SMARTER

SMAll RuminanTs breeding for Efficiency and Resilience

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Business/operation model for international evaluation of rams and bucks

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About the SMARTER research project

SMARTER will develop and deploy innovative strategies to improve Resilience and Efficiency (R&E) related traits in sheep and goats. SMARTER will find these strategies by: i) generating and validating novel R&E related traits at a phenotypic and genetic level ii) improving and developing new genome-based solutions and tools relevant for the data structure and size of small ruminant populations, iii) establishing new breeding and selection strategies for various breeds and environments that consider R&E traits.

SMARTER with help from stakeholders chose several key R&E traits including feed efficiency, health (resistance to disease, survival) and welfare. Experimental populations will be used to identify and dissect new predictors of these R&E traits and the trade-off between animal ability to overcome external challenges. SMARTER will estimate the underlying genetic and genomic variability governing these R&E related traits. This variability will be related to performance in different environments including genotype-by-environment interactions (conventional, agroecological and organic systems) in commercial populations. The outcome will be accurate genomic predictions for R&E traits in different environments across different breeds and populations. SMARTER will also create a new cooperative European and international initiative that will use genomic selection across countries. This initiative will make selection for R&E traits faster and more efficient. SMARTER will also characterize the phenotype and genome of traditional and underutilized breeds. Finally, SMARTER will propose new breeding strategies that utilise R&E traits and trade-offs and balance economic, social and environmental challenges.

The overall impact of the multi-actor SMARTER project will be ready-to-use effective and efficient tools to make small ruminant production resilient through improved profitability and efficiency.

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1 Summary

The deliverable involves pulling together results generated in different tasks of the WP6 as inputs to **define an organisational and business model for international genetic evaluation in sheep and goat**. We first compile, through a survey, the actual situation of the domestic genetic or genomic evaluation systems and the breeding programs run in the SMARTER countries. Then **we acquire the knowledge of the model** that is working in dairy and beef cattle in the Interbull body. To implement case studies of across country evaluation in dairy sheep, meat sheep and goats, we put in place the different pre-requisites required to do such a task: definition of format files to exchange pedigrees, performances and genotypes, signature of sharing agreement between countries, codification of breeds and traits. This helped to generate assessment on connectedness across countries involved in the case-studies and to estimate the genetic correlations across countries for the traits studied. Lessons from these studies were highlighted for possible future routine evaluation. The main results underline existing connectedness between the populations pooled (even though they are quite often due to unilateral exchanges), and high enough genetic correlations to enable an international evaluation. Besides unilateral or too limited exchanges of germplasm, one of the limits for an international genetic evaluation is in the low level of harmonisation for some phenotypes across countries. **The potential market and feasibility of an international evaluation was assessed** through a comprehensive survey towards stakeholders. It appears that the stakeholders mostly agree to share data for international evaluation, and that many breeds are potentially interested. The main expectations and concerns were explored and prioritised. Overall we laid the foundation for an international initiative on international evaluation in the next future. To give a frame to this initiative, a Reference Centre such as the EU Reference Centre existing in cattle, should be beneficial and should help to overcome the main difficulties. From our investigations, the infrastructure of a future EU Reference Centre **for harmonisation of performance and international genetic evaluation in sheep and goat, could be** organized in the same way as for cattle and **integrated either** into Interbull or in ICAR or a consortium of both, with a strong relationship with the existing ICAR working group on sheep, goat and camelid.

2 Introduction

The ambition of WP6 was basically (i) to perform the first across-country genomic evaluations in small ruminants by pooling phenotypic and genomic data and creating new shared reference populations in sheep and goats; and (ii) to create an international initiative that would facilitate, encourage and motivate the exchange of information, know-how and data (phenotypes, genotypes and pedigrees) for international cooperation and improved breeding for resilience and efficiency in small ruminants.
To achieve this goal, WP6 first undertook different actions to build the pre-requisites to enable reaching the ambition: definition of common standards for exchanging pedigrees, performances and genotypes data, signature of sharing agreement, codification of breeds and traits.
All these tasks provided materials to establish a business and operation model for international evaluations of sheep and goats. This deliverable presents the model through three main sections.

- The first section describes some **background information** with (i) a description, obtained by questionnaire, of the domestic genetic evaluation systems and the breeding programs existing in the SMARTER countries, (ii) a description of how Interbull works for dairy and beef cattle international genetic evaluation.
- The second section addresses the assessment of the **interest and willingness of stakeholders** for an international evaluation, using the results of a comprehensive survey carried out to stakeholders

of the different countries. This section, even if it does not explicitly produce elements about cost estimation or consent to pay, suggests that across country evaluations might meet the interest of the breeders and breeding organisations.

- Finally, the three pilot projects produced **operational suggestions, conclusions, but also warnings** about the usefulness of the pre-requisites built by the project. They drew lessons from using data generated by different countries, the actual connectedness across countries, the relevance of the genetic model implemented from true phenotypes, using or not genomic data, and the estimated genetic correlations across countries.

3 Background

The SMARTER project gave the opportunities:

- to have an insight of the different breeding programs and genetic evaluation systems in the SMARTER countries,
- to pay a visit to the INTERBULL evaluation centre in Uppsala (Sweden) to have a better understanding on how the international evaluations are implemented in dairy and beef cattle.

3.1 Genetic/genomic evaluations in sheep and goats

An overview of the different selection programs and systems of genetic and genomic evaluations in the SMARTER countries was established, through a survey of the different partners countries, conducted in 2019. The objectives of the survey were basically to describe the genetic and genomic resources available, the genetic evaluation systems and the breeding schemes of sheep and goats in countries participating in the SMARTER project. Three forms were distributed to all partners:

- Form 1: General information on breeding programs and population description
- Form 2: (National) Genetic evaluations
- Form 3: Genomic evaluations (at research or implementation stages)

The knowledge on the alternative approaches taken by different breeding organizations is paramount to the design of more efficient and integrated genomic breeding programs to further improve resilience and efficiency in small ruminants. Overall, **we summarized and integrated information on 48 sheep and goat breeding programs**, genetic and genomic evaluation systems and resources available **in 12 countries** involved in the SMARTER project.

The survey concerned 9 dairy goat breeds, 16 dairy sheep breeds and 20 meat sheep breeds involved in genetic schemes, representing more than 3 million animals involved in data collection schemes. The main groups of traits recorded across countries are: 1) milk yield and composition, mastitis indicators, udder and body conformation, and reproduction in dairy sheep and dairy goats; 2) growth, reproduction, health, ultrasound measurements, wool, and carcass in meat sheep. Seven countries have progeny testing schemes, but only 5 use artificial insemination. There are numerous challenges to be addressed (e.g. high heterogeneity of trait recording, SNP panels and statistical models used, average of ~30% of animals with unknow sires). However, there are also many opportunities to use the current resources to optimize selection for resilience and efficiency in small ruminants across countries.

The table 1 shows the participating countries and which species x production were covered in the survey. It does not mean that non covered species x production does not exist in the countries, but they were not involved in the SMARTER project.

Table 1 – SMARTER countries responding the survey on breeding programs and genetic evaluation for the small ruminant species x systems.

	Meat/wool sheep	Dairy goats	Dairy sheep
France	X	X	X
Norway	X	X	
Ireland	X		
Canada		X	
Spain			X
Switzerland		X	X
Uruguay	X		
Hungary	X		
Romania		X	X
Italy		X	X
Greece			X
The UK	X	X	

The tables 2a, 2b and 2c show the breeds covered by the survey.

Table 2a – Dairy goat breeds from SMARTER countries involved in the genetic evaluation.

Dairy goats	Alpine	Saanen	Other
The UK			Yorkshire (mixed breed: Alpine + Saanen + Toggenburg)
Canada	X	X	Nubian, La Mancha, Toggenburg
Italy	X	X	
Switzerland	X	X	Toggenburg
France	X	X	
Romania	X	X	Alba de Banat, Carpatina
Norway			Norwegian Dairy Goat (“includes” Alpine + Saanen)

Table 2b – Dairy sheep breeds from SMARTER countries involved in the genetic evaluation.

Dairy sheep	Breeds
France	Black-Faced Manech, Basco-Bearnaise, Corse, Lacaune, Red-Faced Manech
Romania	Awassi, Lacaune, Merinos de Palas, Turcana, Tigaie
Spain	Assaf, Latxa Cara Negra-EUS, Latxa Cara Negra-NA, Latxa Cara Rubia
Switzerland	East Friesian, Lacaune

Table 2c – Meat/wool sheep breeds from SMARTER countries involved in the genetic evaluation.

Meat sheep	Breeds
France	Vendeen, Charollais
Ireland	Belclare, Charollais, Crossbred/composite, Suffolk, Texel, Vendeen
Hungary	BMC, Hungarian Merino, Tsigai
Norway	Norwegian White Sheep

The UK	Beltex, Beulah, Bleu du Maine, Blue Texel, Blue-faced Leicester, Border Leicester, Charmoise Hill, Charollais, Cheviot, Dorset, Dorset Down, Hampshire Down, Hardy Speckle, Ille de France, Jacob, Leicester Longwool, Lleyn, Meatlink, Oxford Down, Romney, Rouge dela Ouest, Roussin, Texel, Suffolk, Scottish Blackface, Shropshire, Southdown, Swaledale, Vendeen, Welsh Mountain, Wiltshire, Zwartbles
Uruguay	Texel, Australian Merino, Corriedale

The table 3 displays the population size of the covered breeds, the number of recorded females and the number of AI per year, which are indicators of the importance of the selection programs.

