Phenotypic recording of dairy cattle

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[Red dairy breeds across Europe represent a unique source of genetic diversity and are partly organized in trans-national breeding programs but are also well adapted to local conditions providing regional identity of products for consumers. Recently the project "Biodiversity Within and Between European Red Dairy Breeds - Conservation through Utilization", project Acronym: "ReDiverse", has been carried out. The main purpose of this project was to develop and to set in place collaborative and integrated novel breeding and management concepts to achieve a resilient and competitive use of these resources and to strengthen best practices for small farm holders for improving product quality and to supply ecosystem services according to their specific circumstances. One task of the project was to investigate the population structure and genetic connectedness as well as phenotype recording schemes for the European Red Dairy Breeds (ERDB). The article was prepared as part of such task, providing an overview on the existing phenotype recordings' procedures and on how and when such traits were measured]

To better understand the difference in data collection and genetic model applied by the countries participating to the ReDiverse study, information from their Genetic Evaluation Forms (GE Forms), as available on the Interbull Centre website between April and May 2019 (revised in 2020), were reviewed. The GE Form does present a detailed description of the genetic evaluation applied by the country and it is limited to the specific traits whose data is submitted for an Interbull international evaluation. Table 1 presents an overview for which breeds and traits, countries within the ReDiverse project, have Interbull international evaluations. As shown, the degree of participation to the international evaluation, both in matters of number of breeds and traits, does vary among countries. If a country is not included in the international evaluation for a given trait (Table 1) it does not mean that it does not have a national evaluation in place for such trait, but only that it has not yet joined the specific international evaluation.

Table 1. Breeds and traits included in the Interbull evaluations by Country

Country	Production	Conformation	Udder Health	Longevity	Calving	Female Fertility	Workability
Norway	Yes, RDC	Yes, RDC	Yes, RDC	Yes, RDC	Yes, RDC	Yes, RDC	Yes, RDC
Denmark, Sweden, Finland	Yes, HOL&RDC&JER	Yes, HOL&RDC&JER	Yes, HOL&RDC&JER	Yes, HOL&RDC&JER	Yes, HOL&RDC&JER	Yes, HOL&RDC&JER	Yes, HOL&RDC &JER
Estonia	Yes HOL&RDC	Yes HOL	Yes HOL&RDC	No	No	No	No
Poland	Yes, HOL	Yes, HOL	Yes, HOL	Yes, HOL	No	Yes, HOL	No
Latvia	Yes HOL&RDC	No	Yes HOL&RDC	No	No	No	No
Lithuania	Yes HOL&RDC	No	Yes HOL&RDC	No	No	No	No
Netherlands	Yes, ALL BREEDS	Yes, ALL BREEDS	Yes, ALL BREEDS	Yes, ALL BREEDS	Yes, ALL BREEDS	Yes, ALL BREEDS	Yes, ALL BREEDS
Germany	Yes, HOL&JER&RDC; BSW; SIM	Yes HOL&RDC, BSW	Yes HOL&JER&RDC; BSW&SIM	Yes HOL&JER&RDC; BSW	Yes HOL&JER&RDC; BSW	Yes HOL&JER&RDC; BSW	Yes HOL&JER&RDC; BSW

National evaluation centres do join the Interbull international evaluation by first sending data related to production (milk, fat, protein) traits for any of the six breeds included in the Interbull evaluation (Holstein, Jersey, Brown Swiss, Red Dairy Cattle, Simmental, Guernsey) and then add new traits and/or breeds as they see fit.

Participation to the Interbull evaluations for a new country, or an existing country for a new breed/trait, is only possible twice a year (January and September) during special evaluations called test runs and which results are not meant for publication. During a test run, the new data is checked to fulfil the minimum requirements in matter of number of common bulls (i.e., connectedness) with the other participating countries, international genetic correlations are estimated and validation results of the genetic model are reviewed. Pre-requisite for a country to join an official Interbull routine evaluation is for its genetic model to pass all Interbull validation results. New updated Interbull GE forms are provided by countries at each evaluation whenever information on their genetic model or data description does change.

