SMARTER – A European project on selection of efficiency and resilience in small ruminants with strong ICAR commitment and implication

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Abstract

SMARTER (SMAll RuminanT breeding for Efficiency and Resilience) is an H2020 EU multi-actor project (number 772787) with a large consortium of 26 academic and non-academic partners from 10 European countries that dominate small ruminant breeding as well as 3 non-European countries. SMARTER is coordinated by Carole Moreno-Romieux from INRA GenPhySE in Toulouse (France). Through its 9 work packages, SMARTER will develop and deploy innovative strategies to improve resilience and efficiency (R&E) related traits in sheep and goats. The outcome of SMARTER will be accurate genomic predictions for R&E traits in different environments for 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 the selection for R&E traits faster and more efficient. SMARTER will also characterise the phenotype and genome of traditional and under-utilised breeds. Finally, SMARTER will propose new breeding strategies that utilise R&E traits and trade-offs and in doing so address economic, social and environmental challenges.

With regards to ICAR, SMARTER will help produce recommendations on the phenotyping strategies for R&E related traits, which will enrich the ICAR guidelines on small ruminants. SMARTER will also build 3 prototypes (meat and dairy sheep, dairy goat) across-country genetic evaluations. This undertaking might result in future routine international evaluations with business model options also developed in the project. Through its phenotyping and evaluation oriented purpose, SMARTER will also help lay the foundations for a European reference center for small ruminants, as mentioned in the European breeding regulation, for which ICAR could be a relevant candidate. Finally, ICAR, along with EAAP, is in charge of the dissemination and exploitation of the result of SMARTER through its vertical network of farm service providers and breeding organisations.

Keywords: small ruminants, sheep, goat, efficiency, resilience, novel phenotypes, international evaluation, genomics.

SMARTER - A European project on selection in small ruminants

What is SMARTER project?

SMARTER stands for "SMAll RuminanTs breeding for Efficiency and Resilience ". It is an H2020 project spanning from November 2018 to October 2022 and coordinated by Carole Moreno-Romieux from INRA in Toulouse (France). This is a multi-actor project with 27 full partners (Figure 1) from 13 countries, of which 10 are European (i.e., UK, France, Italy, Spain, Greece, Ireland, Norway, Switzerland, Rumania, Hungary) all of which dominate the small ruminant breeding sector in the old continent. Half the partners are non-academic. Various stakeholders are also participating in the project.

The core objective of SMARTER is to develop and deploy innovative strategies to improve Resilience and Efficiency (R&E) related traits in sheep and goats. SMARTER will deliver on these objectives by

1. generating and validating novel R&E related traits at a phenotypic and genetic level,

2. improving and developing new genome-based solutions and tools relevant to the data structure and size of small ruminant populations,

3. establishing new breeding and selection strategies for various breeds and environments that consider R&E traits.

Figure 1. Full partners participating to SMARTER.

Which resilience and efficiency traits are studied in SMARTER

SMARTER is based on the following definitions and approaches of resilience and efficiency:

Resilience is defined as the ability of an animal and/or a system to maintain or revert quickly to high production and health status, after a challenge. Nutritional and health challenges will be carried out in SMARTER.

Efficiency in SMARTER is considered as the efficiency of feed resource use by animals. It includes feed efficiency as well as the dynamics of body tissue mobilisation. Focus will be made on the agro-ecological issues and the impact on the environment: competition with human nutrition, water consumption, greenhouse gases emission.

More specifically, the different traits that will be studied are the following:

- **for resilience**: the disease resistance, with particular emphasis on resistance to parasites, foot rot, mastitis; the functional longevity and the lamb survival and embryo mortality. The trade-off between these traits and production traits or feed efficiency and resource allocation will be quantified following a disease or nutritional challenge.

- **for efficiency**: the efficiency and resource allocation with concentrate, but also with hay and grazing. The aim is to detect usable proxies that can be deployed on-farm. Microbiota will be studied to predict digestive efficiency, in particular greenhouse gases emissions. New tools will be tested to measure gaseous emissions.