Table 3 – Importance of breeding programs of small ruminants (performance recording and AI) in the SMARTER countries.

Country/category	Population size	Recorded females	Nb of AI/year
Dairy sheep – France	1,347,000	328,650	223,456
Dairy goats – France	610,000	247,900	65,000
Meat sheep – France	255,000	20,561	7,245
Meat sheep – Ireland	15,740 + 2.4 million composites/crossbred	23,578	4,193
Dairy goats – Italy	29,000	23,000	2,500
Dairy goats – Romania	?	220,082	1,000
Dairy sheep – Romania	12,850,500	1,693,076	0
Meat sheep - Hungary	11,900	9,720	570
Dairy sheep – Spain	1,009,969	177,293	59,118
Dairy goats – Switzerland	?	14,701	0
Dairy sheep – Switzerland	?	9,218	0
Meat sheep – Norway	520,000 (ewes)	260,000	8,900
Dairy goats – Norway	30,000 (does)	25,000	2,400
Meat sheep – Uruguay	4,760,000	22,000	4,400
Dairy goats – Canada	230,034	21,033	?
Dairy goats – the UK	11,336	9,000	?
Meat sheep – the UK	36,000,000	?	?

The traits recorded in dairy sheep and goats are: milk yield, fat yield, protein yield, fat %, protein %, free fatty acids, SCC, mastitis, milking speed, udder morphology (eg. teat angle, udder cleft, udder depth, rear/forward teat position, fore udder attachment, udder profile, udder floor position, udder furrow, rear udder attachment, teat length, teat shape, teat orientation, medial suspensory ligament, fore udder, rear udder), overall conformation for stature, feet and legs, chest width, prolificacy, fertility, body weight, body capacity, feed intake, general appearance.

The traits recorded in meat sheep are: prolificacy, maternal ability, lambing ease (single/multiple), lamb mortality, lamb survival, weights and corresponding growth rate (weaning weight - adjusted 30-day weight -, 40-day weight, 6-week weight, weaning weight - 20 weeks -, mature weight - adjusted 70-day weight -, ultrasound-scan weight, ewe mature weight, 8-week weight, birth weight, 1-year-old weight, 2-years-old weight, post-weaning, shearing weights), ultrasound muscle and fat depth, CT lean, CT fat, CT muscularity, lameness, dagginess, FEC, mastitis, lambing interval, age at first lambing, number of death lambs, weight of raw wool, fiber wideness, height of wool, teat size, ewe culling reasons, carcass weight, meat EUROP score, EUROP fat points, fleece weight, fleece grade, greasy and clean wool, fiber diameter, staple length, longevity.

This list shows that some traits would deserve a harmonisation in the view of running an across country evaluation. This is the case for the different weights that are measured at various periods, according to the production system and the country.

The domestic genetic evaluations display a large variation in data recording and used protocols, in pre-adjustment of records, in models used, in adjustment for heterogeneous residual variance, in the use and definition of unknown parent groups. The expression of genetic values differs across country: in the unit of measures (eg. Kg or liters for milk, fat and protein yield), in genetic standard deviation, in euro per lamb born, in deviation from a middle score, etc.

The number of runs per year ranges from 1 to a weekly evaluation.

Genomic evaluations are run in France (dairy sheep and dairy goats), in Spain (dairy sheep), in Ireland (meat sheep), in the UK (dairy goats) and in Canada (dairy goats). The SNP panels are low or medium density, either from Illumina or Affymetrix, which would require a specific pipeline for pooling genomic data from different countries. The genomic analyses are done with BLUPf90 package or MiX99.

The results of this survey were presented at the EAAP meeting in 2020.

Session 61. **SMARTER: small ruminants breeding for efficiency and resilience**

Chair: Conington / Moreno

Theatre Session 61	Book of Abstracts page

9:15 Genetic evaluation systems and breeding programs in sheep and goats: an international perspective
L.F. Brito, D. Berry, H. Larroque, F.S. Schenkel, G. Ciappesoni, A. O'Brien, F. Tortereau, E. Ugarte, I. Palhiere, B. Bapst, J. Jakobsen, G. Antonakos, A. Kominakis, V. Clement, G. Bruni, V. Loywyck, E. Massender, H.R. Oliveira, J. Posta and J.M. Astruc

3.2 Interbull, a possible organisation for across country evaluation in small ruminants

A visit of the Interbull international evaluation centre was organised in Uppsala (Sweden) on 27 and 28 May 2019 (Jean-Michel Astruc and Sophie Mattalia). The objective was to better know how the international evaluations are organized in cattle through Interbull and Interbeef regarding the governance and the organizational and technical aspects.

What is Interbull?

Interbull is strongly related with three distinct institutions:

- The Interbull Centre has been contracted by ICAR to be the operational unit for ICAR's permanent subcommittee "Interbull" and the ICAR working group "Interbeef"

- The Interbull Centre is a section of the Department of Animal Breeding and Genetics of the Swedish University of Agricultural Sciences (SLU)
- As of 1 November 2018, the Interbull Centre is the EU Reference Centre (EURC) responsible for the "*scientific and technical contribution to the harmonisation and improvement of the methods of performance testing and genetic evaluation of purebred breeding animals of the bovine species*"

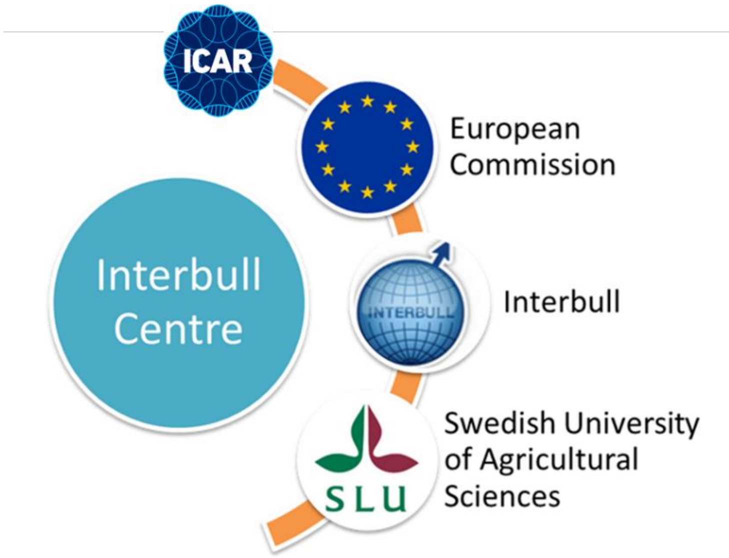

Figure 1 – Interbull and its ecosystem

Therefore, the term Interbull refers both to the evaluation center or operational unit (under the governance of the SLU University) and a body for international evaluation (under the governance of Interbull Sub-Committee of ICAR).

Interbull and ICAR – Governance

Interbull is managed by ICAR Board. The main governance body is the Steering Committee, which is composed by 9 members from different countries, currently chaired by Matthew Shaffer (Australia). The Steering Committee is equivalent to the ICAR Interbull Sub-Committee and is in charge of setting strategy, priorities, work plans and budget for Interbull.

The Steering Committee (or Interbull Sub-Committee) is supported by the Technical Committee (currently chaired by Gerben de Jong), that identifies and reviews technical issues. Until recently, there was a Scientific Advisory Committee, that proposed methodological developments. the Sub-Committee has decided to disband this Scientific Advisory Committee.

Interbull business meetings are regularly organised with the purpose to report on the activities of the Interbull Centre, present decisions of the Steering Committee including budget, and to provide customers a forum for discussion of Interbull services, present and desired. Conclusions and recommendations of the Interbull Business Meeting are brought to the Steering Committee for decision.

Main milestones of Interbull

- Before 1990: Interbull = network
- 1983: Interbull founded
- 1988: Permanent SC of ICAR
- 1990: Interbull Center established in Uppsala
- 1995: 1st routine international evaluation (DAIRY)
- 2006: need of international evaluation in beef expressed
- 2015: 1st routine international evaluation (BEEF)

Objective and infrastructure

The objective is to enable importers and exporters to select, worldwide, the best genetics for different countries, environments or breeding goals. In other words, finding the best bulls for farmers/industry, in the most accurate way.

The Interbull Centre Team is composed by ~10 staff (information technology, geneticists, director). It has computing infrastructure, data security and privacy.

International dairy cattle evaluation

- 32 countries are involved in an across country evaluation.
- Six breeds: Holstein, Brown Swiss, Jersey, Ayrshire, Guernsey, Simmental
- Seven trait groups comprising a total of 50 different traits: Production, Type, Udder Health, Fertility, Longevity, Workability, Calving traits.

Figure 2 – Countries involved in dairy cattle international evaluation

The different kinds of evaluations are:

- CONVENTIONAL evaluations since 1995
  - Method = MACE = Multi-Trait Across Country Evaluation
  - Phenotype = national de-regressed estimated breeding values
  - AI bulls are evaluated
  - Software = Mix99
- GENOMIC since 2014
  - Method = GMACE = Genomic Multi-Trait Across Country Evaluation
  - Phenotype = Mendelian Sampling deviations computed as MS = national GEBV – MACE Parent Average.
  - young bulls less than 7 years without conventional proof evaluated
- GENOMIC since 2011
  - InterGenomics in Brown Swiss = International genotype-based evaluation in the Brown Swiss
  - InterGenomics HOLSTEIN in progress for non aligned countries

The MACE uses all known relationships between animals and accounts for GxE interactions.