After the analysis of the data available for international evaluation (Table 1), we can conclude that international evaluation for all 7 traits evaluated by Interbull for Red cattle population were performed for Germany, Netherlands, Denmark, Sweden, Finland and Norway. Lithuania, Latvia and Estonia only participate to the international evaluation for production and udder health while in Poland 5 out of 7 traits are evaluated internationally although the evaluation is strictly limited to the Holstein breed. Estonia does also evaluate conformation trait but only for Holstein.

A further questionnaire was developed and distributed to the breeding associations of the project partners in order to obtain the missing information for the traits for which an Interbull GE form was not available.

Results of such questionnaire pointed out, as already mentioned, how national evaluations might very well be in place even if the country does not (yet) participate to an international evaluation offered by Interbull Centre. This was the case for Lithuania, Latvia, Estonia and Poland for conformation traits, for example. Details are reported in Table 2.

Table 2. Summary of data analysis from questionnaire and Interbull database for evaluation of conformation traits

Country	Start of data collection	Criteria (data edits) for inclusion of data	Criteria for official publication of evaluations	Number of evaluations/publications per years	Method (model) of genetic evaluation	References
Norway	1987	1st calving (580-975 day)	Daughters in at least 10 different herds. At least 70 daughters with phenotype (50 for imported AI-bulls).	3	MT-AM. Seven groups of traits, udder/teats, leg/body and claw health are analysed separately	Interbull, 2019
Denmark, **Sweden** **Finland**	1988	1st calving	15 classified daughters	4	Multi lactation Animal model BLUP	Interbull, 2016
Estonia	1999	1st calving (20-42 months)	At least 20 daughters in at least 3 herds with min. reliability of 70%	3	ST – BLUP - AM	Interbull, 2017
Poland (HOL only)	1996	1st calving	AI sires, Min. 10 daughters	3	ST BLUP - AM	Survey, 2019,

						Interbull, 2020
Latvia	1996	1st calving, 3 calving	daughters at least in 10 herds	3	ST-ML-RR-TD-BLUP-AM	Survey, 2019
Lithuania	1997	1st calving	Min. of 15 daughters, min. of 3 herds.	3	MT AM BLUP-AM	Survey, 2019
Netherlands, Flanders	1981	cow must have calved before 3 years of age	10 daughters	3	MT, AM	Survey, 2019
Germany	1998	1st calving, (22-36 months)	at least 10 herds	3	MT – BLUP – AM	Interbull, 2015

Multiple trait (MT), Animal model (AM)

The Annual reports of the official data evaluation are published three times per year for the majority of the participating countries, except for Denmark, Sweden, Finland publishing four times per year.

Table 3. **Summary of the data from Interbull database for the evaluation of production traits.**

Country	**Start of data collection**	**Data edits after calving, milking days**	**Criteria for official publication of evaluations**				**Number of evaluations/publications per years**	**Method (model) of genetic evaluation**	**Criteria for official publication**	**References**
			Number of lactations included to evaluation	**Milk yield, min-max/kg**	**Fat, %**	**Protein, %**				
Norway	1979	305	1-3	min 1	1.5-8	2 - 6	3	ST-R -AM	≥70 daughters with phenotype (50 for imported AI-bulls), in ≥10 herds	Interbull, 2019
Denmark	1990	No data	1-3	No data	No data	No data	4	MT–ML-RR-TD-AM	10 daughters milked ≥100 days, R≥60%	Interbull, 2017
Sweden	1995		1-3							
Finland	1988		All lactation							
Poland	1976	from 5 to 305	1-3	1-99.9	1.5-9	1 - 7	3	ST–ML–RR–TD–BLUP–AM	≥10 daughters	Interbull, 2020
Latvia	1996	from 5 to 330	1-3	3-90	1.5-9	1 - 7	3	ST–ML–RR–TD–BLUP–AM	daughters in ≥10 herds, R≥50%	Interbull, 2010
Lithuania	1996	from 5 to 330	1-3	3-80	1.5-9	1 - 7	4	ST-ML-RR-TD-BLUP-AM	Daughters ≥25, herds ≥5	Interbull, 2013
Netherlands, Flanders	1990	from 5 to 420	1-5	no daily yields with the status “unreliable”	No data	No data	3	ST-ML-RR-TD-BLUP-AM	Domestic bull ≥15 daughters past 120 DIM in 5 herds. Foreign AI Bulls R≥90%, Other AI Bulls R≥10%	Interbull, 2017

