

SMARTER

SMALL Ruminants breeding for Efficiency and Resilience

Newsletter – Issue 2



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SMARTER 1st Annual Meeting, 26-29th November 2019

The 1st SMARTER annual meeting took place on 26-29th November 2019 and was hosted in Edinburgh, Scotland, by the Roslin Institute of the University of Edinburgh. The meeting brought together 76 participants representing the 27 partners and 16 different stakeholder's organizations involved in the project.

On 26th November the meeting began with a warm welcome introduction by Roslin Institute and SRUC, followed by a general report by the coordinator, Carole Moreno on the situation of the project at the end of its first year, and a factual report by the project manager on the project key dates for the 2nd year.

- A plenary session was organized then in order to present to everybody an update on the situation and the progress of each of the different work packages of the project.
- In parallel 8 posters were stuck up at the Roslin Institute and presented again during the social dinner, concerning the first important results (see below the reports of the different WPs) and different questions which the task leaders wished to underline (such as the open access issue, and the CDB Fitter Livestock Farming).
- Then workshops were organized during the afternoon of the 1st day and the morning of the 27th November to give the participants time for involvement in the strategies of each work package. The main results of these workshops were a planning of the tasks to be conducted during the second year of the project, and a better identification of the interactions between tasks and WPs at this stage of the project.
- The main part of the afternoon of the 2nd day was devoted to 3 hours meeting with the stakeholders of the sheep and goat sector which are closely associated to the development of the project, in order to make it known and to integrate their needs and advices in SMARTER. 16 stakeholders took part to this meeting, in face to face or on remote by video-conference.



- It was followed by a two-days sheep and goats farms visits on 28th and 29th November organized to give the opportunity to the attendees of the 1st AM to learn about breeding practices in the UK and the breeders needs (see the reports below).



Reports on the different WPs

WP1: Novel traits to improve resource use efficiency

The main objective of WP1 is to understand the genetic basis of the complex trait "feed efficiency" in small ruminants. With this aim in mind, tasks have been divided into four different groups: (i) identification and characterization of novel phenotypes related to feed efficiency; (ii) analysis of the genetic determinism of feed efficiency; (iii) genetic correlations between phenotypes and production traits; (iv) quantification of the extent of genotype-by-environment (GxE) interactions for feed efficiency. Within WP1, there are 11 partners articulated in six working groups, from six different countries, that will contribute to the fulfilment of the objectives. During this first period, the first year, the partners have started to measure feed efficiency and biomarkers in the experimental populations. These populations comprise milk ewes (Assaf, Lacaune, Chios, Frizarta), meat/wool ewes (Romaine, Texel, Norwegian white, Merino and Corriedale), and milk goats (Alpina and Saanen). Residual feed intake (RFI), which is the primary measure of feed efficiency, will be calculated after measuring individual feed intake and productive traits (milk yield, weight gain...) in the experimental populations. Concerning novel biomarkers, these include metabolites linked to feed efficiency, analysis of rumen metagenome for deciphering its role in feed efficiency, measurement of greenhouse gases emissions in animals with different degree of efficiency, and gene expression analysis in various tissues. In the coming years, the most promising predictors of feed efficiency will be validated in commercial farms to identify future phenotypes for improving feed efficiency in small ruminants by genetic means.

WP2: Novel resilience traits to improve health and welfare

The Health and Welfare workpackage of SMARTER aims to identify new traits that have the potential to be integrated into new breeding programmes for sheep and goats. By including new measures of health and welfare into commercial environments, we will ensure that we will not omit a key step which is often missing from research studies. This step is crucial to our results, whilst providing confidence among stakeholders that the results are robust for different breeds and environments. We have already measured more than 8000 records of very detailed health traits in dairy goats in Greece (Eghoria, Skopelos and Damascus) as well as aspects of udder



health and parasite resistance. Similarly, the genetic background to parasites (nematodirus, strongyles and coccidiosis) along with key immunological measures from Scottish Blackface sheep in the UK have been reported along with the genetic associations among these. This is expected to be undertaken for French sheep and Swiss dairy goats during the project so that we can collectively determine novel phenotypes linked to disease. New behavioural measures for early life are being developed by French scientists to determine predictors of later productive and reproductive success. Linking other influences on early life such as parasite burden and body condition score as predictors of lifetime resilience will ensure that more efficient aspects of maternal performance and disease resistance are considered for inclusion as new breeding goals for sheep and goat production.