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, agro-ecological and organic systems). 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 characterise the phenotype and genome of traditional and underutilised breeds. Finally, SMARTER will propose new breeding strategies that utilise R&E traits and trade-offs as well as address 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.

SMARTER is intended to have a substantial impact on the population of small ruminants in Europe and beyond.

Through the involvement of the different countries, SMARTER will directly target 5,000 farmers and 1.5 million ewes or goats and indirectly most of the European sheep and goat industry. High-throughput phenotyping (500,000 animals) and genotyping (70,000 animals) will be used, including existing and newly generated data. Use of genomics is a key point of SMARTER.

Forty-six breeds (19 meat sheep, 13 dairy and 14 goat breeds) from 40 breeding organisations are directly concerned representing 20% of the small ruminant populations of EU. When including all the breeds present in the partners' countries, the impact increases to 70%.

The impact of SMARTER

SMARTER has 10 work packages (Figure 2), 7 research work packages (WP1-WP7), one on dissemination (WP8), one for coordination and management (WP9) and one for ethics requirements (WP10).

WP1 (novel traits to improve resource use efficiency) aims at identifying novel phenotypes related to resource use efficiency, including feed efficiency, the dynamics of body tissue mobilization and methane emissions. Novel phenotypes will be identified by combining existing datasets with new experiments in SMARTER. Experimental

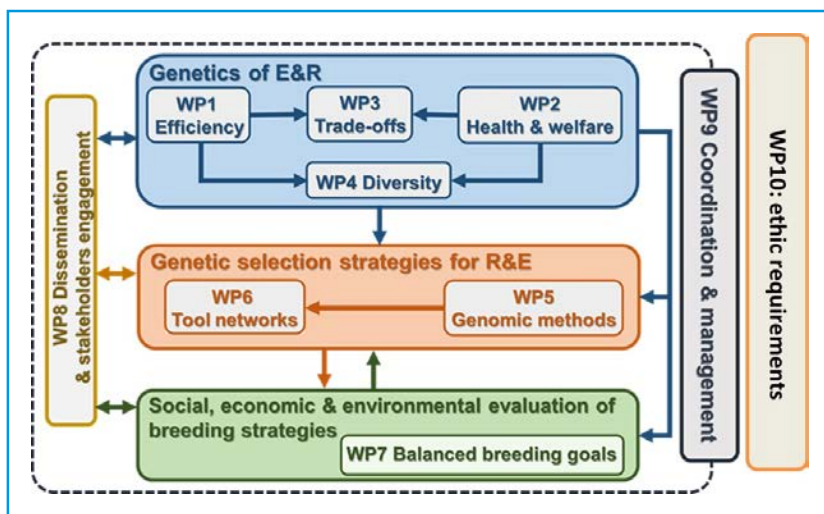**The organization of SMARTER**

Figure 2: Organization of SMARTER project.

populations will be used to measure associated digestive, metabolic and genetic markers. The novel traits selected to be good predictors of efficiency will be measured on commercial farms to estimate genetic variability and quantify possible environments and systems interactions. The results will be applied in trade-off and diversity studies and genomic prediction models in small ruminant populations.

WP2 (novel resilience traits to improve health and welfare) aims at identifying new immunological and phenotypic indicators of resilience/resistance to parasite infections, mastitis and foot rot. These indicators will be quantified in different environments and systems. Measurements will be in tandem with performance indicators measured in the same or related livestock populations including locally-adapted and traditional breeds and crosses of sheep and goats. Lamb survival linked to neonatal lamb vigor scores, and both maternal and lamb behaviors important for maternal-offspring bonding, stress responses, passive immune transfer and new traits for ewe fertility and longevity will be recorded alongside new or existing selection programs.

