SMARTER

SMAll Ruminants breeding for Efficiency and Resilience

Newsletter – Issue 5

© Images Copyright: UPRA Lacaune, AUTH, INRAE, TEXELS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 772787.

Contents

Editorial 2

Meta-analysis of genetic parameters for resilience and efficiency traits in goats and sheep – by S. Mucha, F. Tortereau, A. Doeschl-Wilson, R. Rupp, J Conington 3

Selection on functional longevity in a commercial population translates into significant differences in longevity, and resilience, in a common farm environment - by M. Ithurbide, C. Huau, I. Palhière, T. Fassier, N.C. Friggens, R. Rupp 4

EAAP invited review paper Livestock disease resilience: from individual to herd level - by A. Doeschl-Wilson et al. 5

International Evaluation of Dairy Sheep in Smarter – by A. Legarra 6

Genetic diversity of Saanen and Alpine dairy goat population across four countries – by M. Teissier, C. Robert-Granié, L. F. Brito, H. Larroque 6

International genetic evaluation: a questionnaire to assess the willingness of sheep and goat breeders and organisations in participating in a future routine evaluation - by J.M. Astruc 7

Stakeholders' activities – by C. Mosconi 8

PhD students in SMARTER project: Marie Ithurbide 10

Replacement leadership SMARTER project 10

Editorial

SMARTER is almost at the end of the second period (M36 in October 2021).

Once again, we will have our next annual meeting by video conference because of the COVID crisis. The agenda for the remote SMARTER includes 3-hours meetings per WPs from 11th to 22nd of October and will allow for an overview of the work achieved during the second period. An in depth evaluation of the COVID-19 impact has been achieved at the WP scale. Many experiments and interviews were stopped, or partially reached. Remedial action was taken so that the impact on the overall project would be limited. We have requested an 8 month extension to postpone the end of the project from 31st October 2022 to 30th June 2023. This will allow partners to better consolidate their respective results and provide more time for integrating results obtained by the different groups. As well, an eight month extension would provide a wider opportunity for disseminating and communicating the technical results of WPs (conference, roundtables, stakeholder meeting, website and social media material, etc.). If the request for an 8-month extension is not accepted, the consortium then requests a 6-month extension, which is absolutely necessary to minimise the impacts of covid on the project and to achieve the objectives initially set in the DOA. The extension demand is currently under evaluation by the REA.

Despite the sanitary crisis, many new research results were delivered recently, with 7 papers submitted in 2021. New results were published on feed efficiency in Uruguayan parasite resistance sheep lines (WP1) and on genetic parameters for parasite resistance in Scottish Blackface sheep (WP2). Moreover, this newsletter highlights 3 papers from WP3 with, 1) review on Livestock disease resilience from individual to herd level, 2) a meta-analysis of genetic parameters for resilience and efficiency traits in goats and sheep, and 3) a paper that characterizes resilience in SMARTER experimental longevity goat lines. New methods for maintaining genetic diversity in genetic conservation programmes were proposed (WP5). Progress towards international genetic evaluations (WP6) has been made. Indeed, first analyses of cross-country merged data were achieved for western Pyrenean Dairy Sheep (Spain and France), in Saanen and Alpine goats (Canada, France, Italy, Switzerland). Additionally, a paper on cross-country evaluations for Texel sheep between Ireland and the UK has been published. Moreover, harmonization and wider international cooperation is being promoted by a multi-lingual questionnaire that was widely shared amongst partners. WP4 (genetic diversity) and WP7 (balancing breeding goal) consolidate their data collection and methods before analyses can progress.

The dissemination has been affected by the delays experienced by the project. Such problems were mainly due to the impossibility of travelling to participate in conferences and organizing informative events with major stakeholders. For example, only a remote ICAR Annual Conference in 2021 where a specific SMARTER session was organized. A mixed EAAP Annual Conference in 2021 was organised in August in Davos (Switzerland) where several SMARTER partners presented their work. We hope that the roundtables with stakeholders can take place early 2022 (within each country) as initially planned.