The output is the EBVs and the ranking in the different countries, which may differ across country (figure 3).

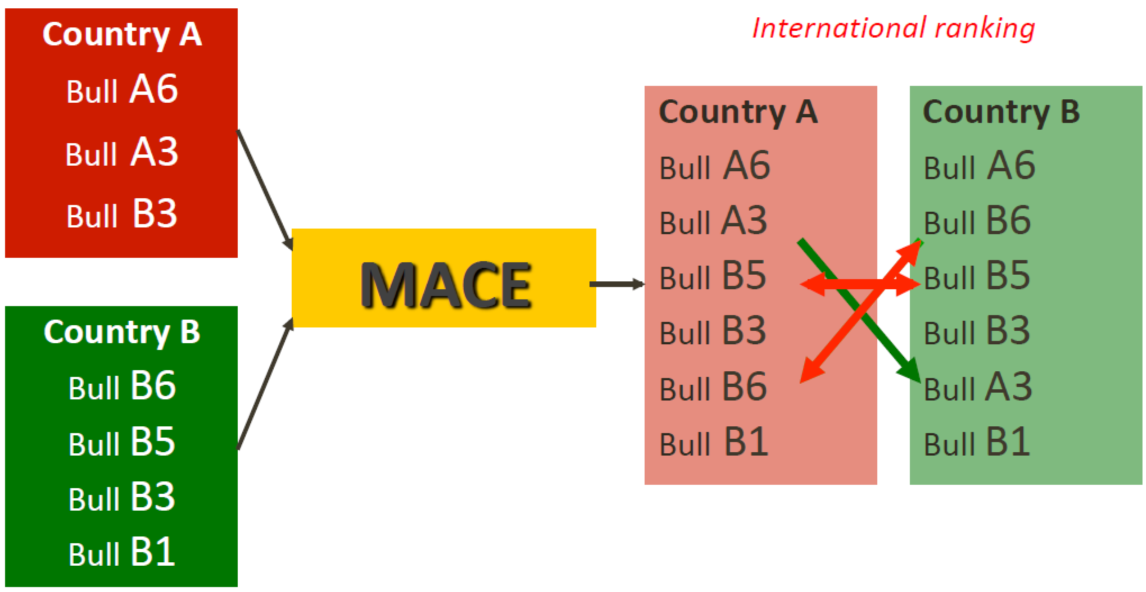

Figure 3 – Illustration of output from international evaluation

International beef cattle evaluation

The service is offered, through ICAR, by the Interbull Centre.

- 14 countries (12 populations)
- 5 breeds: Charolais, Limousine, Hereford, Aberdeen Angus, Simmental
- Traits = adjusted weaning weight + birth weight + calving ease + carcass traits (recently) + female fertility (in progress)

The governance is slightly different from dairy cattle, since it is run by the ICAR Working Group Interbeef, chaired by Andrew Cromie and supported by a technical group chaired by Romain Saintilan. The services of Interbeef are rapidly growing. One of the crucial issues to stimulate countries participate to the Interbeef evaluation concerns the benefits that multi country evaluation can bring to the country.

- CONVENTIONAL evaluations since 2015
  - Method = Multi-Trait model accounting for specificity of each country (recodified environmental effects … better to estimate parameters).
  - Phenotype = raw data
  - AI bulls are evaluated
- GENOMIC … in progress
  - Single step genomic evaluation is becoming a reality, following the outcomes of research undertaken by Interbeef and WUR (PhD by Renzo Bonifazi – 2018-2021).
  - Before developing the service, there is a need to better understand the business, technical and operational requirements of the new service, hence the establishment of a task force to address this issue.

Pedigree

Pedigree management is a key technical issue especially for retrieving the ID(s) of the same animal in different countries. The risk that importing countries change the ID of the animal must be addressed, otherwise one should miss the actual connection.

The unique ID comprises: sex, breed, country, number.

Each country makes its own checking with a software provided by Interbull. When a country brings animals from its own country, the pedigree is considered as correct (sire, dam, sex, breed, birth date). When a country brings a foreign animal, there is a checking and the result is given back if any problem.

At each upload, only new or modified pedigree are brought.

Database and data at Interbull Centre

IDEA = Interbull Data Exchange Area. It is a database for pedigree, EBV's, phenotypes, panel of SNPs for parentage. Data are uploaded through a website-based application (not yet for genotypes - cf. Intergenomics). Genotypes are sent through FTP as flat files. Data uploaded are checked and possible errors are sent back to the countries.

GenoEx Platform and GenoEx PSE service. This platform stores SNP records for parentage verification. It offers a service for exchanging standardised sets of SNP for genotyped animals to facilitate parentage analysis.

Reference Centre

Since November 2018, Interbull is the EU Reference Center (*harmonizing & improving methods for performance testing and genetic evaluation in bovine species*), according to the Breeding Law 2019/1012.

Fees

For dairy cattle, Interbull customers pay their fees directly to Interbull center. ICAR is not concerned. Whereas in Interbeef, customers pay their fees to ICAR, therefore ICAR is actually the direct customer of Interbull center, through a contract between ICAR & Interbull center.
Fee structure is updated when necessary, when there are new services, such as new traits or new methods.
The key point for the fees is the transparency.

As a conclusion of this section, we were told by Interbull staff that if we follow the principle of the Code of Practice of cattle (same format of exchanges, same structure of the database, pooling of raw performance as in Interbeef situation), **Interbull center might perform the evaluation for small ruminants. The infrastructure exists**, even if it must be adapted.

It should be noted that about data, there are two notions: data can be pooled, with only Interbull having access to all data (for example genotypes) for providing the international evaluation, or shared amongst the international evaluation participants.

4 Assessment of interest and willingness for an international evaluation in sheep and goats

A key action of the task 6.3 of SMARTER was to assess the willingness of countries and breeds for an international evaluation, their consent to pool data with the objective of across country evaluation, which breeds might be interested and what would be the opportunities and expectations, as well as the risks and the concerns for the countries.

For undertaking this task, we carried out two surveys:

- A first within the SMARTER partners, on opportunities and risks of international evaluations.

- A second and more comprehensive survey (conceived and set up in 2021) towards the breeding organisations and breeders of the countries involved in SMARTER, as well as towards the stakeholders' platform of SMARTER. WP6 partners prepared, jointly with ICAR who provided the infrastructure and the link, the questionnaire translated in English, German, Spanish, Italian or French, according to the country. Each partner was asked to target at least 5 domestic organisations and 10 breeders. The following 10 countries participated: Canada, France, Ireland, Italy, Spain, Switzerland, Uruguay, Hungary, the UK, Greece, as well as the SMARTER stakeholders. On the whole, 200 responses were received and analysed, from which 2/3 were complete.
- Moreover, we used materials collected from comprehensive interviews towards producers that were conducted in WP7 on selection practices and genetic management of flocks/herds. Among the different questions, some were dedicated to international evaluation with a focus on the agreement to share information across country, the expectations from international evaluation and the added value expected for the breeding programs. France, Greece, Italy and Uruguay participated.

We will present below the results of the survey undertaken within WP6 towards breeders and breeding organisations.

4.1 Willingness to share data

The first question was about the willingness to share data in the objective of an across country evaluation. We separated the 3 kinds of data: pedigrees, phenotypes and genotypes.

At the SMARTER level, the figures 4 and 5 give an overall synthesis of the trends.

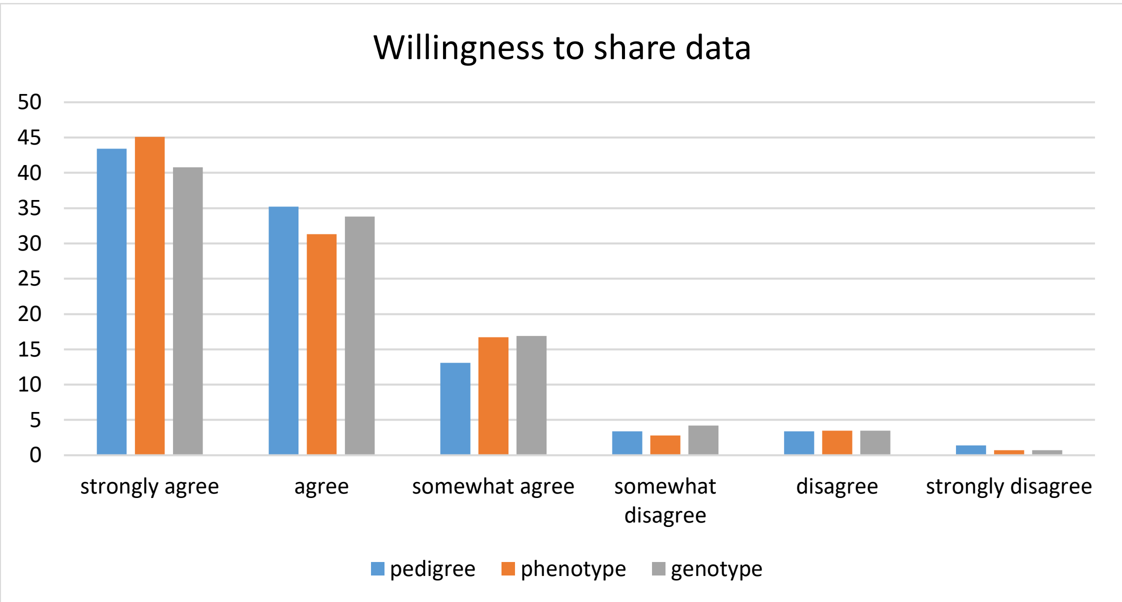

Figure 4 – Willingness to share pedigree, phenotype, and genotype data for international genetic evaluations.