In both WP1 and WP2, genetic parameters (variance components and correlations will be estimated, as well as the assessment of proxies to be used in on-farm phenotyping. Results from both work packages will be combined to provide evidence for trade-offs. They will also provide data for international collaboration and breeding program development.

WP3 (genetics of trade-offs and synergies between R&E related traits) aims to quantify the trade-offs and synergies between R&E and other production related traits under genetic control. It also aims at identifying the underlying biological mechanisms for R&E and develop prediction models to manage such trade-offs and optimise R&E in challenging conditions. Trade-offs will be identified through i) estimation of genetic correlations and identification of pleiotropic effects in existing datasets and data generated in WP1 and WP2, ii) production and analysis of experimental trade-off data in genetically selected sheep and goats undergoing nutritional and health challenges, iii) modelling trade-offs at the animal and farm levels, and iv) assessment of the effects of host genetics and management on these on resulting R&E related traits.

WP4 (genomic characterisation of hardy or under-utilized breeds' environmental adaptation) aims at quantifying the genetic diversity in hardy and under-utilised breeds and identifying signatures of selection related to the breed adaptation to specific geo-

climatic environments. New and available data on R&E phenotypic and genotypic information on different breeds from partners, from previous projects and other WPs will be used and strategies to combine such heterogeneous data will be developed.

WP5 (genomic/genetic modelling and methods of selection for R&E related traits) aims to characterise novel phenotypes defined in WP1, 2 and 3 using new and historical records from classical longitudinal traits (e.g. milk, growth) and developping genomic methods for specific features of R&E related traits. The benefit of genomic predictions in small ruminants will be enhanced by improving the properties of validation methods and by optimising methods to perform multi-population predictions (across countries or breeds). Novel strategies to manage genetic diversity within schemes using genomic information will be developed.

WP6 (practical selection tools to benefit from international harmonization and cooperation) copes with genetic selection strategies through harmonization and sharing of phenotypes and genotypes to set up an across-countries evaluation. ICAR is committed in this work package which will be described below.

WP7 (balanced breeding goals for agro-ecological resilience) aims to develop balanced breeding goals to help European sheep and goat breeders and farmers transition towards resilient breeding. These balanced breeding goals will come from i) estimating the economic, environmental and social/labor value of resilience and production traits on farms, ii) interviewing farmers and breeders about the type of animals they want and other important issues and; iii) estimating the non-economic value of R&E related traits using choice modelling. WP7 will pull together results from WP1-6 to provide practical breeding solutions (including crossbreeding) for European sheep and goat farmers and breeders (including Uruguayan and Canadian populations).

WP8 (dissemination, training and stakeholder engagement) aims at organising the dissemination and the stakeholders' network. ICAR is committed in this work package which will be described below.

ICAR commitment in SMARTER

ICAR is a full partner of SMARTER and has a strong commitment in the project, especially in the key work packages WP6 (harmonization of phenotypes and across countries evaluation) and WP8 (dissemination and exploitation of the results).

Harmonization of phenotypes and across-countries evaluation

WP6 aims at contributing to faster genetic gain for RandE through improved international cooperation by

1. Formalizing the harmonized recording of phenotypes and genotypes and an international pedigree file.

2. Generating international genetic and genomic evaluations for a selection of RandE related traits.

3. Establishing the necessary structures and procedures to facilitate cooperation in international evaluations.

4. Analyzing the cost-benefit of international genetic/genomic evaluations and cooperation including sensitivity analyses.

5. Using low density chips for genomic selection. This WP6 highlights the international cooperation and its benefice while setting up practical tools for selection. ICAR is fully concerned with all the tasks of this WP.

