Dairy udder health trait group report

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Introduction

Udder health plays a vital role in milk production costs and is essential for maximizing profits in the dairy industry. Two key indicators of udder health are the somatic cell count (SCC) and the incidence of (clinical)mastitis (MAS). Mastitis is the most prevalent and costly disease affecting dairy cattle (Wolfová et al., 2006), accounting for approximately 70% of economic losses on dairy farms (Huijps et al., 2008). Furthermore, mastitis can lead to discarded milk, decreased milk production, reproductive issues, and an increased risk of culling (Halasa et al., 2007; Schutz, 1994). Selecting for resistance to mastitis has proven to be difficult, as most countries do not routinely record cases of clinical mastitis. Consequently, most countries have addressed mastitis resistance selection indirectly by using the somatic cell score (SCS) trait or a combination of SCS and different algorithms to model mastitis. This score is a log-transformed representation of the somatic cell count (SCC) recorded in the milking system. Somatic cell count (SCC) serves as an indicator of mastitis and the inflammatory processes occurring in the udder since the late 1970s (Stanek et al., 2024; Sharma et al., 2011). This is because somatic cells include epithelial cells, leukocytes, and macrophages which help defending the udder against infections (Sharma et al., 2011). It is widely accepted that a higher SCC is associated with an increased likelihood of mastitis.

In May 2001, Interbull Centre implemented an international evaluation for udder health traits to improve genetic selection for these traits (Mark et al., 2002). As selecting for mastitis resistance could be challenging, these evaluations have provided a standardized method for assessing genetic merit across different countries: by combining data on SCS and mastitis, Interbull genetic evaluations would allow for a wider selection of foreign bulls that would better align with national breeding goals, promoting long-term improvements in udder health and supporting more efficient and sustainable dairy production, globally.

This report consolidates information about udder health traits within Europe from 17 countries belonging to the EU community and three non-EU member countries. Collecting and comparing such information is made with the scope of supporting and facilitating the standardization and harmonization of udder health traits among countries participating to the

Interbull udder health evaluation. This process involves comparing definitions, measurements, lactation stages of recorded animals and evaluation models used by different countries. It is good to note that all the comparisons described in this report are based on the European countries' national level and NOT the Interbull international evaluation. Data used for this comparison have been provided by each European countries through the udder health form available on the Interbull performance recording, evaluation and publication database (PREPdb) (Interbull Centre 2025). To ensure consistency and enhance international comparability, it is crucial for each country or organization to regularly update the existing form for udder health traits in the PREPdb with the accurate and the most recent information.

Breeds evaluated for the udder health traits

Many European countries involved in the international evaluations offered by Interbull do have a national evaluation in place for Somatic cells score (SCS) although not all of them might send the trait or breed to be evaluated in a given international evaluation (cases reported in *italics*). Holstein (HOL) appears to be the breed where such genetic evaluation is mostly applied, with 19 EU countries: Belgium (BEL), Denmark, Finland, Sweden (DFS), Spain (ESP), Estonia (EST), France (FRA), Croatia (HRV), Germany- Austria-Luxemburg (DEU), Hungary (HUN), Ireland (IRL), Italy (ITA), Lithuania (LTU), Latvia (LVA), the Netherlands (NLD), Poland (POL), Portugal (PRT), Slovakia (SVK), and Slovenia (SVN). Additionally, two non-EU countries also take part to the international evaluation: Switzerland (CHE) and the United Kingdom (GBR).

Simmental (SIM) is the second breed for which this trait is most commonly evaluated with national evaluations carried out in 11 EU countries: *BEL*, Germany and Austria (DEA), FRA, HRV, HUN, *IRL*, ITA, NLD, *SVK* and SVN, and two non-EU countries, CHE and GBR. For Red dairy cattle (RDC), including Ayrshire and other red coat cattle breeds, SCS is evaluated in nine EU countries: *BEL*, DFS, EST, *IRL*, LTU, LVA and NLD and it has also been assessed in three non-EU countries, CHE, GBR and Norway (NOR). For the Brown Swiss breed (BSW) six EU countries evaluates scs: *BEL*, DEA, FRA, NLD, SVN, and two non-EU countries, CHE and GBR. In Jersey (JER) the trait is evaluated in five EU countries: DFS, *IRL*, ITA and NLD, along with two non-EU countries, CHE and GBR. Lastly, Guernsey (GUE) has been evaluated in one EU country, NLD and one non-EU country**,** GBR, making it the least represented breed for SCS.