Germany	1990	from 5 to 330	1-3	No data	No data	No data	3	ST–ML–RR–TD–BLUP–AM	AI Bulls, in ≥10 herds	Interbull, 2019
Estonia	1994	No data	1-3	3 - 90	1.5-9	1 - 7	3	ST-ML-RR-TD-BLUP-AM	≥20 daughters in ≥3 herds, R≥ 0.70	Interbull, 2017

In some countries the use of genetic groups and relationships in evaluation of production trait is different. In the Netherlands and Germany unknown parents are grouped together according to the country of origin, selection path (6 paths), breed and birth year. All known relationships of cows and sires are considered. In Denmark, Sweden, Finland, Estonia, Lithuania and Latvia four genetic groups of unknown parents are defined on the basis of sex, breed and year of birth of animals. In Norway and Poland unknown parents are grouped by sex and year of birth.

The summarized data from different countries indicates that Norway is the only country having different sire category in the production traits, i.e., they evaluate sires only born after artificial insemination. Other countries evaluate all bulls with progeny information including domestic and foreign AI bulls plus natural service herd sires.

Table 4. **Summary of the data from Interbull database for the evaluation of Udder Health traits**

Country	Start of data collection	Criteria (data edits) for inclusion of data	Criteria for official publication of evaluations	Number of evaluations/ publications per years	Method (model) of genetic evaluation	References
Norway	1978	SCS, OD, CM	Daughters in ≥10 different herds. ≥ 70 daughters with phenotype (50 for imported AI-bulls).	3	SCS: ST-R-AM OD: ML-AM per disease CM: MT-AM	Interbull, 2019
Denmark,	1990	SCS	All sires with R>0.40	4		Interbull, 2014

Sweden					Multiple-trait-reduced-rank-random-regression-test-day-animal-model	
Finland						
Estonia	1994	SCS	≥ 20 daughters in ≥ 3 herds, with R ≥0.70	3	ST-ML-RR-TD-BLUP-AM	Interbull, 2017
Poland	1995	SCS	AI Bulls with ≥10 daughters	3	ST-ML-RR-TD-BLUP-AM	Interbull, 2020
Latvia	1996	SCS	Sires with daughters in ≥10 herds, R - 0.50	3	ST-ML-RR-TD-BLUP-AM	Interbull, 2010
Lithuania	1996	SCS	Daughters ≥25, herds ≥5	4	ST-ML-RR-TD-BLUP-AM	Interbull, 2013
Netherlands, Flanders	1990	UHI, SCS	Bulls: R - 30% of Index Udder Health	3	MT-BLUP-AM	Interbull, 2017
Germany	1990	SCS	AI Bulls with daughters in ≥10 herds, R>0.50	3	ST-ML-RR-TD-BLUP-AM	Interbull, 2015

Somatic cell score (SCS); UHI - € per animal per lactation, expected savings on economic damage of infection; OD - Other Diseases; CM-Clinical Mastitis.
R - reliabilities

Summarized analysis of the Udder Health evaluation data showed that most countries do evaluate Somatic Cell Score and all the data collected do abide to the ICAR certified milk recording methods. Only Netherlands and Norway have different Udder Health evaluations. Netherlands evaluates Udder Health Index (UHI) - € per animal per lactation, expected savings on economic damage of infection. Somatic Cell Score: geometric mean of 305-day lactation. Evaluation of the Udder Health is based on the data from first three lactations, Somatic Cell Score - from first five lactations. Collection of the data on milk recording and Clinical Mastitis are available from farm management program registrations.

In Norway Udder health is evaluated using three different ways: Somatic Cell Score (SCS); Clinical Mastitis (CM), other diseases evaluation (OD). Other Diseases: recorded veterinary treatments for ketosis, milk fever or retained placenta between 15 days prepartum and 120 days postpartum. A health card for each cow resides on the farm. Veterinarians record all treatments and diagnostics according to the coding system on the health card together with his identity number. In addition, treatments for the fertility disorders: Cystic ovaries, metritis and silent heath, 0=no treatments recorded, 1=one or more treatments recorded. In Norway, five lactations beginning from 1st to 5th are included in the data evaluation. Clinical Mastitis is recorded from veterinary treatments for acute clinical or chronic clinical mastitis during 1st, 2nd and 3rd lactations. A health card for each cow resides on the farm. Veterinarians do record all treatments and diagnostics according to the coding system on the health card together with the identity number. The farmer does record treatments that he can carry out (no drugs included), together with the identity number signalling farmers' treatment. The farmer or the advisor reports the treatment codes from the health cards as events to the milk recording system.