75% (for genotypes), 76% (for phenotypes) and 79% (for pedigree) of the respondents agree or strongly agree to share data in a perspective of an international genetic evaluation. When generating an indicator of willingness, from 1 = strongly disagree to 6 = strongly agree, the general average is about 5, that means “agree”. Only 8% (for pedigree and genotypes) and 7% (for phenotypes) of the respondents disagree to pool data. There are no significant differences between the answers about pedigree, phenotypes and genotypes. We might have expected more reluctance to share phenotypes or genotypes, which is not the case.

The figure 5 shows the situation of the different countries in comparison of the SMARTER average (quoted “ALL”). The countries are anonymised, the objective being to highlight that some differences of view exist. The countries 2 and 6 appear more reluctant to pool data together, especially for pedigree in the country 6. Conversely, the countries 4, 5, 8 and 9 express enthusiasm to pool data. However, in the country 4, we observe a slight reluctance to share genotypes, while for this country, pooling pedigree and performance is fully accepted.

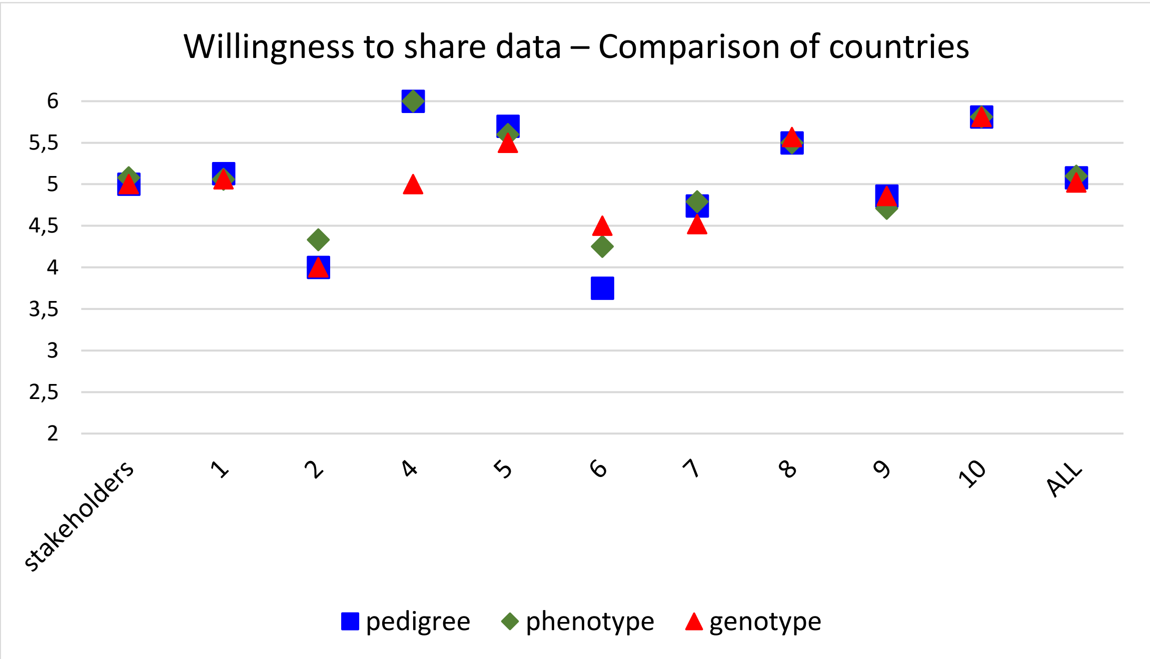

Figure 5 – Willingness to share data for international genetic evaluations: comparisons of countries.

4.2 Interested breeds

The table 4 summarizes the breeds considered as potential candidate for an across country evaluation.

The analysis of this table must be done having in mind that the SMARTER countries are not representatives of all the small ruminant populations. For example, wool populations (Merino, Corriedale and Dohne) are cited by Uruguay only just because Uruguay is the only SMARTER country with wool populations in sheep.

The results, however, show that some breeds are more frequently cited:

- In meat sheep: Texel, Charollais and Ile-de-France

- In dairy sheep: Lacaune, Assaf, Manech x Latxa
- In goats: Alpine, Saanen mainly, and in a lesser extent Toggenburg and Boer

Table 4 – Breeds that might find a benefit in international genetic evaluation.

Production x species	Breed	Respondents having cited the breed
Meat/wool sheep	Texel	Stakeholders, Uruguay, Ireland, France
	Charollais	Stakeholders, Ireland, France
	Ile-de-France	Stakeholders, Hungary, France
	Dorper	Stakeholders, Hungary
	Beltex	Stakeholders
	Suffolk	Stakeholders
	Vendéens	Stakeholders
	Southdown	Stakeholders
	Merino	Uruguay
	Corriedale	Stakeholders
	Dohne	Stakeholders
	Lleyn	Stakeholders
	Rouge de l'Ouest	Stakeholders
	Charmoise	Stakeholders
	Hampshire	Stakeholders
	Romane	France
Dairy sheep	Lacaune	Stakeholders, France, Spain, Greece
	Assaf	Stakeholders, France, Spain, Greece
	Manech tête rousse	France, Spain
	Manech tête noire	France, Spain
	Latxa	Spain, France
	Sarde	France
	East Friesian	Stakeholders
	Frizarta	Greece
Dairy goats	Saanen	Stakeholders, Canada, France, Spain, Switzerland, Italy
	Alpine	Stakeholders, Canada, France, Spain, Switzerland, Greece, Italy
	Toggenburg	Canada, France, Switzerland, Greece
	Boer	Stakeholders, Canada, France
	Camosciata delle Alpi	Stakeholders
	Murciano	France, Greece
	Angora	France
	Kiko	Canada
	Savannah	Canada
	La Mancha	Canada
	Nubian	Canada
	Kalahari Red	Stakeholders
	Skopelos	Greece

4.3 Opportunities and risks

An important part of the questionnaire aimed at prioritising the expectations and concerns regarding across country evaluation. The objective was to assess the opportunities and risks to be involved in an international evaluation. For that, the results of a first questionnaire sent to SMARTER partners were synthetised in a short list of 6 expectations and 6 concerns that were highlighted. In the comprehensive survey, the respondents were asked to rank the expectations and concerns, from 1 (ranked first, the most important) to 6 (ranked last). Open responses were also permitted.

The expectations were (alphabetical order):

1. Benefit for the national breeding programs
2. Benefit for the breeders
3. Commercial benefits (import/export)
4. Fair exchanges
5. International networking
6. International recognition

The concerns were (alphabetical order):

1. Disadvantage for local breeds
2. Loss of independence / competence for evaluation
3. Not enough connections between countries
4. Promote few commercial breeds
5. Too expensive and time consuming for small ruminants
6. Unbalanced interests between countries

The figures 6 and 7 show the average ranking across all the responses.
The major expectations are the benefits for the domestic breeding programs and the breeders, far ahead of the economic benefits and the international cooperation. The international recognition and the fairer exchanges are not the most expected items.
The ranking of concerns is tighter than the expectations. However, three concerns appear as the most important: loss of independence on genetic evaluation process, unbalanced benefits across countries, too expensive and time-consuming. The technical constraint (lack of connections between countries) is surprisingly the less important concern.

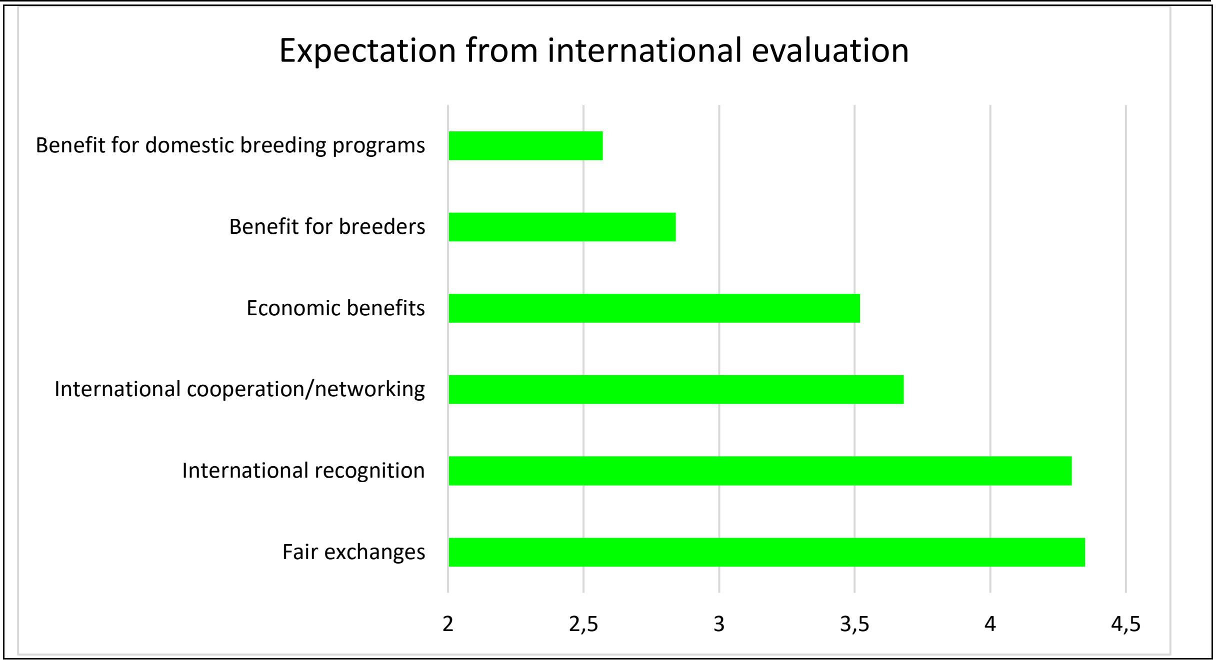

Figure 6 – Ranking of expectations from international genetic evaluation (the lower the figure, the most popular).