***Harmonizing the phenotypes**, genotypes and pedigree*. The ICAR Working Group on Sheep, Goats and Small Camelids has in charge the ICAR guidelines dedicated to these species. To-date, the existing sections of the guidelines are section 16 (milk recording in dairy sheep and goats), section 14 (fiber recording traits in alpaca and goat). A section on recording meat and reproduction in small ruminants is under construction. The ambition of SMARTER is to add a brick to these sections by producing recommendations on recording efficiency and resilience in sheep and goats. Such a harmonization is a prerequisite to facilitate future common evaluation

International evaluation. WP6 will assess the feasibility and the benefice of sharing phenotypes, pedigree, and if possible genotypes from different countries to produce an international evaluation. During the project, three pilot studies will be achieved: one in dairy sheep, one in dairy goats and 1 in meat sheep. This task is an exciting challenge because the level of exchanges and connectedness is currently low, the reference population are small, mainly due to higher cost of genotyping in small ruminants relative to value of the animals, and the phenotypes are less precise than in cattle (few if not lack of progeny testing). ICAR will be especially involved in a task that will consist in throwing the basis of future possible routine evaluation. A business plan will be conceived, according to the learning from the pilot studies, but also from surveys targeting farmers and breeding organizations on their willingness to share data for a common benefit. In this respect, Interbull and/or interbeef will be scrutinized with interest to construct such a plan.

Reference center. ICAR is also connected with the reference center topic. SMARTER has the ambition to propose, define and conceive what could be a zootechnical reference center in small ruminants, aligned with the EU regulation on Animal Breeding. In cattle such a EURC has existed since November 2018: it is Interbull who is EURC for performance testing and genetic evaluation in bovine. In small ruminants, ICAR could be this EURC.

The role of ICAR in the dissemination and the exploitation of the results of SMARTER

WP8 aims at optimising and strengthening the impact of innovation on R&E in small ruminants on targeted stakeholders by i) ensuring stakeholder commitment, and encouraging interactions and feedback among partners and other stakeholders ii) maintaining the dissemination plan iii) disseminating the project results to the scientific community and to target stakeholders; iv) training and capacity building for academics and industry and v) enhancing tools to facilitate and deepen the dissemination of the output. This WP will rely on Operational Groups, thematic networks, EAAP and ICAR partners with complementary networks of members and stakeholders. The inclusion of 13 industry partners from the different countries will be an asset to effectively disseminate regionally.

ICAR is co-leader, along with EAAP, of this action on dissemination and stakeholder engagement. ICAR leads 2 tasks. One task consists of organising the network of stakeholders through a stakeholder's platform. The purpose is to chair the dialogue between SMARTER partners and other stakeholders. The ICAR family is part of these stakeholders. ICAR also leads the task on dissemination and training for stakeholders. In this respect, ICAR will organise 2 SMARTER-oriented technical sessions in the 2020 and 2022 ICAR annual meeting. Moreover, 10 out of the 13 SMARTER countries will organise round table sessions in their local language dedicated to national stakeholders interested in the exploitation of the results.

International cooperation is a key factor for a successful selection of small ruminants. Small ruminants are mostly reared in harsh environments where rearing cattle is difficult if not impossible. Despite some breeds that have become international, a large variety of local breeds are still valorized because they display zootechnical adaptation to their specific environment and thus exhibit economic and social benefits. In this context, innovative methods must be developed to maintain or improve the resilience ability of small ruminants, while improving their efficiency. New technologies (genomics, cutting-edge phenotyping methods) and cooperative approaches must help to reach this overall objective.

The role of ICAR is fundamental to succeed in helping achieve this objective:

- by producing recommendations on phenotyping and proposing tools for international evaluation;

- by promoting, disseminating and exploiting these methods and tools through its network of stakeholders producing services to farmers, and by hosting an EU Reference Center on performance testing and genetic evaluation in sheep and goats.

For more information, the website of SMARTER is *www.smarterproject.eu*

Conclusion

ICAR, 2019. ICAR guidelines. Section 16 on Dairy Sheep and Goats. *https://www.icar.org/index.php/icar-recording-guidelines/*

SMARTER Project, 2019. Website *www.smarterproject.eu*

References