SMARTER

SMAll Ruminants breeding for Efficiency and Resilience

Newsletter – Issue 6

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SMARTER Third Annual Meeting! – by R. Rupp

EAAP Newsletter n. 209 where the article appeared on 9th November 2021

SMARTER has held the third annual meeting from 11th to 22nd of October 2021, once again by video conference because of the COVID crisis. The agenda for the remote SMARTER included 3-hours meetings per WPs with 17 to 56 participants each. The meeting gave an overview of the great work achieved during the third year of the project. Despite the sanitary crisis, many new research results were delivered recently, with 7 papers submitted in 2021. New results were presented on proxies and genetic parameters for feed efficiency, feed intake and methane emission (WP1) and for resilience traits (health such as parasite resistance, immune response and mastitis, behavior, well-being, longevity and lethal mutations) (WP2) in sheep and goat. First results from trade-off experiments created in SMARTER (milk production dairy sheep line, goat longevity lines, residual feed efficiency sheep lines) were delivered (WP3). The experiments feed two allocation models in sheep and goat (WP3 and WP7). Additionally, a method for characterising resilience based on short time responses to infection was proposed (WP3). New methods for maintaining genetic diversity in genetic conservation programs were evaluated (WP5). Also, the general use of method LR ("Linear Regression") for evaluating bias and accuracy in small ruminant genetics was endorsed (WP5). International Evaluation in sheep and goats (WP6) has progressed. Indeed, first analyses of across-country merged data were achieved in western Pyrenean Dairy Sheep (Spain and France) and in Saanen and Alpine goats (Canada, France, Italy, Switzerland). Moreover, harmonization and wider international cooperation is being promoted by multi-lingual questionnaire that were widely shared among partners. WP4 (genetic diversity) and WP7 (balancing breeding goal) consolidate their data collection and methods before analyses can progress. Several of the new results were presented during the EAAP meeting in Davos. Five theatre presentations and two posters were undertaken by four SMARTER partners (INRAE, INIA-UY, AUTH and FiBL/QUALITAS…) All the presentations will be available on SMARTER website.

The majority of SMARTER Consortium agreed to ask for an 8-month extension (end June 2023) to allow partners to better consolidate and integrate results that were delayed because of the COVID-19 crisis. We hope that the roundtables with stakeholders (WP9) can take place in 2022 (within each country) as initially planned, as well as a face-to-face meeting in Leon before summer.

REA 2nd Review Meeting Outcome – by R. Rupp and R. Bica

The second review meeting with REA was held on the 28/01/22. The meeting was moderated by Francisca Cuesta-Sanchez of the European Commission, and the two reviewers were Luca Fontanesi and Ismo Stranden.

The review started off with a brief introduction of the project and recap of what was done in RP1 and in the most recent RP2. This was done by Project Coordinator Rachel Rupp and was then followed by 20-minute presentations from each Work Package (WP) leader, detailing what has been done in their individual work packages, what is still to be done and the achieved milestones/deliverables.

Regarding the ongoing sanitary crisis and how that was assessed in the meeting, there were several WP's that were affected more than others due to the nature of the work undertaken (more practical vs more computer based). This was mainly observed in WP's 1 and 2 in which much of the practical work had to be postponed, however with the approved extension of the project deadline to June 2023 everything is still set to be completed on time.

Overall, the meeting was a success, with positive feedback both by Francisca Cuesta-Sanchez and the two reviewers. The main discussion points of the review were the following:

- Every WP needs to ensure that what they are doing is in line with the original submitted DOA, as some inconsistences were noted, and deviation from the original plan may need to be carefully explained.
- For WP1 and WP2, reviewers highlighted the high number of phenotypes, the diversity of datasets and experiments with low numbers at times. They raised the possibility of focusing more specifically on a few key selected phenotypes/populations.
- More and improved cooperation between and within WP's has been requested to ensure that we are all working together to achieve a common goal.
- Practical WP's need to ensure that their original suggested objectives are still achievable under the current conditions, and whether it is worth altering their schedule. As the reviewers pointed out that this may be necessary to ensure the completion of the project by June 2023.
- Each new change made should always keep in mind the final objective of the SMARTER project to ensure that, especially for the upcoming RP3, the approval of the changes by the European Commission is a straight forward and quick process.