Table 5. **Summary of the data from Interbull database for the evaluation of Longevity traits.**

Country	Start of data collection	Criteria (data edits) for inclusion of data	Criteria for official publication of evaluations	Number of evaluations/publications per years	Method (model) of genetic evaluation	References
Norway	1990	1st to 3rd lactation	≥70 daughters with phenotype (50 for imported AI-bulls), in ≥10 different herds.	3	ML-AM	Interbull, 2019
Denmark	1985	1st to 5th lactation	R≥50%	4	AM-MT 5 traits	Interbull, 2010
Sweden	1985					
Finland	1988					
Netherlands, Flanders	1988	All animals with information up to 72 months after first calving	Bull should have at least a proof for milk production traits.	3	ST-RR-BLUP-AM	Interbull, 2018
Germany	1995	1st to 3rd lactation	Daughter observations from ≥10 herds	3	ST-ML-AM-BLUP	Interbull, 2018
Poland	1995	Age at first calving between 18-40 months	R≥0.20	3	Only conventional evaluation	SLU, 2019 Interbull, 2020

R -reliabilities

The analysis of the longevity trait evaluation data indicated that all four countries which reported their own data using an Interbull GE Form did include all used bulls for evaluation.

The evaluation of calving trait (Table 6) does appear to be quite subjective and depending on farmer's consciousness.

Table 6. **Summary of the data from Interbull database for the evaluation of Calving traits.**

Country	Start of data collection	Criteria (data edits) for inclusion of data	Criteria for official publication of evaluations	Number of evaluations/publications per years	Method (model) of genetic evaluation	References
Norway	Stillbirth, gestation length – 1978 Calving ease – 1989; Calf size-2002	Calving ease, stillbirth, calf size and Gestation length	Daughters in at ≥10 different herds. ≥70 daughters with phenotype (50 for imported AI-bulls).	3	ST- AM with correlated direct and maternal effect	Interbull, 2020
Denmark,	1985	Calving	Maternal R≥35 %, Direct traits R≥50, ≥35 daughters/calving	4	MT	Interbull, 2016
Sweden	1992					
Finland	1985					
Netherlands, Flanders	1986	Calving ease, farmer scores dystocia, birth weight, gestation length - computed	Domestic Proven bulls: Direct effect: R ≥35 %; Foreign Proven bull: Interbull R ≥90% for the vitality trait, calving ease trait, direct and maternal.	3	MT-BLUP-AM with correlated direct and maternal effects	Interbull, 2010
Germany	Calving ease - 2000	Calving ease, stillbirth	AI sires of cows or calves with R ≥ 35%	3	MT-ML-BLUP-AM with correlated direct and maternal effects	Interbull, 2018
R -reliabilities						

In the Netherlands, birth events are reported by farmers through voice response (by phone) or through (online) management systems when a new born calf is reported. The farmer would score dystocia and birth weight while gestation length is reconstructed from the information on insemination date and date of calving. In Germany, farmers would report about calving ease scored and stillbirth. In Norway, farmers would make record on stillbirth, size and use of a calf. They would subjectively score calving difficulties if the calving was observed. The farmer, or the advisor, would report the events in the milk recording system.

Table 7. **Summary of the data from Interbull database for the evaluation of Female fertility traits.**

Country	Start of data collection	Criteria (data edits) for inclusion of data	Criteria for official publication of evaluations	Number of evaluations/publications per years	Method (model) of genetic evaluation	References
Norway	1978	NoInsH, NoInsC1, NoInsC1_4, CFI1, CFI1_4, KgProt1, KgProt1_3	Daughters in at ≥10 different herds. ≥70 daughters with phenotype (50 for imported AI-bulls).	3	MT-AM, (NoInsH, NoInsC1, CFI1, KgProt1). MT-R-AM, (NoInsC1_4, CFI1_4, KgProt1_3).	Interbull, 2019
Denmark,	1985	CRh; CF, in days; CR; FSc, in days; Days open (DO) of cow is derived as sum of CF and FSc.	R≥35% for the combined index	4	MT-ML-RP-AM (1,3), MT-ML-AM (2,4)	Interbull, 2016
Sweden	1982					
Finland	1993					

