional traits are now being genetically evaluated for on a routine basis in many countries; further, the need to combine such information and compute international evaluations for these traits is more pronounced than ever. Experience from

similar practices with dairy production traits together with the flexibility of the available methodology allow, without a doubt, room for optimism. However, several technical questions specific to traits of this kind need to be addressed in research.

Given the overall picture with regards to data availability and comparability across countries as well as experiences with pilot studies, we are now closer to international evaluations for some conformation traits and for somatic cell count than for any of the other traits. Data availability for calving difficulty, milking speed, and temperament does not seem to pose any problems, but research is needed to gain experience with these traits at the international level. Female fertility may be a problem area since there are about as many trait definitions as there are countries with genetic evaluations. Estimation of genetic correlations of such different traits across countries is needed in order to assess the magnitude of the problem and evaluate the possibilities that may be open

Acknowledgements

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Table 1. Presence of national genetic evaluation system (Y) for functional traits, by breed, for the 21 countries that have responded to the INTERBULL Centre survey.

	Breeds						
	Holstein group[1]	Ayrshire group[2]	Brown Swiss	Guernsey group	Jersey group	Simmental group[3]	Non-Ayrshire Red/Red & White
Country							
Australia	Y				Y		
Austria	Y		Y			Y	
Belgium	Y						Y
Canada	Y	Y	Y	Y	Y		
Czech Republic	Y					Y	
Denmark	Y		Y		Y		Y
Finland	Y	Y					
France	Y		Y				
Germany	Y		Y[4]			Y[4]	Y
Ireland	Y						
Israel	Y						
Italy	Y		Y				
Netherlands	Y						Y
New Zealand	Y	Y			Y		
Norway		Y					
Slovenia	Y		Y			Y	
Spain	Y						
Sweden	Y	Y					
Switzerland			Y			Y	
United Kingdom	Y	Y		Y	Y		
United States	Y	Y	Y	Y	Y		Y

[1] Includes Black-and-White and Holstein-Friesian strains
[2] Includes Red-and-White Ayrshire type populations
[3] Only dairy and dual purpose populations considered
[4] Regional evaluations only

Table 2. Summary of genetic evaluation systems for **calving difficulty** in various countries applying BLUP evaluation models; breeds with at least three evaluating countries are considered; SM=Sire Model, AM= Animal Model, MT=Multi-Trait.

		Breeds			
		Holstein	Ayrshire	Brown Swiss	Simmental
trait definition:	subjective score[1]	10 countries	3 countries	6 countries	3 countries
	% difficult births	2 countries			1 country
maternal effect		≥ 8 countries	3 countries	≥ 5 countries	≥ 2 countries
age groups:	first calvers only	3 countries	2 countries	2 countries	1 country
	later calvers only	4 countries			
	all animals	5 countries	1 country	4 countries	3 countries
model of evaluation:	SM	7 countries	2 countries	2 countries	2 countries
	SM MT[2]	1 country		1 country	
	SM threshold	1 country			
	AM	3 countries	1 country	3 countries	2 countries
proof expression:	standardized[3]	7 countries	3 countries	5 countries	4 countries
	trait units	5 countries		1 country	
countries with evaluation:		12 countries	3 countries	6 countries	4 countries

[1] Two to five classes
[2] First and later calvers are considered different traits; evaluated together with stillbirth
[3] Standard deviation 5-12 or normalized score

Table 3. Summary of genetic evaluation systems for **stillbirth** in the Holstein breed in various countries applying BLUP evaluation models; SM=Sire Model, AM=Animal Model, MT=Multi-Trait.

trait definition[1]:	subjective score	2 countries
	% dead	2 countries
maternal effects		4 countries
age group:	first calvers only	2 countries
	all animals	2 countries
model of evaluation:	SM	2 countries
	SM MT[2]	1 country
	AM	1 country
proof expression:	standardized[3]	3 countries
	trait units	1 countries
countries with evaluation:		4 countries

[1] Usually dead/alive with 24 hours
[2] First and later calvers are considered different traits; evaluated together with calving difficulty
[3] Standard deviation 5-12 or normalized score

Table 4. Summary of genetic evaluation systems for **female fertility** in various countries applying BLUP evaluation models; breeds with at least three evaluating countries are considered; SM=Sire Model, AM= Animal Model.

		Breeds		
		Holstein	Ayrshire	Brown Swiss
trait definition[1] [2]:	NR	4 countries	1 country	3 countries
	CV1INS	3 countries	1 country	1 country
	1LINS	1 country		1 country
	CI	2 countries		1 country
	DO	1 country	1 country	1 country
	INS/CON	2 countries	1 country	
	Heat Strength	1 country	1 country	
model of evaluation:	AM[3]	4 countries	1 country	2 countries
	SM[3]	4 countries	2 countries	3 countries
proof expression:	standardized[4]	2 countries	3 countries	5 countries
	trait units	2 countries		
countries with evaluation[2]:		8 countries	3 countries	5 countries

[1] NR=Non Return to 56-90 days; CV1INS=calving to first insemination; 1LINS=first to last insemination; CI=Calving interval; DO=days open; INS/CON=function of number of inseminations per conception

[2] In some countries more than one trait are evaluated

[3] In one country heifers and older cows are evaluated separately

[4] Standard deviation 5-12

Table 5. Summary of genetic evaluation systems for **somatic cell count** in various countries applying BLUP evaluation models; breeds with at least three evaluating countries are considered; SM=Sire Model, AM= Animal Model, MT=Multi-Trait.