The priority now will be to work on the amendments requested from RP2, which will feed into the completion of RP3, which is scheduled for September 2022.

Eghoria goats - © AUTH

Boutsko sheeps - © AUTH

SMARTER participation to World Congress on Genetics Applied to Livestock Production (WCGALP 2022)

Several SMARTER partners will participate to the World Congress on Genetics Applied to Livestock Production will be held in Rotterdam (The Netherlands) from 3 to 8 July 2022. Here the list of all the contributors.

Some of the studies that have been submitted:

1. ***Validation and genetic analysis of a feed efficiency criterion in French Lacaune ewes – by C. Machefert, C. Robert-Granié, P. Hassoun, S. Parisot, C. Allain, D. Portes, G. Lagriffoul, J.M Astruc, and H. Larroque***

Improving feed efficiency have environmental, economic and social benefits for dairy ewes farming systems. Selection of animals using efficiently their feed resources while maintaining a quality milk production is therefore a major objective for breeders. However, phenotyping feed efficiency remains difficult to achieve on-farm on a large scale. Indeed, it required individual performances as milk production and its components, body weight, body condition score and feed intake. The objective of our study was to propose a new criterion to approximate feed conversion ratio (FCR) of lactating ewes in a collective feeding context of commercial farms named lactation feed conversion ratio (LFCR). LFCR is the ratio between energy lactation requirements and energy inputs used to produce milk from feed and body reserves.

First, accuracy of this criterion was evaluated on experimental data (70 lactations of Lacaune ewes obtained in the European iSAGE project) with precise phenotypes including individual feed intake. The effect of replacing individual data with batch average data for each of the LFCR components could thus be evaluated. The lack of individual feed intake has the most impact on LFCR and can leads to reclassification of ewes. In this case, the coefficient of determination (R^2) between the LFCRs, with or without individual data, was 0.37 and the root mean square error was 0.21. Then, the LFCR trait was applied to 6 test-days (TD) from 6425 lactations of Lacaune ewes from 8 production farms that were monitoring during two dairy years in the framework of Smarter project. In these conditions, this feed efficiency trait presented a low heritability (0.12 ±0.02) and a strong genetic correlation with the daily milk yield (0.80 ±0.03). Estimation of variance components for each TD showed that heritability and repeatability of this trait seemed to be lower at the beginning than at the end of lactation (Table 1).

Table 1. Heritabilities and repeatability of LFCR calculated at each test-day.

	TD 1	TD 2	TD 3	TD4	TD 5	TD 6
Heritability (± SE)	0.07 (± 0.02)	0.11 (± 0.02)	0.11 (± 0.02)	0.12 (± 0.02)	0.12 (± 0.03)	0.20 (± 0.03)
Repeatability	0.26	0.28	0.28	0.29	0.35	0.40

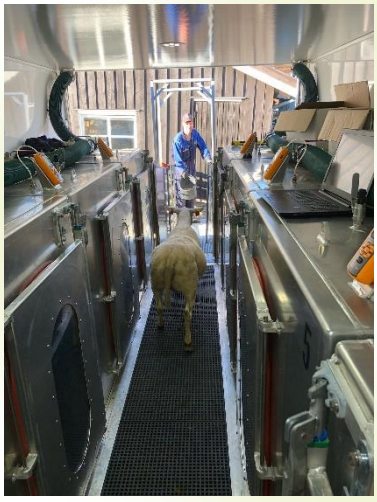
It has been shown that selecting a population on a ratio is difficult to implement because of the difficulty to predict the response to selection of ratio traits. However, our criterion can be measurable on commercial farms, and reflects an overall feed efficiency of ewe in a collective feeding context.