Meta-analysis of genetic parameters for resilience and efficiency traits in goats and sheep – by S. Mucha, F. Tortereau, A. Doeschl-Wilson, R. Rupp, J Conington

Genetic selection focused purely on production traits has proven very successful in improving the productive performance of livestock. However, heightened environmental and infectious disease challenges have raised the need to also improve the resilience of animals to such external stressors, as well as their efficiency in utilizing available resources. A better understanding of the relationship between efficiency and production and health traits is needed to properly account for it in breeding programs and to produce animals that can maintain high production performance in a range of environmental conditions with minimal environmental footprint. The aim of this study was to perform a meta-analysis of genetic parameters for production, efficiency and health traits in sheep and goats. The dataset comprised 963 estimates of heritability and 572 genetic correlations collated from 162 published studies. A three level meta-analysis model was fitted. Pooled heritability estimates for milk production traits ranged between 0.27±0.03 and 0.48±0.13 in dairy goats and between 0.21±0.06 and 0.33±0.07 in dairy sheep. In meat sheep, the heritability of efficiency traits ranged from 0.09±0.02 (prolificacy) up to 0.32±0.14 (residual feed intake). For health traits pooled heritability was 0.07±0.01 (faecal egg count - FEC) and 0.21±0.01 (somatic cell score - SCS) in dairy goats and 0.14±0.04 (FEC) and 0.13±0.02 (SCS) in dairy sheep. In meat sheep, the heritability of disease resistance and survival traits ranged between 0.07±0.02 (mastitis) and 0.50±0.10 (breech strike). Pooled estimates of genetic correlations between resilience and efficiency traits in dairy goats were not significantly different from zero with the exception of SCS and fat content (-0.19±0.01). In dairy sheep only the unfavourable genetic correlation between SCS and protein content (0.12±0.03) was statistically significant. In meat sheep only the correlations between growth and FEC (-0.28±0.11) as well as between growth and dagginess (-0.33±0.13) were statistically significant and favourable. Results of this meta-analysis provide evidence of genetic antagonism between production and health in dairy sheep and goats. This was not observed in meat sheep where most of the pooled estimates had high standard errors and were nonsignificant. Based on the obtained results, it seems feasible to simultaneously improve efficiency and health in addition to production by including the different types of traits in the breeding goal. However, a better understanding of potential trade-offs between these traits would be beneficial. Particularly more studies focused on reproduction and resilience traits linked to the animal's multitrait response to challenges are required. *The study was submitted for publication to Animal.*

© Grivette (Meat Production) - copyright OS ROM

Selection on functional longevity in a commercial population translates into significant differences in longevity, and resilience, in a common farm environment - by M. Ithurbide, C. Huau, I. Palhière, T. Fassier, N.C. Friggens, R. Rupp

The aim of the first article of Marie Ithurbide's PhD (submitted to JDS in august 2021) was to validate the use of functional longevity as an indicator of resilience for selection. To address this question, we created 2 divergent lines of Alpine goats using artificially inseminated bucks with extreme estimated breeding values for functional longevity. A total of 440 goats, 228 in high_LGV and 221 in low_LGV lines, were bred and monitored for 4 years. Health treatments, serum immunoglobulin G concentration in early life, kidding, age and reason of culling were systematically noted. Weight and morphology were monitored. Weight and growth during the first year of life were similar in both goat lines. In contrast, the low longevity goats (low_LGV) received slightly more treatments and had a lower weight during the beginning of first lactation than high longevity goats (high_LGV). The fat to protein ratio was also significantly higher in low_LGV goats during first lactation. A multivariable Cox regression was fitted to the data in order to decipher survival at different stage of life in the two lines. The overall survival of high_LGV goats was significantly better than low_LGV goats (hazard ratio=0.63, CI=0.47;0.86) even after we implemented treatment, growth, serum immunoglobulin concentration during first days of life, difficult kidding and year effect in the model. The line effect was not constant over time: no significant effect was found during the first year and the difference was built after first kidding. This result provides initial evidence that survival at early stage of life or during productive life are under different genetic regulation. Altogether, this monitoring of the goat lines indicated that functional longevity based selection helps to improve resilience by improving survival and reducing the use health treatments and mitigating some indicators of fat mobilization during early lactation. As further characterization of resilience in the longevity line goats, we will analyse their response trajectories to nutritional and infection challenges.