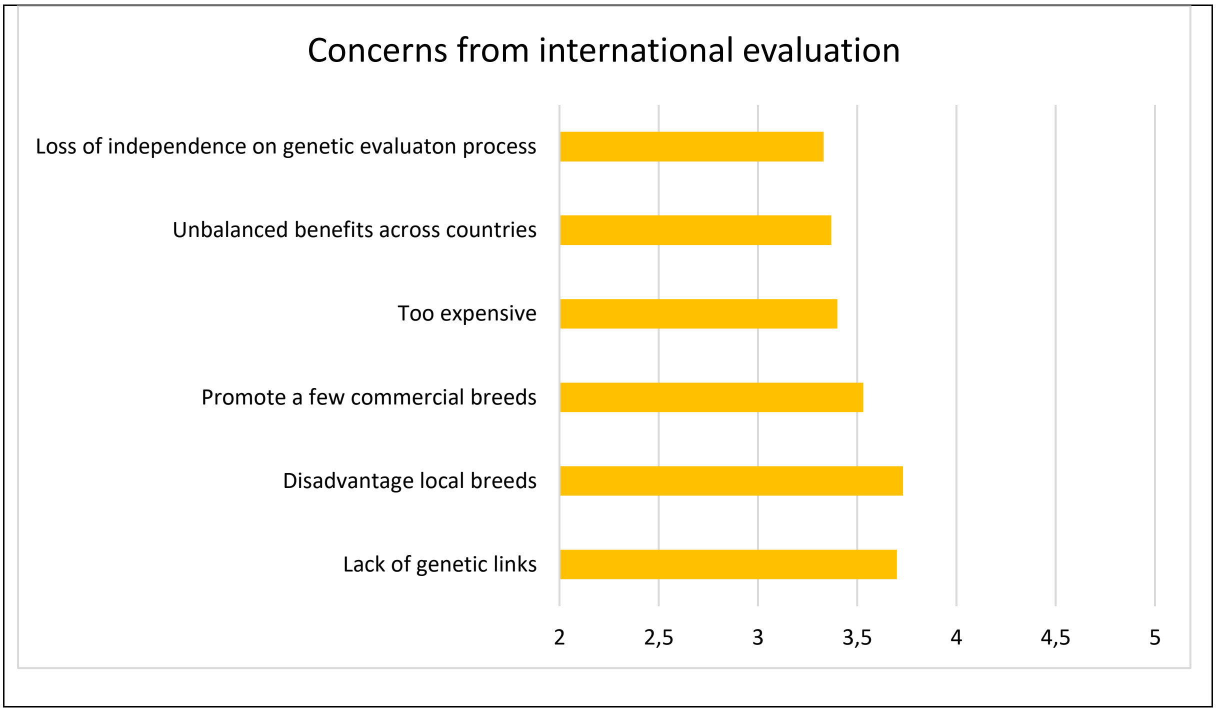

Figure 7 – Ranking of concerns from international genetic evaluation (the lower the figure, the most popular).

Amongst the responses that are the most deviant from the SMARTER average, we can underline:

<u>Expectations</u>

-In the UK, Canada and Ireland, fair exchanges and international recognition are far behind the other expectations.
-In Spain, fair exchanges look like being more important than in other countries, while the benefit for breeding program are less highlighted.
-In Italy, on the contrary, the benefit for the breeding program is prioritised, whereas the economic benefits have the lowest rank.
-The best rank for international recognition is in Switzerland and the best rank for international collaboration is for the stakeholders' platform respondents.

Concerns
-In the UK, Ireland and Spain, the risk of promoting few commercial breeds and disadvantaging local breeds is not really a concern.
-On the contrary, in the above three countries the loss of independence in genetic evaluation is a major concern.
-Lack of genetic links does not appear as a problem in Hungary, Greece and Italy.
-The cost of an international evaluation is put forward in Ireland, the UK, Uruguay and Italy.

As a general conclusion, we showed through the survey a global willingness and acceptance for pooling data with an objective of international evaluation.

The different concerns that are highlighted must be considered and mitigated if a routine evaluation was implemented in the next future.

5 Operational model

5.1 Pre-requisites

A major objective of the task 6.1 in SMARTER was to focus on the conception and establishment of the pre-requisites that would enable an across country genetic/genomic evaluation.

These pre-requisites are fully described in the deliverable D6.1 titled "Document specifying the exchange of pedigree, phenotypes and genotypes" and in the milestone MS23 titled "Physical agreement for sharing data for international evaluation".

This paragraph synthesises the operational achievements that would be useful to implement an international evaluation routinely after SMARTER.

Physical agreement for sharing data for international evaluation

The objective of the physical agreement is to give a common framework for the supply of data (including personal data) necessary to carry out an across country genetic evaluation, in a purpose of research, as it was done in SMARTER, or routine evaluation, as it could be achieved beyond SMARTER.

The agreements are bilateral, signed between a provider of data and a recipient in charge of the research/routine on across country evaluation.

The main statements of the agreements are:

-The provider agrees to supply to the recipients the data (phenotype, genotype, pedigree) described in an appendix of the agreement for the purpose of aggregating the data and performing statistical analysis upon it in order to carry out research or routine evaluation required by the purpose. The term of the agreement shall specify a period during which the data may be used for the purpose. The General Data Protection Regulation from the EU is considered in the agreement.
-the agreement specifies that the data must be treated as confidential, used only for the defined purpose.
-The agreement specifies the rules of publication
-The agreement specifies the legal conditions in case of failure of the agreement.
In SMARTER, the objective was to pool data at the partner making the research, but not to share data across partners.

In appendix 1 is an example of agreement that was signed within SMARTER (case of dairy sheep, between NEIKER and INRAE.

Format file for exchanging pedigree, phenotypes and genotypes

International ID

The international ID contains in itself the breed, the country, the sex and the ID number

- Breed on 3 letters
- Country on 3 letters
- Sex on 1 letter (“M”,”F”)
- IDNumber on 16 digits including (for European countries) the country code at the beginning (2-letters for country code: IE / FR/ IT / CA / ES / GR / HU / NO / GB /CH / UY, etc).

All ID numbers: registration numbers, right justified, leading blanks as zeros

Example: CHAFRAM000FR12345678901
In this example, the original ID is FR12345678901. This original ID on 13 digits is right justified and completed by three ‘0’ to obtain an IDNumber on 16 digits.

Pedigree, phenotype, genotype and parameter files

The name of the files is as follows:

- pedigree_species_production_country_version_date.txt
- phenotype_species_production_country_version_date.txt
- genotype_species_production_country_version_date.txt
- parameter_species_production_country_version_date.txt

with

- Species = ‘sheep’ or ‘goat’
- Production = ‘meat’ or ‘dairy’
- Country on 3 letters (see below)
- Version = ‘v1’, ‘v2’, etc
- Date=yyyymmdd

Files are flat file, with delimiter “;”.

For the phenotype file, one single file is required, even if there are several phenotypes. There are 9 columns, the same as in Interbeef format. It includes the weight of performance, the number of environmental effects and the recoded level of the environmental effects.
The genotype file includes the international animal ID, the SNP name and the allele in format A/B

The file formats are in appendix 2.

The parameter file describes, for each trait, the heritability, the maternal genetic and maternal permanent environmental effects, the animal permanent environmental effect, the number of environmental effects included in the national model, the environmental effects recoded and the type of effects (contemporary group, fixed, covariate, random).
It has the same format as in Interbeef.

Codification of breeds

A breed coding was proposed, composed of 3 letters. This codification will be proposed to ICAR for any purpose related to performance recording or selection operation, including genetic evaluation. The table 5 gives 5 examples (representing meat, wool and dairy sheep, goats and crossbred.

Table 5 – Example of breed coding (not comprehensive).

Breed wording	Breed code
Texel	TEX
Merino	MER
Latxa cara rubia	LCR
Alpine	ALP
Crossbreds	XXX

Codification of traits

A trait coding was also proposed, composed of 3 letters. This codification will be proposed to ICAR for any purpose related to performance recording or selection operation, including genetic evaluation. The table 6 gives some examples representing the different groups of traits.

Table 6 – Example of trait coding (not comprehensive).