2. *Methane emission has low genetic correlations to lamb growth traits in Norwegian White sheep – by J.H. Jakobsen, T. Blichfeldt, L.B. Linneflaatten, M.O. Gløersen, L.E. Wallin and J.C. McEwan*

Norwegian white sheep – Photo: Jette Jakobsen © NSG

The main source of GHG emission in lamb meat production comes from enteric methane (CH_4) emission produced as a by-product in the non-aerobic fermentation of feed. Other countries have shown that enteric CH_4 emission is heritable in sheep and in cattle. Breeding is thus a mitigation option and including CH_4 emission as a trait in the breeding goal will result in a cumulative and permanent reduction in the national GHG emission from lamb meat production. Inclusion of CH_4 reduction into the breeding goal requires knowledge of correlations to other traits in the genetic evaluation. The aim of the current study was to investigate the heritability of CH_4 in Norwegian White sheep and to compute the genetic correlations to direct and maternal genetic effect of 42-day and 140-day weights.

Fifty-minute CH_4 emissions were measured in portable accumulation chambers (PAC) on 4,534 Norwegian White mixed age ewes from 44 breeding flocks and expressed as grams per hour. Liveweight at PAC measurement was also recorded. Ten years of observations for the lamb growth traits 42-day and 140-day weights were extracted from the Sheep Recording Database along with the corresponding pedigrees. Heritabilities and direct and maternal genetic correlations were estimated for liveweight adjusted CH_4 and the lamb growth traits. The heritability for liveweight adjusted CH_4 was 0.17, and heritabilities for the growth traits were in the range 0.07 to 0.13. The genetic correlation between liveweight adjusted CH_4 and maternal genetic effect of 42-day weight was 0.32 and significantly different from zero, while other correlations between CH_4 and growth were non-significant.



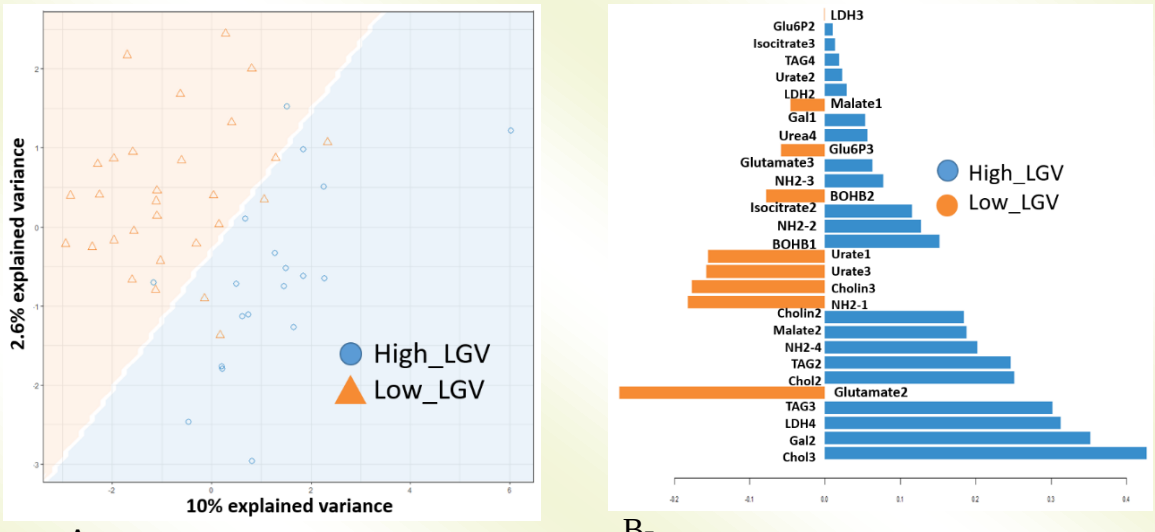
The PAC equipment inside the truck. An ewe is getting treat to exit after measurement. Photo: Lars-Bjarne Linneflaatten, © NSG

The truck used for the measurements. Photo: Martin Gløersen, © NSG

Based on this study, including liveweight adjusted PAC CH_4 emission into the breeding goal for Norwegian White sheep imply a reduction in the CH_4 conversion factor Ym (% of gross energy intake partitioned into CH_4) and as such also the national emissions, given no additional feed stuffs are grown or imported. However, based on the antagonistic genetic correlations to maternal genetic effect of 42-day weight selection solely for reduced methane emission would result in a decrease in the maternal effect on lamb growth during main suckling period. This antagonistic relation should therefore be handled carefully when including methane emission in the breeding goal via appropriate weighting in the overall selection index.