© Alpine goats - Copyright FiBL

EAAP invited review paper Livestock disease resilience: from individual to herd level - by A. Doeschl-Wilson et al.

Infectious diseases are a major threat to the sustainable production of small ruminants and other livestock species. Control efforts, such as vaccination or breeding approaches often target improvements to individual resilience to infections, i.e. they strengthen an animal's ability to cope with infection, rather than preventing infection *per se*. There is increasing evidence for the contribution of non-clinical carriers (animals that become infected and are infectious but do not develop clinical signs) to the overall health and production of livestock populations for a wide range of infectious diseases. Therefore, we strongly advocate a shift of focus from increasing the disease resilience of individual animals to herd disease resilience as the appropriate target for sustainable disease control in livestock. Herd disease resilience not only captures the direct effects of vaccination or host genetics on the health and production performance of individuals, but also the indirect effects on the environmental pathogen load that herd members are exposed to. For diseases primarily caused by infectious pathogens shed by herd members, these indirect effects on herd resilience are mediated both by individual susceptibility to infection and by characteristics (magnitude of infectiousness, duration of infectious period) that influence pathogen shedding from infected individuals. There may be trade-off between these different traits that need to be considered in the context of herd-resilience.
This paper reviews what is currently known about how vaccination and selective breeding affect herd disease resilience and its underlying components, and outline the changes required for improvement. To this purpose, it also seeks to clarify and harmonise the terminology used in the different animal science disciplines to facilitate future collaborative approaches to infectious disease control in livestock. The paper concludes that vaccination and breeding programmes that target improvement of herd disease resilience will lead to more effective control of many infectious diseases in production animals, as they not only reduce the impact of infectious pathogens on the health and production performance of individuals, but also on pathogen transmission.

The review paper has been published in the EAAP commissioned special issue "Sustainable livestock systems for high-producing animals", in the journal Animal Vol. 15, Issue 7, July 2021: Doeschl-Wilson, A., Knap, P. W., Opriessnig, T. & More. "Livestock disease resilience: from individual to herd level", Animal 100286, https://doi.org/10.1016/j.animal.2021.100286. The review contributes to Smarter WP3 (trade-offs) and WP6.

International Evaluation of Dairy Sheep in Smarter – by A. Legarra

We work with two groups of breeds from western Pyrenees, the black-faced (Manech Tête Noire and Latxa Cara Negra from Navarre), and the blond faced (Manech Tête Rousse and Latxa Cara Rubia). These breeds follow separate breeding schemes although with frequent exchanges, in particular in the last 10 years. Therefore, there is an interest of breeders to have a common international evaluation, within either black-faced or blond-faced. The first step involved generating data sets: pedigree, records and markers. Merging pedigree and records was not too difficult. Merging markers involved considerable work because they were generated with two different chips. Then we have done preliminary joint analyses (REML and ssGBLUP) for milk yield – results show high genetic correlation across breeds, but a difficulty in estimating both Latxa and Manech genetic trends simultaneously. Future work will involve deleting old data to simplify analyses.
Work done by Carolina Garcia-Baccino, Jean Michel Astruc, Andrés Legarra, Eva Ugarte and Carolina Pineda-Quiroga.