Trait wording	Trait code
Milk yield	MYI
Protein content	PCO
Somatic cell score	SCS
Longevity	LON
Feet angle	FAN
Teat angle	TAN
Weaning weight	WEW
Ultrasonic fat depth	UFD
Litter size	LIT
Lameness	LAM

Lessons drawn from the data handling/editing in SMARTER case studies

- Take care that all genotyped animals are known in the pedigree file (as it should be also for phenotyped animals).
- The international ID must comply with the format proposed in SMARTER. This was not always the case, since this ID was built from domestic ID (e.g. spaces in the ID must be removed).
- The main difficulties come from finding connections across countries, through the pedigree file:
  - Some animals in common (e.g. sires used across 2 or more countries) are identified differently in the different countries, hence a miss of link. Be careful to avoid that, for example by managing a table of aliases.
  - The country of origin must be carefully assigned.
- When genotypes come from different platforms (e.g. Affymetrix and Illumina), take care of data editing for the same loci and remove the outliers to solve any problem.
- Remove upstream (prior to exchange information) the animals with too poor genotypic information (low call rate).

5.2 Genetic evaluation

Three case-studies on across-country genetic evaluation have been implemented in dairy sheep, meat sheep and dairy goats within SMARTER, as a proof of concept. They are summarised in the table 7. The work is related to task 6.2 and was made possible thanks to the prerequisites set up in the task 6.1 (see §5.1 of this D6.4 - definition of the file format for data exchanges, signing of sharing agreements, and codification of breeds and traits).

The level of connectedness among countries participating in the across country evaluations was described in the MS24 written in May 2020.

Table 7 – Case-studies undertaken in SMARTER.

Species x production	Partners	Breeds	Traits
Meat sheep	TEAGASC, RDF, SRUC, and IDELE	Texel, Suffolk, and Charollais from Ireland and the UK (French data too poorly connected with Irish and British data)	Life weight, scan weight, muscle depth, fat depth
Dairy sheep	INRAE, NEIKER, RDF and IDELE	French Manech Tête Rousse (MTR) x Spanish Latxa Cara Rubia (LCR) French Manech Tête Noire (MTN) x Spanish Latxa Cara Negra (LCN)	Milk yield
Dairy goat	INRAE, ARAL, FIBL, UGUELPH, CAPGENES and IDELE	Alpine and Saanen from France, Canada, Italy, Switzerland	Milk yield, fat content, udder morphology

These case-studies generated 5 publications:

JDS Communications®
2022; 3:260–264
https://doi.org/10.3168/jdsc.2021-0195
Short Communication
Genetics

High genetic correlation for milk yield across Manech and Latxa dairy sheep from France and Spain

C. A. Garcia-Baccino,[1,2,3] C. Pineda-Quiroga,[4] J. M. Astruc,[5] E. Ugarte,[4] and A. Legarra[1]*

Journal of Animal Breeding and Genetics

ORIGINAL ARTICLE | Open Access

Across-country genetic evaluation of meat sheep from Ireland and the United Kingdom

Shauna Fitzmaurice, Joanne Conington, Kevin McDermott, Noirin McHugh, Georgios Banos

First published: 01 February 2022 | https://doi.org/10.1111/jbg.12668

This study has been funded under the Teagasc Walsh Scholarship Scheme (REF 2016140) and the Horizon2020 SMARTER (REF 772787-2) project.

ELSEVIER
Animal
Volume 14, Issue 5, 2020, Pages 899-909

Genetic analyses of live weight and carcass composition traits in purebred Texel, Suffolk and Charollais lambs

S. Fitzmaurice[1,2], J. Conington[1], N. Fetherstone[2], T. Pabiou[3], K. McDermott[3], E. Wall[3], G. Banos[1], N. McHugh[2]

frontiers | Frontiers in Genetics

ORIGINAL RESEARCH
published: 17 June 2022
doi: 10.3389/fgene.2022.862838

Genetic Characterization and Population Connectedness of North American and European Dairy Goats

Marc Teissier[1], Luiz F. Brito[2,3], Flavio S. Schenkel[3], Guido Bruni[4], Pancrazio Fresi[5], Beat Bapst[6], Christèle Robert-Granie[1] and Hélène Larroque[1]*

Proceeding of 12th World Congress on Genetics Applied to Livestock Production (WCGALP) Technical and species orientated innovations in animal breeding, and contribution of genetics to solving societal challenges

2932-2935

Wageningen Academic Publishers

711. Genetic parameters across European and North American Alpine goats for two milk production and one udder type traits

M. Teissier[1], L.F. Brito[2], F. Schenkel[3], B. Bapst[4], G. Bruni[5], P. Fresi[6], C. Robert-Granié[1*] and H. Larroque[1]

Figure 8 – Articles published on the case-studies on across country genetic/genomic evaluation.

Different methods for assessing the proximity of the populations were used. In dairy sheep, a PCA revealed a clear overlap of French Manech Tête Rousse (MTR) and Spanish Latxa Cara Rubia (LCR) with a smaller overlap between French Manech Tête Noire (MTN) and Spanish Latxa Cara Negra (LCN). In goats, the overlap is important between France and Italy (whatever the breed), but to a lesser extent between French, Italian and Swiss Alpine; the Canadian populations are clearly separated from the European ones.

In the three case-studies, the variable evaluated is the true phenotype used in the domestic evaluation, as it is the case in beef cattle (Interbeef). It is neither a de-regressed proof as it is the case in dairy cattle (Interbull) nor a (daughter-)yield deviation. To estimate genetic parameters, multi-trait animal models were fitted for each trait and breed, where each country was considered as a different trait, using models of the routine genetic evaluations.

Most of the genetic correlations were estimable and were stronger than 0.7 with some exceptions (table 8). In dairy sheep, the estimated genetic correlations were approximately 0.7, both in blond strains (MTN x LCR) and in black strains (MTN x LCN). This is sufficiently strong to permit an across country evaluation. In meat sheep, the correlations, estimated in the Texel breeds, were stronger than 0.8 for Irish pre-weaning weight and British early-life weight (0.82), scan weight (0.88), muscle depth (0.85) and fat depth (0.85). The weak correlation between Irish weaning weight and British early-life weight (0.38) indicates that both traits are different. In goats, the genetic correlations were strong for the udder type traits in both breeds. For example, they were above 0.75 for rear udder attachment (in Alpine: 0.92 between Canada and France; 0.78 between Italy and Canada; 0.76 between France and Italy). Including genomic information had minimal effect on the estimated genetic correlations between populations. Covariance could not be properly estimated between some goat populations or were not consistent across analyses for milk yield.

Table 8 – genetic correlations (sheep) / correlations between EBVs (goat) estimated across countries in the three case-studies.

Species x production (countries)	Breeds	Traits	Genetic correlation
Dairy sheep (France x Spain)	MTR x LCR	Milk yield	0.70
	MTN x LCN	Milk yield	0.70
Meat sheep (Ireland x the UK)	Texel	Irish pre-weaning weight x British early-life weight	0.82
		Scan weight	0.88
		Muscle depth	0.85
		Fat depth	0.85
		Irish weaning weight x British early-life weight	0..38
Dairy goats (France x Italy)	Alpine	Milk yield	0.45
		Fat content	0.78
		Rear udder attachment	0.76
Dairy goats (France x Canada)		Rear udder attachment	0.92
Dairy goats (Italy x Canada)		Rear udder attachment	0.78

Overall, these results are encouraging for running routinely international evaluations. Nevertheless, several limitations were identified: first, the question of the harmonization of the phenotypes is important. This is especially true for milk yield with different ways of calculating the lactation yield or for weights measured at different ages in meat sheep. Second, exchanges (at least in dairy sheep and dairy goats) of germplasm were sometimes just unidirectional, and exchanges in both ways might strengthen the connection across countries. Third, in some cases, the sizes of the phenotyped or genotyped populations were very unbalanced.

However, strong genetic correlations estimated between two countries, in most cases, warrant possible benefits from a joint genetic evaluation. This also suggests that limited re-ranking of sires would be expected between countries.

We highlighted in dairy sheep an issue that must be tackled to complete the feasibility assessment of an across country evaluation (at least in this case-study). Genetic trends for any breed (Manech or Latxa) are identical in BLUP or ssGBLUP, and by analysing the breeds separately (single-breed) or jointly (two-breed, each breed a trait). However, the genetic trend of a breed, in the scale of the other breed, is not correctly estimated. This means that a MTR breeder that would look at the EBV of LCR rams in the MTR scale, would see that EBVs of all LCR rams look terrible - and much worse than reality. The example of LCR/MTR is illustrated in the figure 10. A similar behaviour exists for MTN/LCN. The phenomenon is not fully symmetric because exchanges are one-way only. Thus, trends in the other scale are biased. At the beginning, LCR has no genetic trend in the MTR scale (whereas it should have) because the data has no information on that (there were no exchanges before the year 2005). As a result, differences across breeds are unfairly high (or unstable) and not according to actual records. This phenomenon illustrates the importance of connection. Despite all our sophisticated BLUP methodology and SNP chips, we need to inseminate females of one side with rams from the other side. As we can’t go back to the past and inseminate, the most sensible solution is to truncate data and keep the last 15 years which are well connected. This must be done.