3. *Milk metabolite profiles in goats selected for longevity support link between resource allocation and resilience – by M. Ithurbide, H. Wang, C. Huau, I. Palhière, T. Fassier, J. Pires, T. Larsen, J. Cao, N.C. Friggens and R. Rupp*

Resilience is the ability of a goat to cope with environmental disturbances, such as pathogens or feed restriction. Genetic selection on resilience remains a challenge. Because resilience translates into enhanced functional longevity, we created two lines of Alpine goats using hyper-selected bucks with the most extreme estimated breeding values for functional longevity (high-LGV and low_LGV). In the present study, we explored the evolution of metabolic pathways related with lipomobilisation during feed restriction among goats selected for extreme functional longevity. Accordingly, an experiment was carried out in which time-series measurements of 14 milk metabolites were made in dairy goats exposed to an underfeeding challenge during early lactation. The aim of this study was to validate the use of milk metabolites as an indicator of resilience. The first step of the article was to compare survival and resilience indicators of the two lines of goats. Weight and growth during the first year of life were similar in both goat lines. In contrast, the low_LGV goats had a lower weight during the beginning of first lactation than high_LGV goats. The milk fat to protein ratio was also significantly higher in low_LGV goats during first lactation. The overall survival (from birth to death) of high_LGV goats was significantly greater than low_LGV goats. The line effect was not constant over time: no significant effect was found during the first year of life and the difference emerged after first kidding. These results support the hypothesis that the two lines of goats present different resilience levels and that this may be linked to different resource allocation profiles between lines. We characterized the 14 milk metabolite profiles upon challenge using a functional PCA (fPCA) for each milk metabolite. The daily concentration of each metabolite during the whole challenge period was included in the fPCA. Each individual milk metabolite curve was then characterized by a PCscore for each component. Between 2 and 4 components were required to explain at least 80% of variation resulting in 50 variables per goats. We then used Sparse PLS-Discriminant Analysis (sPLS-DA) to evaluate the ability of milk metabolites to distinguish the longevity lines. The method integrated a continuous data matrix comprising the individual PCscores and a categorical outcome variable: the line of the goat (high/low_LGV). The balanced error rate estimated for the model was 30.2% (respectively 30.0 and 30.3 for low_LGV and high_LGV lines). As shown in Figure 1 the most discriminating parameters between lines were Chol3, Gal2, LDH4, and TAG3. These results indicate that differences in functional longevity, which are seemingly due to differences in resilience, can be detected from milk metabolite responses to a short-term underfeeding challenge. Further, this preliminary analysis suggests that the physiological mechanisms underpinning differences in resilience are related in part to lipid metabolism.



A- B-

Figure 1. A- Sample plot from the sPLS-DA applied to the fPCscores of milk metabolites to discriminate lines of goats for functional longevity. B- Loading plot from the sPLS-DA. Colors indicates the line in which the median is maximum for each fPCscore.

4. *Using machine learning to predict feed intakes of meat sheep from animal traits and ruminal microbiota – by Q. Le Graverand, C. Marie-Etancelin, J.L. Weisbecker, A. Meynadier, D. Marcon, F. Tortereau*

To our knowledge, there is no comparison between accuracies of feed intake predictions from animal traits or microbiota with machine learning. Goals of our study were to check whether microbial information improves feed intake predictions, and to assess if a genetic selection is feasible with machine learning predictions.

Overall, 277 Romane male lambs were reared between 2018 and 2020, and fed concentrates. Average Daily Feed Intakes (ADFI) of lambs were computed from records between 12 and 18 weeks of age. Rumen fluids were sampled at the end of ADFI recording period to be sequenced for the 16S rRNA gene.

Three approaches were carried out to predict phenotypic ADFI: sparse Partial Least Squares (sPLSR), support vector (SVR) and random forest (RFR) regressions. Different predictor sets were considered: animal traits (body weights, growth traits and body composition), or rumen microbiota compositions (adjusted and transformed abundances). Those two predictor sets were used separately or combined. Successively, animals of two different years were used as training/validation sets. Lambs of the remaining year were used as a testing set in order to assess the accuracy of predictions. Estimated Breeding Values (EBVs) of predicted and actual ADFI were computed with PEST and a pedigree of 4,102 animals (including 277 records). Depending on the year considered as the "testing set", predicted ADFI represented 73 to 101 of the 277 records used for the genetic evaluation.