© Manech tête noire breed - copyright ICAR

© Manech tête noire rousse - copyright OS ROLP

Genetic diversity of Saanen and Alpine dairy goat population across four countries – by M. Teissier, C. Robert-Granié, L. F. Brito, H. Larroque

© Saanen Goats - copyright CAPGENES

In the WP6 of Smarter, the ambition is to study the implementation of an international genomic evaluation in dairy goats. The first studies focused on the analysis of available genomic data shared between 4 countries (Canada, France, Italy, Switzerland) on the two main dairy goat breeds (Alpine and Saanen) in order to estimate genetic connections between populations. After control quality and filtering steps, 9 855 genotyped animals (6 102 Alpine and 3 753 Saanen) on 50 678 SNPs were available. In Alpine, genotypes data were distributed as follows: 13% from Canada, 49% from France, 17% from Italy and 21% from Switzerland. In Saanen, the distribution of genotypes was 24% from Canada, 54% from France, 9% from Italy and 13% from Switzerland. We observed uneven distribution of genotypes over time (between 1997 and 2019), with many females genotyped born between 2008-2009 in France (from a QTL experiment), first genotyped Italian animals born in 2010 only, and in Switzerland genotyped animals were born recently between 2002 and 2013. First populational statistical analyses have been carried out from the genotype

data (consistency of gametic phase, PCA, MAF and linkage disequilibrium analyses, Admixture, ...) to characterize genetic similarity between the eight populations (4 countries x 2 breeds). The results indicate that consistency of gametic phase between France and Italy remains high (>0.7) even for large distances (SNP more than 500kb away); lowest consistencies were observed when comparing Canadian and European genotypes dropping below 0.1 for SNP more than 500kb away for both breeds. Based on PCA results, the Alpine and Saanen are quite different within and between countries with two main groups (Canada versus European), genotypes of French and Italian animals were closed (cf. Figure). LD at 50kb is higher in Canada (0.14 in Alpine and 0.16 in Saanen) than in France (0.13 in both breeds) and lower and quite similar in Italy and Switzerland (0.11). These results are in accordance with weak animal exchanges observed between countries based on pedigrees. France exports animals to all partner countries, but does not import any animals. Canada and Switzerland have imported some animals mainly from France, while Italy has imported more, mainly from France but also from Switzerland. The second study, currently underway, concerns the implementation of multi-country genomic evaluation models (estimation of genetic parameters and genetic correlations). These models are being studied on traits common to the different countries (milk production and type traits).

This work is carried out thanks to data provided by the Smarter project partners in Italy, Canada, Switzerland and France.