WP3: Genetics of trade-offs and synergies between resilience and efficiency related traits

The aim of WP3 is to identify trade-offs and synergies between resilience and efficiency and other production related traits under genetic control. We also aim to identify the underlying biological mechanisms for resilience and efficiency and develop prediction models to manage such trade-offs and optimise resilience and efficiency in challenging conditions.

During the first year, we collated over 1100 genetic parameter estimates (heritabilities and correlation between efficiency and resilience traits). Data came from 13 partners and 14 datasets in 23 populations of meat sheep (Scottish Blackface, Lley, Dorset, Texel, Romane, Blanc du Massif Central, Corriedale, Merino), dairy sheep (Sarda, Manech, Churra, Lacaune) and goat (Alpine, Saanen, Yorkshire composite). By analysing these data, we expect to have a good overview of trade-offs and synergies under genetic control.

During the first period, INRA and UELEON also started to produce four experimental data to better understand the biological mechanisms underlying those trade-offs and synergies and how they affect resilience and efficiency. UELEON creates lines of Assaf sheep selected for high and low milk production. INRA creates lines of Romane sheep selected for high and low resistance to gastro-intestinal parasite. In the same breed they create lines based on high and low feed efficiency. Regarding goats, INRA creates lines divergently selected for functional longevity in the Alpine breed. These animals will undergo nutritional and infection challenges.

Using the experimental data generated, UEDIN and INRA developed a data-driven mechanistic host-pathogen interaction model for gastro-intestinal parasite infections in sheep. The first application of the model is to determine energy costs associated with immune – production trade-offs. The model will then be extended at a population level to integrate genetic variation in its key underlying parameter. Finally, work has started on adapting and extending a resource allocation model to allow it to simulate the impact of nutritional challenges on performance trajectories and trade-offs between life functions. This has included two main developments: relative contribution of acquisition and allocation of resource to the response to nutritional challenge and, second, the quantification of individual variation in response-recovery profiles in dairy goats.

WP4: Genomic characterization of hardy or underutilized breeds' environmental adaptation using existing and newly generated data

The goal of the WP is to contribute to unravel the genetic bases for the adaptation of hardy and underutilized small ruminants populations by combining newly generated datasets with existing public data. The approaches that will be taken are aimed at contrasting the genetic make up of populations thriving in different environments with the objective to pinpoint genomic regions that can be linked to their specific adaptation. This can inform on the relevant metabolic pathways that are leveraged to confer resilience and robustness to hardy breeds. During this first year, the selection of breeds and populations to be collected and genotyped during the project have been performed and the relevant publicly available genetic data identified. The next steps will be to set up the IT infrastructure to host the data so that they can be available for a global analysis that will begin during the second year of the project.



WP5: Genomic/genetic modelling and methods of selection for resilient and efficiency traits

The goal of the WP is to develop and test new tools, methods and breeding strategies which better suit the characteristic of the phenotypes identified as indicators of resilience and efficiency in sheep and goats. This will be done using simulation and real data analysis. Research activities within this WP in the first year of the project have increased the theoretical understanding to improve genomic prediction schemes. A method for identifying and quantifying any potential bias in the prediction has been developed, and an approach to better integrate pedigree and genomic information using metafounders has been proposed. A study has been carried out to optimise the genotyping strategies to increase the genetic gain when using ssGBLUP. Works on the identifications of event of environmental challenges are under way as well as the development and testing of methods to account for GxE with the aim to develop optimum strategies for selecting for resilience. Finally, the impact of inbreeding depression on reproduction traits are being carried out. The results from this WP will be used in other WP such as WP6.