Regarding mastitis trait, this trait also appears to be mostly evaluated nationally in the HOL breed with evaluations performed in five EU countries: DFS, Germany, Austria, Luxembourg (DEU), FRA and NLD, as well as in two non-EU countries, CHE and GBR. In the RDC breed the traits is evaluated in three EU countries: DFS, DEU and NLD, along two non-EU countries: NOR and GBR. For Jersey it has been evaluated in DFS and NLD and GBR (non-EU) countries. For BSW and SIM the trait is evaluated in two EU countries, FRA and NLD, as well as in two non-EU countries, CHE and GBR. Finally, for GUE mastitis is evaluated in one EU country, NLD, and in one non-EU country, GBR.

Trait definition and method of recording/ measurement

The SCS evaluation method varies across European countries, combining both standardization and distinct approaches. Many countries, including BEL, CHE, DEA, ESP, EST, FRA, HRV, HUN, LTU, LTV, NLD, POL, PRT and SVK utilize a consistent formula defined as log2(SCC/100000) + 3. This method facilitates uniform evaluation of SCS across various breeds and improves harmonisation for a possible international evaluation. This is, however, not the case for all countries having a national evaluation for SCS. For instance, SVN used only the log2 and GBR used log10 instead. In CHE, the calculation for BSW and JER breeds has used log2 as the average daily score. Some countries, like DFS and IRL, utilized the natural logarithm (ln) instead of log2, defining their SCS as ln(SCC) based on test-day records (Table1).

On the other hand, some countries have employed alternative calculations for SCS: NOR has adopted a 305-day lactation geometric mean rather than a log-based transformation. In ITA, the score for HOL breed is based on test-day SCC records collected within 24 hours, averaging these for further evaluation. Additionally, ITA for SIM breed assesses test-day records that range from 6 to 360 days.

The methodology for recording mastitis also varies across European countries, reflecting both standardized and distinct approaches based on clinical and subclinical detection methods. Some countries assess mastitis using binary classifications, while others quantify the number of recorded events (Table 2).

In NOR, mastitis is recorded based on veterinary treatments for acute or chronic clinical mastitis during the first, second, and third lactation periods. This trait is recorded as a binary indicator, where a score of 0 signifies no recorded treatments and a score of one indicates at least one recorded treatment. In GBR, mastitis is assessed for several breeds, and the trait is evaluated as a binary measure (presence or absence) for each lactation period in the first three parities. DEU recorded mastitis for HOL, JER, and RDC breeds by quantifying the number of mastitis events within each lactation. A score of 0 indicates no recorded mastitis, while values greater than 0 represent the number of distinct mastitis cases. Moreover, DFS has recorded clinical mastitis as a 0/1 trait (binary), covering occurrences from the first to the third lactation for RDC, JER, and HOL breeds (Table2).

NLD takes a different approach by focusing on subclinical mastitis (SCM). This recording is also binary (0/1) and is based on SCC patterns (Table2). If a cow exhibits a '- - +' SCC pattern (low-low-high) on three consecutive test days within a lactation, SCM is recorded as 1; otherwise, it remains 0. CHE includes observations of both clinical and SCM for HOL, SIM, and BSW breeds from 10 to 150 days in milk (DIM) across parity 1 to 5. This trait is recorded as a binary indicator, where a score of 0 represents no observed mastitis, and a score of 1 indicates at least one mastitis event. FRA records clinical mastitis for HOL, SIM, and BSW breeds during milk recording as a binary classification (0 = no clinical mastitis, 1 = clinical mastitis) (Table 2).

Statistical models and parity/lactation recordings

The evaluation models for SCS vary significantly across European countries (Table 1). Several countries employ single-trait (ST) Best Linear Unbiased Prediction animal models (ST-BLUP-AM). The most commonly used model is the ST random regression test day model for multiple lactations (ST-RR-TD-ML-BLUP-AM), which is implemented in CHE, EST, IRL, LIT, LVA, SVK and POL (Table 1). In CHE, the model accounts for 1 to 3 lactations for HOL and SIM breeds, while all lactations are considered for JER and BSW breeds. Similar practices of including all lactations are followed in IRL as well. For the other countries they used 1 to 3 lactations/parity (Table1). Additionally, another common model implemented by six countries, ESP, FRA, GBR, HUN, ITA, and SVN, is the ST repeatability BLUP AM (ST-RP-BLUP-AM). The number of parity or lactations included in this model varied across these countries (Table 1). For instance, ESP, GBR, and SVN have considered 1 to 5 parity or lactations; FRA and HUN have utilized 1 to 3, while ITA has taken all parity into account for the SIM breed (Table 1). However, HRV, PRT and SVK have been implemented different ST-BLUP-AM. HRV has used a fixed regression TD (ST-FR-TD-BLUP-AM) considering 1 to 10 parity and PRT has applied a ML Repeatability (RP) autoregressive BLUP AM (ST-ML-RP-TD-AU-BLUP-AM) from 1 to 3 lactations (Table 1).