When it comes to predict ADFI phenotypes, there was no significant difference between sPLSR, SVR and RFR accuracies whatever the testing set or the predictors. Correlations between actual and predicted ADFI were always lower with microbiota predictors only ($R_{Pearson}$ ranging between -0.11 and 0.35), compared to predictions with animal traits (0.71 to 0.82). Combining animal traits and 16S data together as predictors never improved correlations significantly. High correlations could be achieved between EBVs of actual ADFI and predictions from animal traits ($R_{Pearson}$ ranging between 0.62 to 0.86). With one testing set, SVR underperformed compared to sPLSR, while RFR had intermediate values.

Our results do not advocate for the use of metabarcoding data to predict feed intake phenotypes. However, the microbiota composition could be more relevant when one is trying to predict feed efficiency. Correlations between EBVs of predicted and actual ADFI suggests that predictions could be used for genetic selection. Further research in the phenotyping strategy should be carried out such as the number of records, or whether contemporaneous animals should be present in the testing and training sets.

Romane sheeps – © INRAE

National Round Tables – by C. Mosconi

Ten National Round Tables will be organised in 2022. Here below the scheduled new dates:

1. France: 5-6 April 2022. Possible location: Vendée (OS Moutons Vendéens)
2. Greece: July 2022.
3. Hungary: probably mid-April 2022
4. Italy: June 2022
5. Spain: 6-7-8 June 2022
6. Switzerland: 30 April 2022.
7. Uruguay: 21-22 April 2022 in Tacuarembó (400 km north of Montevideo)

Dates still to be decided:

- Ireland
- Norway
- UK

New members in SMARTER project: Riccardo Bica

Riccardo Bica (European Project Manager– INRAE)

Riccardo obtained his PhD, funded by SRUC, at the University of Edinburgh/SRUC in June 2021, with Richard Dewhurst as his supervisor. Prior to that he undertook a BSc in Biology at the University of Brighton and subsequently an MSc in Ecosystem Services at the University of Edinburgh. Following his PhD, he started a short 3-month Research Assistant role within SRUC. Throughout these experiences Riccardo developed his interests in fields relating to climate change and environmental studies. As Project Manager, alongside Project Coordinator Rachel Rupp, he is now helping with the coordination of the SMARTER project as of 15/01/2022. The tasks he is currently working on are the organisation of the national round tables as well as contributing to achieving milestones and deliverables outlined in the project.

PhD Thesis

Riccardo's thesis was entitled "Short-term measurements and proxies for ruminant methane emissions". It focused on modelling rumen metabolites under different scenarios which led to reduced methane emissions, such as concentrate vs forage diets, legumes vs grass diets and using methane inhibitors, to see if the metabolite concentrations in the rumen could accurately predict the methane emissions. Throughout his PhD, he also spent one year in New Zealand at AgResearch working with David Pacheco looking at in vitro direct methane inhibition with a methane inhibitor. He also published two papers, one of which is fully published, and the other has recently been accepted.

- Nuclear Magnetic Resonance to Detect Rumen Metabolites Associated with Enteric Methane Emissions from Beef Cattle, Scientific Reports, 2020.
- Methane Emissions and Rumen Metabolite Concentrations in Cattle Fed Two Different Silages, Scientific Reports, 2021. (accepted by Scientific Reports).

He is also collaborating alongside the partners he worked with in New Zealand to publish the work he undertook there. Despite the fact that this is a new role and a new experience, he looks forward to contributing in the successful completion of the project.

Coming events

List of the upcoming events with SMARTER project partners attendance.

Event	Date	Location	Partners
ICAR Annual Conference	30 May – 3 June 2022	Montreal, Canada	IDELE
World Congress on Genetics Applied to Livestock Production	3 – 8 July 2022	Rotterdam, The Netherlands	INRAE, NSG, INIA-UY, UNILEON, CNR, SRUC, IDELE, CAPGENES,
EAAP Annual Meeting 2022	5 -9 September 2022	Porto, Portugal	INRAE, AUTH, INIA-UY

Manech Tête Rousse (Milk Production) - Copyright JM Astruc

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