WP6: Practical selection tools to benefit from international cooperation

WP6 aims at contributing to faster genetic progress for resilience and efficiency traits in sheep and goats through harmonisation and improved international cooperation. The following lines emphasize the achievements in the first year of SMARTER:

Descriptions of breeding programs and genetic/genomic evaluations in SMARTER countries have been gathered. A presentation will be done in EAAP Porto and a paper is in preparation.

Harmonisation of formats for exchanging pedigree, phenotypes and genotypes is adopted. A codification of breeds of small ruminants has been initiated.

Most of the agreements to share data for across country evaluation have been signed.

A visit to Interbull centre in May 2019 was a starting point for a further conception of a business & operation model to possibly establish routine international evaluations in the future.

Summary genotype data have been shared from multiple meat sheep breeds in multiple countries. These data include the type of SNP-chip used and the minor allele frequency. Such information will be useful in quantifying the informativeness of different SNPs in each breed and country facilitating a more optimal design of a pan-European SNP chip for meat sheep. Coupled with the same knowledge in dairy sheep, a potential optimally designed SNP-chip for both meat and dairy sheep can be generated.

Examination of the extent of connectedness in sheep between countries is underway. Between Ireland and the UK for example, there are 3,511 Texel sheep with progeny in both countries; the corresponding number for Suffolk and Charollais are 765 and 324, respectively. While the estimated genetic correlations between the same trait in both countries in Texel varies per trait, most are around 0.60 to 0.70.

Algorithms on the approaches to quantify the benefit in genetic gain from the cross-border transfer of germplasm is underway.



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WP7 plan: from Surveys to limited case-studies the choice of the consistency!

During the annual meeting, all WP7 participants had the opportunity of have interesting exchanges to build and update the works of WP7. The various WP partners represent 5 countries (Greece, France, Italy, Spain, Uruguay) and 15 breeds of sheep and goat. The objectives of the WP7 is to develop balanced breeding goals to support European sheep and goat breeders and farmers in the transition towards resilient breeding. The WP propose to combine two types of approaches, on one hand modelling approach and on other hand comprehensive approach. Modelling approach will simulate both (i) the impacts of new resilience and efficiency traits, (ii) the preferences of farmers and breeders in choosing these traits. A comprehensive approach will aim to identify and analyse the expectations and preferences of breeders and farmers. The four tasks of WP7 must be linked to be relevant. Although this WP requires a lot of data to use different models and methods (Optimization model, Mathematical programming model, Collective design of breeding strategies, Individual farmer's interviews of traits preferences, Life-Cycle Assessment, Choice modelling, Modelling of Balancing breeding goals, ...). Not all



the methods can be implemented for all the cases of breeds and systems. To this end, during the workshop, we acted on the need for consistency in the choice of sheep or goat systems combining the features of breeds and countries, with the challenge of choosing a combination that includes agroecological transition objectives.

The general organisation of the cases studied is a bottleneck, which combine a large number of surveys for all breeds in each of the five countries and a limited number of case studies for a few

illustrative examples in each of the five countries. The next weeks will permit to define these combinations to identify the more illustrative case-studies.

WP8: Dissemination, training and stakeholder's engagement

WP8 is structured in 4 tasks: Task 8.1: Stakeholders' engagement, Tasks 8.2 & 8.3: Dissemination and training for scientific community, & for stakeholders, Task 8.4: Dissemination tools. During the 1st year only tasks 8.1 and 8.4 have been handled, the two others will be addressed at the end of the project. For 8.1, the Plan for the dissemination of the results has been finalized, a stakeholder's platform has been created (gathering 28 different stakeholders), and the 1st stakeholders meeting has been organized during the annual meeting in Edinburgh. For the moment the stakeholders engagement has proved to be a success: a real interest seems to exist among stakeholders for the questions on which Smarter focuses: rusticity, resilience, food efficiency and agroecology, they seem to share several concerns with the project and wonder whether the project might influence and change the orientations of the breeding schemes among the producers during the next years. As regards the building of communication and dissemination tools, the main achievements during the first year are: the creation of SMARTER's website, the development of SMARTER graphic identity and communication package (logo, ppt template, poster and leaflet), the creation of Facebook and Twitter accounts, and the publication of the two first issues of SMARTER Newsletter.