Netherlands, Flanders	1978	a) ICI, days; NR, binary trait; CI, days; IFL; CR; CRh; AFI. b) Milk Production 305-day milk, fat and protein yield c) Type traits - Body Condition Score (BCS)	Bulls: Fertility index, R≥30% Cows: Fertility index, R≥10%	3	MT-BLUP-AM	Interbull, 2015
Germany	1995	NRh, in %; FSh, in days; ICI, in days; NRc, in %; FSc, in days; Days open (DO) of cow is derived as sum of ICI and FSc.	Bulls: fertility index R≥30% and daughters in ≥10 herds (interval from calving to first insemination ICI).	3	MT–ML–RP–BLUP–AM	Interbull, 2018
Poland (HOL only)	1995	CRh, ICI, CR;	≥10 daughters	3	MT BLUP AM for crc, cc2, int MT BLUP AM for conception rate in three parities	Interbull, 2020
Reproductive traits: Interval from calving to first insemination - ICI, days; non-return rate 56 days - NR, binary trait; Calving Interval - CI, days; Interval first-last insemination - IFL; Conception rate – CR; Conception rate virgin heifers – CRh; Age first insemination virgin heifers – AFI; Interval from first to last inseminations of cow - FSc, in days; Interval from first to last inseminations of heifers - FSh, in days Body Condition Score – BCS; R -reliabilities						

According to the Interbull GE Forms, all 5 countries reported using recalculations of environmental effects in their genetic evaluation model. In all countries, insemination data are recorded by AI-technicians and farmers while calving interval information do come from milk recording data.

Table 8. **Summary of data from Interbull database for the evaluation of Workability traits.**

Country	Start of data collection	Criteria (data edits) for inclusion of data	Criteria for official publication of evaluations	Number of evaluations/ publications per years	Method (model) of genetic evaluation	References
Norway	Calving - 1989 Temperament - 1987	Temperament - 3 level scale (1=easy, 2=average, 3=uneasy), with frequencies 22%, 69%, 9%. Milking speed - 3 level scale (1=fast, 2=average, 3=slow), with frequencies 24%, 64%, 12%. Leakage - 3 level scale (1=none, 2=a little, 3=obvious), with frequencies 80%, 16%, 4%	R > 0.5	3	Temperament: ST-AM Milking speed/Leakage: ST-AM	Interbull, 2019
Denmark	1988 (2008)	Milkability scale 1-9; Temperament scale 1-9	15 classified daughters	4	ST AM BLUP	Interbull, 2014
Sweden						
Finland						
Netherlands, Flanders	1994	Milking Speed scale 1-9, Temperament during milking scale 1-9	Bulls R≥30%, Cows R≥10%	3	MT-BLUP-AM	Interbull, 2016
Germany	1990	RZD = information from measured milk flow rate (kg/min) and milking speed scale 1-5. Temperament scale 1-5	RZD: ≥20 daughters in 10 herds for milking speed or ≥10 daughters in 5 herds for milk flow rate	3	Multiple trait (5-traits), repeatability (for milk flow rate only), animal model, MT-AM	Interbull, 2016
RZD - relative breeding value for milkability: R - reliabilities						