Some countries have adopted multi-trait (MT) approaches to evaluate SCS. The CHE for JER and BSW breeds, as well as ITA for HOL, have implemented a MT-ML-TD-RR-BLUP-AM model that considers all lactations or 1 to 3 parity/lactations, respectively. DEA has used the MT-ML-FR-TD-BLUP-AM method, while DFS has adopted the MT reduced rank ML TD RR BLUP AM (MT-RED-ML-TD-RR-BLUP-AM), focusing on 1 to 3 lactations/parity (Table 1). BEL is the only country that has implemented a weighted MT-ML-TD-RR-BLUP-AM approach. In this model, record weights are based on the likelihood of mastitis infection; SCS values above expected levels, determined by standardized residuals, are given higher weights, while those below expected levels receive lower weights. The NLD stands out for a MT-BLUP-AM model applied across six breeds, considering 1 to 5 parity (Table 1).

The evaluation of mastitis traits varied depending on the model used, which differed across countries and breeds (Table 2). The MT-RP-BLUP-AM model is the most commonly used, implemented in CHE, DEU, and GBR, each focusing on their respective breeds. CHE has applied this model considering 1 to 5 parity, while GBR focused on 1 to 3 parity, and DEU has considered all parity (Table 2). In contrast, the MT-RD-RR-TD-AM model has been adopted in DFS for HOL, JER, and RDC breeds, specifically examining 1 to 3 lactations. A more comprehensive MT-BLUP-AM model is utilized in the NLD and NOR, covering multiple breeds. In the NLD, it is applied across HOL, RDC, JER, GUE, BSW, and SIM breeds, evaluating 1 to 3 parity. Meanwhile, Norway has used this model exclusively for RDC, also considering 1 to 3 parity. Finally, the ST-RP-BLUP-AM model is only applied in FRA for HOL, SIM, and BSW breeds, with a focus on 1 to 3 parity (Table 2).

Table 1. Country, breeds, trait definition, method of measurement, evaluation model and lactation parity for udder health traits- Somatic cell count (SCC) in European countries.

Country	**Breeds**	**Trait definition**	**Method of measurement** [a]	**Evaluation model** [b]	**Parity/lactation of recorded animals**
BEL	HOL, SIM, RDC, BSW	Somatic cell score	SCS=log2(SCC/100000)+3	Weighted MT-ML-TD-RR-BLUP-AM	1-3 parity
CHE*	JER, BSW	Somatic cell score	SCS=log2(SCC)	MT-ML-RR-TD-BLUP-AM	All parities
CHE*	HOL, SIM	Somatic cell score	SCS=log2(SCC/10000)+3	ST-ML-RR-TD-BLUP-AM	1-3 lactations

DEA	SIM, BSW	Somatic cell score	SCS=log2(SCC /10000)+3	MT-ML-FR-TD-BLUP-AM	1-3 lactations
DFS	RDC, JER, HOL	Test day somatic cell score	SCS=ln(SCC)	MT-RED-RR-TD-BLUP-AM	1-3 lactations
ESP	HOL	Somatic cell score	SCS=log2(SCC /10000)+3	ST-RP-BLUP-AM	1-5 lactations
EST	HOL, RDC	Somatic cell score	SCS=log2(SCC /10000)+3	ST-ML-RR-TD-BLUP-AM	1-3 parity
FRA	HOL, BSW, SIM	Somatic cell score	SCS=log2(SCC /10000)+3	ST-RP-BLUP-AM	1-3 parity
GBR*	HOL, RDC, JER, GUE, BSW, SIM	Somatic cell score	SCS=log10(SCC)	ST-RP-BLUP-AM	1-5 parity
HRV	HOL, SIM	Somatic cell score	SCS=log2(SCC *10000)	ST-FR-TD-BLUP-AM	1-10 parity
HUN	HOL, SIM	Somatic cell score	SCS=log2(SCC *10000)	ST-RP-BLUP-AM	1-3 parity
IRL	HOL, JER, SIM, RDC	Test day somatic cell score	SCS = loge(SCC)	ST-ML-RR-TD-BLUP-AM	All lactations (up to 15)
ITA	HOL, JER	Test day somatic cell score	Test-day SCC records collected within 24 hours	MT-ML-RR-TD-BLUP-AM	1-3 parity
ITA	SIM	Test day somatic cell score	Test-day SCC records from 6 to 360 days	ST-RP-BLUP-AM	All parity
LTU	RDC, HOL	Somatic cell score	SCS=log2(SCC /10000)+3	ST-ML-RR-TD-BLUP-AM	1-3 parity
LVA	RDC, HOL	Somatic cell score	SCS=log2(SCC /10000)+3	ST-ML-RR-TD-BLUP-AM	1-3 lactations
NLD	HOL, RDC, JER, GUE, BSW, SIM	Somatic cell score	SCS=log2(SCC /10000)+3	MT-BLUP-AM	1-5 parity
NOR*	RDC	Somatic cell score	305-day lactation geometric mean	ST-RP-BLUP-AM	1-5 parity
POL	HOL	Somatic cell score	SCS=log2(SCC /10000)+3	ST-ML-RR-TD-BLUP-AM	1-3 lactations
PRT	HOL	Somatic cell score	SCS=log2(SCC /10000)+3	ST-ML-RP-TD-AU-BLUP-AM	1-3 lactations
SVK	SIM, HOL	Somatic cell score	SCS=log2(SCC /10000)+3	ST-RR-TD-BLUP-AM	1-3 lactations