		Breeds		
		Holstein	Ayrshire	Brown Swiss
trait definition:	test day	1 country		
	lactation mean	6 countries	3 countries	3 countries
age groups considered:	first lactation	2 countries	1 country	2 countries
	multiple lactations	5 countries	2 countries	1 country
model of evaluation:	SM	2 countries	1 country	1 country
	AM	3 countries	2 countries	1 country
	SM MT[1]	1 country		1 country
	AM MT[2] test-day	1 country		
proof expression:	standardized[3]	4 countries	2 countries	2 countries
	trait units	3 countries	1 country	1 country
countries with evaluation:		7 countries	3 countries	3 countries

[1] Evaluated together with clinical mastitis
[2] Lactation means are considered different traits
[3] Standard deviation 5-12

Table 6. Summary of genetic evaluation systems for **milking speed** in various countries applying BLUP evaluation models; breeds with at least three evaluating countries are considered; SM=Sire Model, AM= Animal Model, MT=Multi-Trait.

		Breeds		
		Holstein	Ayrshire	Brown Swiss
trait definition:	subjective score[1]	12 countries	5 countries	6 countries
	output/minute			1 country
age groups:	first lactation	9 countries	5 countries	4 countries
	multiple lactations	3 countries		2 countries
model of evaluation:	SM	6 countries	4 countries	3 countries
	AM	4 countries	1 country	1 country
	AM MT[2]	2 countries		2 countries
proof expression:	standardized[3]	10 countries	4 countries	4 countries
	% satisf. daughters	1 country		
	trait unit	1 country	1 country	2 countries
countries with evaluation:		12 countries	5 countries	6 countries

[1] In several countries compared to herd average
[2] In one country evaluated together with conformation and in another country lactations are considered different traits
[3] Standard deviation 5-12 or normalized score

Table 7. Summary of genetic evaluation systems for **udder conformation and locomotion traits** in various countries applying BLUP evaluation models; breeds with at least three evaluating countries are considered; SM=Sire Model, AM= Animal Model, MT=Multi-Trait.

	Breeds				
	Holstein	Ayrshire	Brown Swiss	Guernsey	Jersey
trait definition[1]:					
1) Udder conformation					
fore udder attachment	17 cou				
udder depth	16 cou				
teat placement	16 cou				
rear udder height	14 cou				
rear udder width	14 cou				
teat length	14 cou				
ligament	13 cou				
udder composite/overall score:					
as separate trait	8 cou	4 cou	1 cou	2 cou	4 cou
as index	7 cou	3 cou	3 cou	1 cou	2 cou
2) Locomotion					
rear leg set	15 cou				
foot angle	14 cou				
feet & leg composite/overall score:					
as separate trait	6 cou				
as index	5 cou				
age groups considered:					
single lactation[2]	13 cou	5 cou	5 cou	2 cou	4 cou
multiple lactations	4 cou	2 cou	2 cou	1 cou	2 cou
model of evaluation:					
SM	5 cou	2 cou	2 cou		2 cou
AM	9 cou	4 cou	2 cou	2 cou	2 cou
AM MT[3]	3 cou	1 cou	3 cou	1 cou	2 cou
proof expression:					
standardized[4]	14 cou	6 cou	7 cou	3 cou	4 cou
trait units	3 cou	1 cou			2 cou
countries with evaluation:	17 cou	7 cou	7 cou	3 cou	6 cou

[1] In all countries more than one trait are evaluated; mostly scores in 9-50 classes; individual traits evaluated in coloured breeds are not shown

[2] In all but one case, classified animals are up to 2 years of age

[3] In two countries conformation traits are evaluated for simultaneously (in one evaluated together with milking speed) and in another country lactations are considered different traits

[4] Standard deviation 5-12 or normalized score

Table 8. Summary of genetic evaluation systems for **temperament** in various countries applying BLUP evaluation models; breeds with at least three evaluating countries are considered; SM=Sire Model, AM= Animal Model, MT=Multi-Trait.

		Breeds	
		Holstein	Ayrshire
trait definition:	subjective score[1]	8 countries	4 countries
age groups:	single lactation	7 countries	4 countries
	multiple lactations	1 country	
model of evaluation:	SM	5 countries	3 countries
	AM	2 countries	1 country
	AM MT[2]	1 countries	
proof expression:	standardized[3]	6 countries	3 countries
	trait units	1 country	1 country
	% satisf. daughters	1 country	
countries with evaluation:		8 countries	4 countries

[1] In many countries it is defined as temperament while milking
[2] Lactations are considered different traits
[3] Standard deviation 5-12 or normalized score