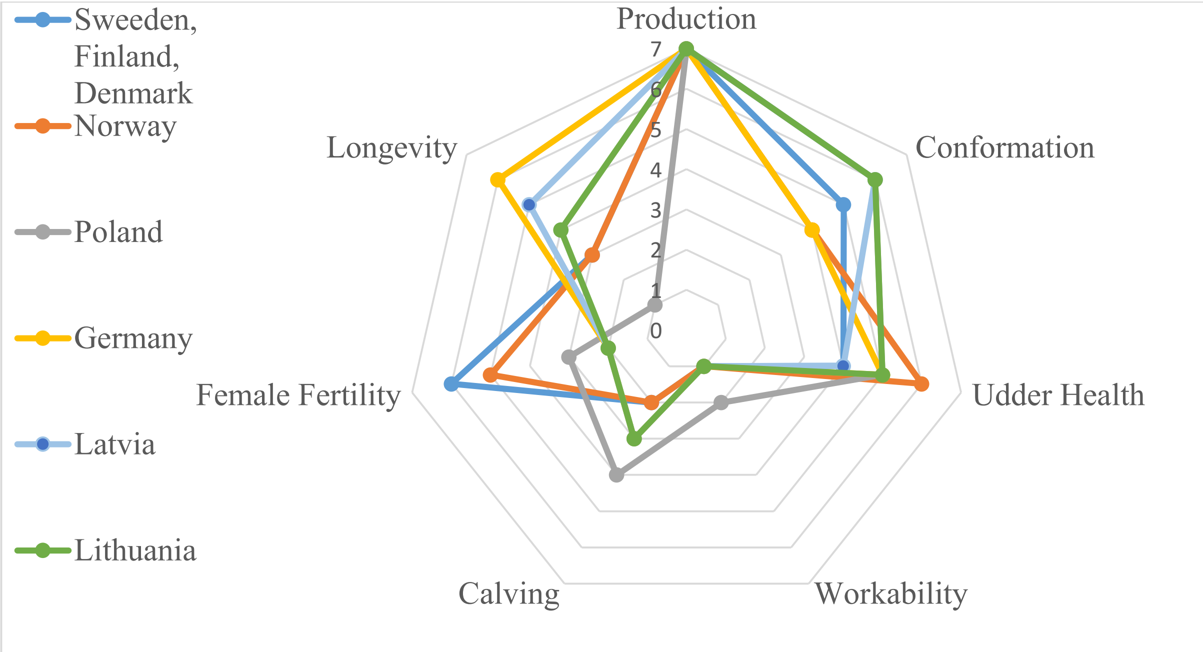
Workability is a relatively new group of traits including milking speed and temperament of the animal. Regarding temperament, in several countries the evaluation is based on different scales (see Table 1) and is subjectively scored by the farmer. For Milking speed, in Germany milk flow rate (kg/min) is defined as average milk yield per minute measured with a machine, and milking speed score is assigned subjectively by the farmer. Only first lactation cows are scored / measured and included in the genetic evaluation. The original subjective scores for milking temperament and milking speed, assigned before 2005, were converted to the scale of 1 to 5 used from 2005 onwards.

In the Netherlands, Dutch farmers do score the traits on a 1 to 9 scale for all parity 1 animals included in the herd classification program while Flemish farmers used to score the traits on a 1 to 5 scale until 2003 but later on, they also started using a 1 to 9 scale as the Dutch farmers. In Norway, traits like Temperament, Milking speed and Leakage are subjectively scored by the farmer on a 3-level scale (Table 8). Subjective scoring on a 3-level scale is carried out by the farmer by comparing the cow to other primiparous cows in the herd. The milk recording system would issue a reminder for each cow at the first test day report after 45 DIMs. Then the scoring would take place and has to be reported on the next test day. Before 1999 temperament was scored by technicians.

After data summary it can be concluded that only Dutch farmers have the requirement that animals should be registered in the herd book to be included in the evaluation system.

Another questionnaire was developed to find out the relevance of the different phenotypic traits in the different countries' breeding programs. Results of the questionnaire are reported in Figure 1.

Figure 1. Relevance of different phenotypic traits in different countries' breeding programs.



Participating countries were asked to rank the relevance of the difference traits' groups in their breeding programs from a scale from 0 to 7, where 7 was the highest value of importance.

As can be seen in Figure 1, the most important traits, according to the goals of breeding organizations, are production, conformation and udder health traits. Other traits, such as longevity and female fertility, shows different level of importance in different countries. Calving and Workability traits are subjectively scored by the farmers. All traits' weights in a breeding objective should have a uniform basis of units of expression which is difficult to achieve for traits that are evaluated subjectively. Many breeding programs do suffer from the fact that their objectives are not properly defined. If breeding organizations want to expand their breeding programs towards the inclusion of new traits, their decision will depend on the correct characteristic of the trait. Furthermore, the outcome from breeding programs is visible only after many years. Therefore, investments in breeding programs are often related to trait measurement and genetic evaluation.

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