SVN	HOL, SIM, BSW	Somatic cell score	SCS=log2(SCC)	ST-RP-BLUP-AM	1-5 parity

*= Non-EU countries

[a] Traits' abbreviations=SCC = Somatic cell count; SCS = Somatic cell score; CM = Clinical mastitis; SCM = Subclinical mastitis.

[b] Models' abbreviations: AM=Animal Model; ST=Single Trait; MT= Multi Trait; BLUP= Best Linear Unbiased Prediction; RP= Repeatability; ML = Multiple lactations; TD = Test day; RR = Random regression; FR = Fixed regression; AR = Autoregressive; RED = Reduced rank model.

Table 2. Country, breeds, trait definition, method of measurement, evaluation model and lactation parity for udder health- Mastitis trait in European countries.

Country	**Breeds**	**Trait definition**	**Method of measurement [a]**	**Evaluation model [b]**	**Parity/lactation of recorded animals**
CHE*	HOL, SIM, BSW	Observed mastitis (acute, chronic clinical or subclinical)	From 10 to 150 DIM. 0=no mastitis, 1=at least one mastitis event observed	MT-RP-BLUP-AM	1-5 parity
DEU	HOL, JER, RDC	Number of mastitis events within lactation	0 indicating no recorded mastitis and values > 0 indicating the number of distinct mastitis events	MT-RP-BLUP-AM	All lactations
DFS	HOL, JER, RDC	Clinical mastitis	Measured as 0 or 1	MT-RED-RR-TD-AM	1-3 lactations
FRA	HOL, SIM, BSW	Clinical mastitis	Measured as 0/1(0=no clinical mastitis, 1=clinical mastitis)	ST-RP-BLUP-AM	1-3 parity
GBR*	HOL, RDC, JER, GUE, BSW, SIM	Mastitis events within lactation	Measured as a binary trait	MT-RP-BLUP-AM	1-3 parity
NLD	HOL, RDC, JER, GUE, BSW, SIM	Subclinical mastitis	Binary (0/1) trait and is based on SCC patterns.	MT-BLUP-AM	1-3 parity
NOR*	RDC	Clinical mastitis	Measured as 0=no treatments recorded. 1=one or more	MT-BLUP-AM	1-3 parity

			treatments recorded		

*= Non-EU countries

[a] Traits' abbreviations=SCC = Somatic cell count; SCS = Somatic cell score; CM = Clinical mastitis; SCM = Subclinical mastitis.

[b] Models' abbreviations: AM=Animal Model; ST=Single Trait; MT= Multi Trait; BLUP= Best Linear Unbiased Prediction; RP= Repeatability; ML = Multiple lactations; TD = Test day; RR = Random regression; FR = Fixed regression; AR = Autoregressive; RED = Reduced rank model.

Conclusion

Most European countries have established standardized traits, measurements, and recording systems for evaluating udder health, primarily focusing on SCS and MAS at the national level. However, there are some substantial differences in the measurement/recording methods and evaluation models used across these countries.

Therefore, the main objective is to compare and harmonize various traits and evaluation methods across countries with the help of the information reported in the PREPdb. This initiative aims to improve the accuracy of genetic predictions and enhance the genetic correlations between countries in Interbull's international evaluations. Standardizing traits and information related to udder health is crucial for improving the genetic correlations among countries and therefore the comparability of evaluations within the European dairy cattle population.

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