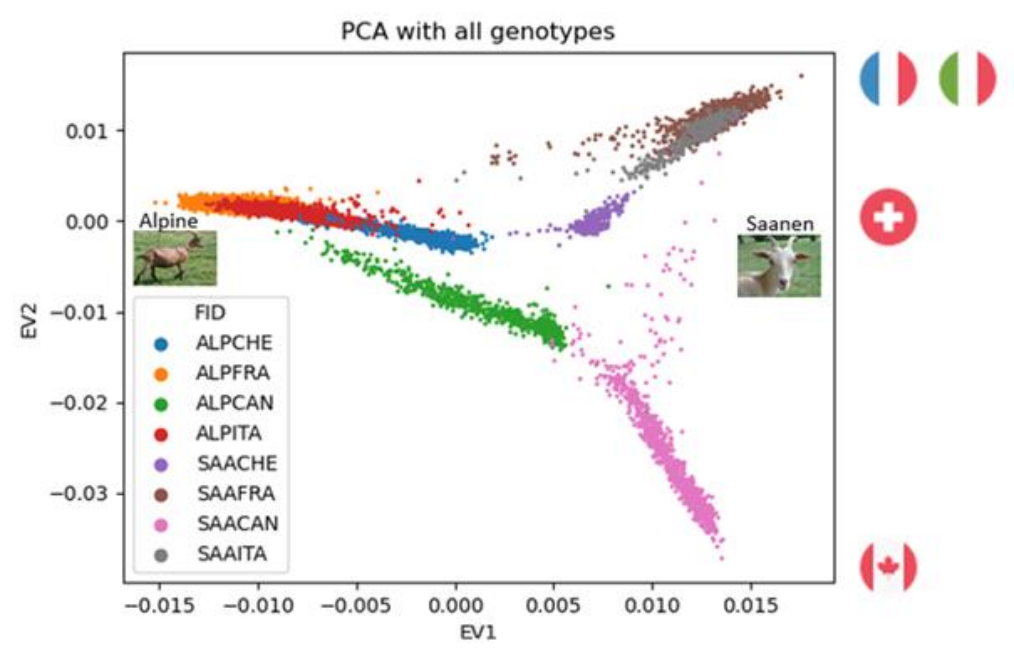

Figure: PCA analysis on Alpine and Saanen genotypes of Canada, France, Italy and Switzerland

International genetic evaluation: a questionnaire to assess the willingness of sheep and goat breeders and organisations in participating in a future routine evaluation - by J.M. Astruc

Work package 6 is dedicated to the development and implementation of practical selection tools to achieve the overarching objective of SMARTER (develop novel and collaborative strategies to improve the resilience and efficiency of the sheep and goat sectors), especially through harmonisation and international cooperation. In order to propose an organisation and business model for a future across country genetic evaluation, a questionnaire has been distributed in early September:

- to assess the willingness of the countries and breeds to participate in the future in routine runs,
- to have an overview of the expectations and concerns that such evaluations should raise,
- to know which breeds would be interested.

This questionnaire, organised by ICAR and the WP6 partners, targets the breeders and organisations of the SMARTER countries, as well as the members of the stakeholders' platform. It is multi-lingual (English, Spanish, French, Italian, German) in order to have a wider participation. Through a large panel of respondents, we aim at having the vision of various stakeholders to strengthen the partners' perspective. The results will be shared with WP7. A first synthesis of the results will be presented during the virtual meeting organised remotely in October.

Stakeholders' activities – by C. Mosconi

In 2021, the dissemination activities for stakeholders will be focused on the ten National Round Tables to be organized in the second part of the year and the first part of 2022. Moreover, during the ICAR Annual Conference a Smarter session was held.

The ten National Round Tables (NRTs)

The programme for the ten National Round Tables has (NRTs) been mostly designed during the summer and can be identified as it follows

- December 2021 in Hungary
- October/December 2021 in UK/Ireland/Norway
- April 2022 in Uruguay
- April 2022 in France
- April/May 2022 in Italy
- April 2022 in Switzerland
- June 2022 in Spain

The scheduled NRD to be held in Greece previously scheduled in October 2021 has been moved since the Zootechnia Exhibition 2021 (30 September - 3 October 2021) in Thessaloniki cannot take place as the Exhibition has been postponed. The partner is examining alternative ways of dissemination activities.

The partners responsible for the organization of the roundtables are:

Country	Partner
France	RACES DE FRANCE
Greece	FRIZARTA
Hungary	UNIDEB
Ireland	TEAGASC
Italy	ARAL
Norway	NSG
Spain	UNILEON
Switzerland	FIBL
UK	SRUC
Uruguay	INIA-UY

Programme of the NRT

A common set of presentations that would be done in each country, including

- A set of presentations focused on main objectives, main (practical) results of the Project.
- A presentation from each WP will be provided (for use as it is or for possible personalization, up to the country to translate). For that target, each WP will prepare a set of 10-12 slides for this common part.
- A custom part adapted to the needs of each country (traits-oriented, evaluation-oriented, breeding goals-oriented …). This is an opportunity to go further in the discussion and to interact with the stakeholders.

List of invited organization

The participants to the NRTs include:

- Sheep and Goat Breeding Organizations and partners (AI centers, breeding centers / stations, recording organizations)
- Sheep and Goat inter-professional organizations
- Stakeholders of the sheep and goat industry: specialized labor unions, cooperatives, merchants, slaughterhouses
- Inter-professional organization for cattle, sheep and goat industries and the stakeholders of the breeding programs.
- Partners of Research and Development Institutes
- Agricultural training institutions and farming high schools involved in sheep and goat breeding
- Specialized newspaper
- Local farmers
- Industry representatives
- PhD Students
- Sheep cooperatives,
- Students and re-searchers

In each NRT, about 50 participants are expected for the 1–2-day meeting.