Identification and selection of the stakeholders, and their first meeting with the partners of Smarter

1.1 Identification and selection of the Stakeholders

For selecting the most appropriate stakeholders, two surveys (for national and trans-national stakeholders) have been carried out among the partners of the project, having each of them the chance to indicate three stakeholders in each survey. Following the indications received, an attempt of keeping a wider composition has been tried for preventing overlapping of stakeholders with similar activities and keeping the broadest composition as possible, balancing private and public sectors and keeping a diversification in the its composition

considering academics, research bodies, breeding organisations, research and technology companies, dairy industries, interprofessional organisations, private companies involved in the different chain of the animal sector (feeding, genetics and health), both for sheep and goats. The result of this effort brought to the identification of 28 stakeholders whose list is available [on the website](#).

1.2 First meeting of the stakeholders with the WPs

The recent meeting in Edinburgh (26-28 November) had a specific session organised with the stakeholders to develop a primary contact with them, introduce their Organisations to the WP Partners and collect their first views beneficial to the management of the project. Such meeting has been the best opportunity to foster positive associations and interactions for the creation of a network able of keeping a uniqueness of the project but also to approaching innovation through a multi-expertise vision. The afternoon of 27 November was entirely dedicated to a meeting of the stakeholders with the partners where each of stakeholders had the chance to introduce their respective organisation and to list the expectation that they have for the wished outcomes of the project. Some elements have been clearly mentioned by many of them making such themes an agreed demand of the stakeholders. These, include:

- A higher productivity of the sheep and goat sector, primarily from an efficiency point of view but also environmentally and economically sustainable.
- A unique system for the international genetic evaluations that would improve the efficacy of the genetic improvement programmes (International comparable breeding values).
- Improved genetic elements for the milk and meat production, their quality and composition, both in sheep and goats.
- Establishment of long-terms relations between breeders and research.
- The development of an international network for sharing ovine and caprine genetic information and experiences with different and local breeds.
- The incorporation of new genetic traits in breeding programmes such as health traits, reproductive traits and feed efficiency, to be achieved by the improvement of traits for longevity, rusticity and resilience.

The use of genomics, accomplished to genetic improvement programmes was broadly suggested by many stakeholders as a major outcome of the Smarter

Report on the farm visits

- **28th November: SMARTER tour in the Highlands: discovery of SRUC hill sheep farming at Kirkton & Auchtertyre farm, Scotland (SRUC is a partner of SMARTER)**

After 2 busy days of SMARTER meetings at the Roslin Institute, one of the 2 field tours was organized in the region of the Trossachs National Park, in the Highlands, at the Kirkton & Auchtertyre farm (SRUC Hill & Mountain Research Center) near Crianlarich. 22 people participated to the very well organized and informative visit hosted by Davy McCracken, Nicola Lambe, Claire Morgan-Davies and Ann McLaren. 1,500 sheep (Scottish Blackface, Black Welsh Mountain, Lleyn and crossbred) are raised in quite harsh conditions (annual rainfall of 2.5 meters). The farm is dedicated to improve the benefits of hill meat sheep farming. For that, high throughput data are collected, using the Precision Livestock Farming system. We were explained and demonstrated different devices (handling of the sheep, feed efficiency devices) and experiments targeting at saving cost and labour. Thanks to the SRUC for this enthusiastic discovery of hill sheep farming.