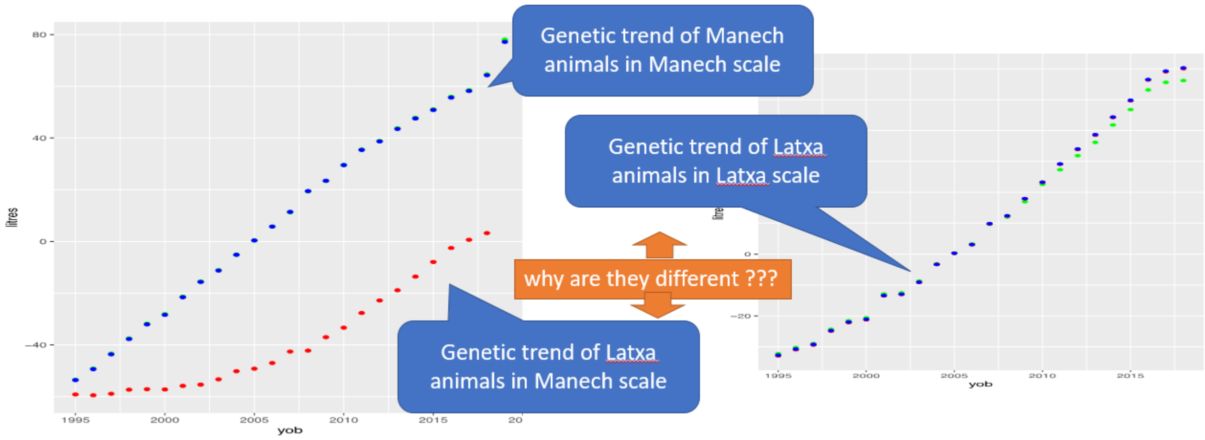

Figure 10 – Genetic trends in Latxa (left – red points: in Manech scale; right – dotted line in blue and green: in Latxa scale) and Manech (left – dotted line in blue and green: in Manech scale) according to the scale in which the EBVs are expressed. Blue line: breeds analysed jointly (each breed a trait); green line: breeds analysed separately (single breed)

5.3 Cost estimation: not covered

The cost estimation of an across country evaluation in routine was not possible during the SMARTER project. As stated above, we focused during the project on the pre-requisites to implement an international evaluation, on the technical issues of the evaluation *per se*, including the connectedness across populations, on the willingness of countries to share data, as well as the opportunities and risks of such multi-country evaluations.

However, the cost of an across country evaluation appears to be the third concerns for the SMARTER community, just after the risk of loss of independence / competence for evaluation and the unbalanced interests between countries. As people seem to will to keep domestic competence on genetic evaluation, an across country evaluation would not replace the domestic ones but be an extra evaluation. This evaluation would benefit from an increase in reliability for genomic prediction from a larger reference population, a fairer choice of animals for breeders and consequently a greater genetic progress across the populations involved. That means an extra-cost. The concern of unbalanced interests between countries suggests that the structure of fees across participating countries must be thought carefully so that each party feels a benefit.

A first application post-SMARTER of international evaluation should be an informative workshop for trying to meet such requirements.

5.4 Reference Centre: some propositions to be considered

We explained above that Interbull was, since November 2018, the EU Reference Center [EURC] for ***harmonizing & improving methods for performance testing and genetic evaluation in bovine species***, according to the Breeding Law 2019/1012.

There is no such EURC for small ruminants.

The cooperative initiatives undertaken in SMARTER (recommendations for harmonizing the recording of efficiency and resilience traits, international collaboration for implementing across country evaluation), combined with the existing ICAR working group on sheep, goat and camelid which works on harmonisation of performance recording, is an opportunity to conceive what could be an EU Reference Centre on performance testing and genetic evaluation in small ruminants.

The table 9 lists some services that could be provided by a zootechnical EURC in small ruminants according to the requirements stated in the Breeding Law and according to what is done in Interbull for cattle. This outline meets both the scope of the existing EURC in cattle and the expectations we had in our investigations.

Table 9 – Requirements of an EU zootechnical Reference Centre and services that could meet these requirements and our expectations.

Breeding Law - requirements	What could be provided in sheep and goats
Facilitate the uniform application of methods for performance testing and genetic evaluation	ICAR guidelines (new guidelines + update current guidelines). Existing ICAR guidelines: • Section 16 – Dairy sheep and goat • Section 21 – Meat, reproduction and maternal traits in sheep and goat New section: recommendations from SMARTER project (and Grass to Gas project for feed efficiency and GHG emissions) on resilience and efficiency traits with 7 sub-sections (see deliverable D6.3) • Feed efficiency • Green House Gases emissions • Record of the environment (diet, meteorological data) • Health and disease • Survival of foetus and young • Behaviour • Lifetime resilience Another section on wool traits is currently on-going at ICAR level (work of the sheep, goat, camelid working group). Guidelines may be needed for genetic evaluation (either for national or international evaluation) The guidelines are managed by ICAR and are under the responsibility of the Sheep Goat and Camelid ICAR working group (SGC-WG).
Inform breed societies on methods	Through ICAR website and guidelines. Must be improved. A demand of some ICAR partners is to explicitly include breeding society in the ICAR community (sheep and goat) in addition to performance recording organisation.

Review regularly the results	ICAR survey: a yearly on-line survey exists for dairy sheep and goats at ICAR level. It should be enriched with a survey on meat sheep and wool sheep. The survey carried out in SMARTER on domestic genetic/genomic evaluation and selection program might be routinely set up by the EURC.
Compare methods (phenotyping and genetic evaluation)	Comparing methods of phenotyping are in the scope of the ICAR SGC-WG. Comparing method of evaluation would be more in the scope of a specialised organisation such as it exists in Interbull.
At the request of EU/member state: provide assistance in the harmonization of methods ; recommend calculation methods ; establish a platform for the comparison of the results (developing control protocols, carrying out an international assessment of livestock, disseminating the results, provide data on the genetic evaluation)	We need a network of experts that could assist and pro-vide these assistance and recommendations and that could build the platform. This network might be based on the ICAR SGC-WG, helped by ad hoc expert advisory group. This network must be enlarged to experts on genetic evaluation for addressing methods and recommendations on genetic evaluation. This network, whatever the organisation that supports it, should organise webinars or technical meetings to spread the methods and discuss with the stakeholders
Provide data on the genetic evaluation	The implantation of international genetic evaluation must obviously result in providing EBVs to the participating countries. In cattle, the EURC is the calculation centre itself (Interbull), hence the easiness to meet this requirement. In small ruminant, meeting this requirement will depend on the organisation chosen (see below § elements of organisation of a EURC in small ruminants).
Facilitate the resolution of emerging problems, cooperate, provide technical expertise	Might be developed but would require persons to do it. Maybe too time-consuming for small ruminant community

Elements of organisation of a EURC for harmonising & improving methods for performance testing and genetic evaluation in bovine species in small ruminants

To meet the requirements and the expectations exposed in the table 9 above, two organisations seem to be natural candidates: ICAR and INTERBULL.

ICAR, through the working group on Sheep, Goat and Camelid (SGC-WG) as a technical body, and through the ICAR Board and the ICAR general Assembly as governance bodies, is already meeting the needs for performance testing part.

As there is not yet routinely run international evaluation, there is de facto no existing body that produces the needs on genetic evaluation in small ruminants, such as Interbull plays this role in cattle. Given the needed infrastructure for international evaluation, and especially the platform to pool and share pedigree, performance and genotypes, Interbull should play a key role in future across country evaluations.

If the EURC might be either ICAR or Interbull, the above statements would lead to **propose a mixed organisation based on a consortium of both Interbull and ICAR**, given that Interbull is a permanent Sub-Committee of ICAR. Such a solution (a consortium gathering 3 partners) has been adopted for the EURC on endangered animal breeds in January 2023. Practically, the consortium of the EURC for small ruminants should gather Interbull, as it has technical permanent staff, as it already is EURC for cattle, and as it has expertise in international evaluation, and ICAR, as it has a strong expertise in sheep and goat recording and small ruminant breeding programs, through the SGC-WG that should be extended to more expertise in genetic evaluation to cover all the scopes. This would foster a tight cooperation between ICAR and Interbull in the small ruminant sector. This would be somehow similar as the beef cattle organisation with Interbull providing the infrastructure and the governance stemming from the ICAR Interbeef working group.

6 Deviations or delays

No delay nor deviation

7 Acknowledgements

All the people working in WP6 have participated in this collaborative work. Beyond the participants to the WP6, we may express a special thanks to all the breeders and breeding organisations who answered the questionnaire they received.

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9 Appendix

9.1 Example of sharing agreement

Below is an example of sharing agreement (dairy sheep between NEIKER and INRAE) signed within SMARTER.

AGREEMENT FOR THE SUPPLY OF DATA (INCLUDING PERSONAL DATA)

This Agreement is dated 1st of July 2019 and is made between:

1. **NEIKER TECNALIA: CAMPUS AGROALIMENTARIO DE ARKAUTE, N-104, E-01192 ARKAUTE (ALAVA), SPAIN ("NEIKER"), AND**

2. **INRAE: UMR GENPHYSE, INRAE CENTRE OF TOULOUSE, 24 CHEMIN DE BORDER-OUGE, 31326 CASTANET-TOLOSAN, FRANCE (THE "RECIPIENT").**

Background:

NEIKER possesses phenotypic and genomic Data on the pedigree flocks of France
The Recipient wishes to access the Data and NEIKER is willing to allow the Recipient, on the terms and conditions set out in this Agreement, to access and use the Data for tasks described within the EU funded project Smarter (772787) and disseminate Results to the Consortium Partners of same.
Both parties are aware of their responsibilities in relation to the Regulation (term is defined below).