SMARTER Session at the ICAR 2021 Annual Conference

Organised in April as a remote event, around 520 registrations have been received and a specific Session was reserved to the SMARTER Project.

Chaired by Jean-Michel Astruc, (INRAE), the Session on “Resilience and Efficiency in Small Ruminants” presented five papers:

- Flavie Tortereau - SMARTER – Which novel traits to improve feed efficiency?
- Antonello Carta - Feasibility of a genomic selection approach for gastro-intestinal nematodes resistance based on a female informative population in Sarda breed sheep.
- Mojca Simčič - The variance components estimation for growth traits of kids in Slovenia.
- Jean-Michel Astruc - Selection tools to benefit from international cooperation in small ruminants: a comprehensive work package of the SMARTER project.
- Martin Burke - A stakeholder platform to disseminate results from SMARTER project.

The Abstracts and the Presentations of the whole ICAR Sessions have been made available in the ICAR site (here) while all the videos of the ICAR Sessions have been also integrally available (here). The Proceedings of the ICAR Conference are expected to be published in September and they will be immediately available on the ICAR web site (here).

PhD students in SMARTER project: Marie Ithurbide

Marie Ithurbide (PhD student – INRAE)

Marie became a Doctor of Veterinary Medicine in 2020 at the national veterinary school of Toulouse (ENVT). She completed an M1 in public health at Paul Sabatier University then an M2 in tropical animal disease management (GIMAT) co-supervised by ENVT and CIRAD. This double course allowed her to acquire a transversal knowledge of animal health, livestock farming as well as biostatistics and data analysis. She is working on a thesis titled: "Combining genetic and modelling approaches to develop new non-invasive biomarkers of resilience based on milk metabolites". This PhD thesis is supported by the SMARTER (WP3) and the ApisGene funded project RESILAIT. The supervisors are: Mrs. Rachel Rupp and Mr. Nicolas Friggens.

The thesis

Resilience is the ability of a goat to cope with environmental disturbances, such as pathogens or negative energy balance. To improve resilience through breeding, we need resilience indicators. Recent literature support the assumption considering milk profiles as a potential indicator of resilience (Friggens et al. 2016; Adriaens et al. 2020; Poppe et al. 2020).

The goals of Marie's thesis are:

- Validate the use of milk metabolites as non-invasive biomarkers to characterize resilience.
- Explore the genetic variability of these biomarkers.
- Provide a solid scientific basis for non-invasive biomarkers that could phenotype resilience and could be quickly implemented on farm.

To do so, two divergent lines of goats for functional longevity have been bred since 2017 at INRAE facilities of Bourges. Those goats underwent two days underfeeding challenge during the beginning of their first lactation. In 2021, one month after the underfeeding challenge an infectious challenge based on LPS injection was run. From 5 days before the beginning of the challenges, milk and blood metabolites were monitored for 10 days. Those metabolites are part of several metabolic pathways of interest and their evolutions partly characterize the individual responses to the challenge. We hypothesize that this response is under some same genetic regulation as underlying mechanisms of resilience. If so, a proper modelling of the metabolic pathways should be an indicator of the goat's resilience potential.

Replacement leadership SMARTER project

Because of sudden and severe health problems, Carole Moreno was obliged to withdraw from the leadership of SMARTER. Rachel Rupp (WP3 leader), who is working in the same INRAE lab will take the lead until she comes back. Carole wishes us to carry on united and as enthusiastic as ever and assures us that she will fight back. We wish her a full and quick recovery!

© Lacaune dairy breed flock of Lafage INRAE experimental farm. Copyright INRAE, credit: Charlotte Alain

For more information visit our website: www.smarterproject.eu

Twitter: @SmarterprojectE - Facebook: @smarterproject.eu