1. In consideration of the entering into of this Agreement by the Recipient and for other good and valuable consideration (the receipt and sufficiency of which is hereby acknowledged and confirmed), NEIKER agrees to supply to the Recipient the data described in Part 1 of Schedule 1 (the "**Data**") for the purpose stated in Part 2 of Schedule 1 (the "**Purpose**") subject to the terms of this Agreement for the term stated in Part 3 of Schedule 1 (the "**Term**").

2. The terms "**Data Subject**" and "**Processing**" shall have the meanings given to them in Regulation (EU) 2016/679 of the European Parliament of the Council of 27 April 2016 (the General Data Protection Regulation) (the "**Regulation**") or the Data Protection Act 1988 to 2003 (the "**Act**"), both as may be amended from time to time.

3. The Recipient acknowledges, accepts, agrees and undertakes to comply with the following conditions:

3.1 The Data must only be used for the Purpose and for no other purpose whatsoever.

3.2 The Data must be treated as confidential and must not be made available to any person(s) who do not require it for the Purpose (as outlined in Schedule1 Part 3). Any person other than the Recipient to whom the Data is given must also be under an obligation to treat the Data as confidential.

3.3 No individual animals, persons or organisations shall be identified in any documents, reports, data manuals, codes (including source codes) and/or other materials including all and any audio or audio-visual recordings, transcripts, books, papers, records, notes, illustrations, photographs, diagrams arising in whatever form or format, or any part or parts thereof ("**Materials**") produced in connection with the Purpose.

3.4 No Materials which use or include the Data shall be published unless NEIKER has been consulted prior to such publication and has consented, in writing, to such publication.

The Recipient shall submit its proposed publication in writing to the NEIKER at least thirty (30) business days before submitting it for publication ("Publication Proposal").

Removal of Confidential Information: All Data shall be treated as Confidential Information. NEIKER may, by giving written notice to the Recipient, require the removal of any of the NEIKER's Confidential Information from the publication.

Assumed permission: If the Recipient does not receive a written objection from the NEIKER within thirty (30) business days of submission of the Publication Proposal, then permission to publish shall be deemed to have been given.

3.5 Without prejudice to Clause 3.4, NEIKER shall be acknowledged as the source of the Data in any published Materials which use the Data.

3.6 All reasonable costs incurred by NEIKER in extracting or providing the Data shall be reimbursed, in full, by the Recipient to NEIKER, upon request.

3.7 Any Results generated, developed or arising from the use of the Data or the Purpose shall be made available to NEIKER, at no cost, for use in the services NEIKER provides.

3.8 When using the Data, the Recipient must comply with all applicable regulations, laws and codes of practice.

4. The Recipient further acknowledges, accepts, agrees and undertakes that:

4.1 It does not and shall not obtain any rights in the intellectual property rights or any other such rights of any nature or in any form whatsoever, whether registered or unregistered (the "**IPR**") in or connected with the Data;
4.2 it shall not claim or assert any right to or register or attempt to register any IPR in the Data;
4.3 NEIKER gives no warranties that the receipt or use by the Recipient of the Data will not infringe the rights of any third party and NEIKER shall not be responsible for any costs, damages or expenses arising out of proceedings of any nature brought against the Recipient or any other person for infringement of the rights of any third party.

5. Data shall be supplied by secure access control mechanisms. For this project the SFTP (Secure File Transfer Protocol) site shall be used to transfer the Data to INRAE.

6. NEIKER shall have no liability to the Recipient, whether in contract, tort, negligence or otherwise, in relation to the supply of the Materials or their use or keeping by the Recipient, or the consequences of their use, to the maximum extent permitted under applicable law.
7. The parties agree that this Agreement shall continue in force for the Term unless the Recipient breaches its terms, in which case NEIKER shall be entitled to terminate the Agreement immediately by giving notice to the Recipient. The termination of this Agreement shall not affect any provision of this Agreement that is intended to survive the termination of this Agreement nor affect the rights of any party against the other party in respect of any breach of this Agreement.
8. If any provision in this Agreement is deemed to be, or becomes invalid, illegal, void or unenforceable under applicable laws, such provision will be deemed amended to conform to applicable laws so as to be valid and enforceable, or if it cannot be so amended without materially altering the intention of the parties, it will be deleted, but the validity, legality and enforceability of the remaining provisions of this Agreement shall not be impaired or affected in any way.
9. This Agreement shall be binding upon and run for the benefit of the parties, their successors and permitted assigns.
10. This Agreement constitutes the entire agreement and understanding between the parties with respect to their subject matter, and except as expressly provided, supersedes all prior representations, writings, negotiations or understandings with respect to that subject matter.
11. Every party shall do and execute, or arrange for the doing and executing of, each necessary act, document and thing reasonably within its power to implement this Agreement.
12. A failure to exercise or delay in exercising a right or remedy provided by this Agreement or by law does not constitute a waiver of the right or remedy or a waiver of other rights or remedies. No single or partial exercise of a right or remedy provided by this Agreement or by law prevents further exercise of the right or remedy or the exercise of another right or remedy.
13. This Agreement shall be governed by and construed in accordance with the laws of Belgium and shall be subject to the exclusive jurisdiction of the Belgian courts.

Notices. All notices given by either Party to the other pursuant to this Agreement shall be in writing and may be delivered by pre-paid post, registered courier or by hand to:

	Neiker	***INRAE***
Name		
Title		
Address		
Email		

Any such notice, if so given, shall be deemed to have been served:

13.1.1 if sent by hand, when delivered;

13.1.2 if sent by post or courier, one business day after posting.

14. IN WITNESS THEREOF, the Parties have executed this Agreement as of the dates set forth below

SIGNED AND DELIVERED
AS A DEED by:

Name, Managing director

For and on behalf of:
NEIKER

SIGNED AND DELIVERED
AS A DEED by:

Name, Managing director

For and on behalf of:
INRAE

SCHEDULE 1

Part 1

(Data)

Animal data and phenotypes relating to the execution of Research & Interrogation of Data as part of the Research project SMARTER.

- Data Origin: Farm (anonymised)
- Specie: Dairy Sheep
- Breeds: Red-Faced Manech, Black-Faced Manech, Basco-Béranaise
- Efficiency Related Traits: Milk Yield, Fat Yield and Content, Protein Yield and Content records
- Resilience Related Traits: Longevity, Resistance to Mastitis (Somatic Cells Count)
- Phenotyped Animals/year: 100,000 for MY & longevity ; 20,000 for FY, PY, FC, PC, SCC
- Depth of phenotyping: since 1978 (800,000 females phenotyped for MY)
- Genotyped Animals: 6,500

Part 2

(Purpose)

For the purpose of aggregating the data and performing statistical analysis upon it in order to carry out the research required for the H2020project “Small Ruminants breeding for efficiency and resilience, SMARTER” Grant no. 772787.
Completion of these tasks will involve the dissemination of “Results” obtained from experiments using the Data provided by NEIKER to specified third parties, who are signatories of the Smarter Consortium Agreement.

Part 3

(Term)

This Agreement shall continue in full force and effect from the Effective Date for a period of 3 years unless terminated by either party giving the other party a minimum of 1 months’ notice.

9.2 File format for exchanging data

Pedigree file format

N°	Data	Comment	Example
1	International ID animal	Interbull format	Please see below
2	International ID sire	Interbull format	
3	International ID dam	Interbull format	
4	Birth date		20120425
5	Year of birth	Useless if birth date known	2012
6	Name of animal		
7	Country sending data		FRA
8	National ID animal	Official ID in the country of origin	FR45512540012
9	Animal_ID_alias1	Facultative, if any	CH2507
10	Animal_ID_alias2	Facultative, if any	
11	Animal_ID_alias3	Facultative, if any	
12	National ID sire	Official ID in the country of origin	FR45234290120
13	Sire_ID_alias1	Facultative, if any	CH1247
14	Sire_ID_alias2	Facultative, if any	
15	Sire_ID_alias3	Facultative, if any	

16	National ID dam	Official ID in the country of origin	FR45512520001
17	Dam_ID_alias1	Facultative, if any	
18	Dam_ID_alias2	Facultative, if any	
19	Dam_ID_alias3	Facultative, if any	

Phenotype file format

N°	Data	Comment	Example
1	Trait		MYI
2	Breed of evaluation		MTR
3	Country sending data		FRA
4	International animal ID	Interbull format	
5	Herd/flock	Official ID in the country of origin	FR64124012
6	Dependent variable		345
7	Statistical weight of the performance		1
8	Number (n) of environ-mental effects included in the national model		4
9	Environmental effects recoded (n times)		4 fields (e.g. 245;14;8;67)

Genotype file format

N°	Data	Comment	Example
1	International animal ID	Interbull format	
2	SNP name		OAR1_110509088.1
3	Allele A/B		AB,--

Parameter file format

N°	Data	Comment	Example
1	Trait		MY
2	Breed of evaluation		MTR
3	Country sending data		FRA
4	Trait heritability		30
5	Min. number of obs. per CG		5
6	Maternal genetic effect fitted in the model		N
7	Maternal permanent en-vironmental effect fitted in the model		N
8	Permanent environmen-tal effect fitted in the model		Y

9	Number (n) of environmental effects included in the national model		4
10	Environmental effects recoded (n times)	Name of effect in clear	Flockxyear;mth of lambing;interval btw lambing;parity
11	Type of effects (contemporary group, fixed, covariate, random) (n times)	F, C, R	F;F;F;F