- **29th November: Technical visit to Yorkshire Dairy Goats (YDG), Seaton Ross, Yorkshire (hosts: Angus and Kathleen Weilkopolski, YDG is a partner of SMARTER).**

About 20 people between partners and stakeholders of the Smarter project participated to a technical visit to a relevant goat farm in central UK. Thanks to the collaboration with SRUC, this farm makes a wide use of genomics and of advanced solution in its managing. This collaboration with SRUC, accomplished with the adoption of animal welfare principles and the use of advanced selection programs for productive traits, robustness and health made possible an increase of the productivity by 3% per year of the milk production in the last 10 years. The farm, that includes also a cheese making factory, is mainly involved in the milk production but also having a relevant percentage of the incomes generated by yogurt processing and other dairy products. This unique reality is certainly a single one, particularly if compared with the other production systems for goat developed in other EU countries.



An opportunity: the CDB (Common Dissemination Booster) Fitter Livestock Farming

In Horizon 2020 many projects share the same concerns, and the EC encourages them to do a joint dissemination, to gather their objectives, pool their results and their stakeholders, and organize joint communication events. In the field of animal science, the CDB Fitter Livestock Farming has been created, and at the moment six projects do participate to it (FeedaGene, Image, Saphir, GplusE, GenTORE and SmartCow). This joint tool has been created with the support of the EC and is coordinated by Trust IT-Services.

SMARTER has been invited to participate on 6th November 2019 in Brussels to a joint event organized by Fitter Livestock Farming and focusing on “What R&I can deliver to support climate mitigation and adaptation in livestock farming”. It was organized jointly by ATF, EAAP and the CDB (about 120 stakeholders have participated). Carole Moreno, coordinator of SMARTER made an oral presentation of the project during this meeting. Moreover, a poster was presented, and some brochures distributed. [See all the presentations here.](#)

This cluster will continue, and SMARTER might eventually join it in association with other new research projects when Horizon Europe will have been launched. On 6th November Methagene, Roadmap, HealthyLivestock, Bovine, Eurodairy, Ok-Net-EcoFeed had been also invited, and made also short presentations of their objectives during the meeting.

Joint dissemination activities such as sessions in scientific conferences (e.g. EAAP Porto 2020) and an annual meeting in Brussels would be organized.



New people in SMARTER project: Carolina Garcia-Baccino, Brenda Vera, Gracialda Ferreira, Fernando Amarilho Silveira, Rodrigo López Correa, Masoud Ghaderi

Carolina Garcia-Baccino (Post-doc, INRA)



Carolina Garcia-Baccino is Argentinian, she studied in Universidad de Buenos Aires. She graduated in Animal Science (2012), then obtained MSc (2017) and PhD (2019) in Animal Breeding and Quantitative Genetics. In June 2019 she started working in INRA Toulouse in a two-year contract as a postdoc paid by SMARTER. Carolina will work in WP 5, with specific focus on two methods. First, mining of longitudinal performance data to identify and characterise events of environmental challenges. This work is being carried on dairy sheep test-day records and meat sheep feed intake automatic measurements. Second, assessing the importance of non-additive effects that hamper prediction across populations. This will evaluate the importance of epistasis and dominance on across-breed genomic predictions

Brenda Vera (Phd student, INIA fellowship)



Brenda Vera obtained the title of Parasitologist Bacteriologist Chemist from the National Polytechnic Institute in Mexico. In Uruguay, obtained the title of Master's in Bioinformatics in the design and repositioning of antiparasitic drugs assisted by computer. In addition, for two years has collaborated with a Mexican research group dedicated to genomic analysis in humans using microarray genotyping techniques. Currently is a PhD student at INIA-Uruguay under the guidance of Ing. Agr. PhD Gabriel Ciappesoni and her thesis is related to genomic selection aimed at parasitic resistance and conversion efficiency in Merino sheep.

Gracialda Ferreira (MSc student, INIA)



With Brazilian origins, Gracialda Ferreira graduated as a Veterinarian at the Federal University of Pelotas (UFPEL) in 2013. In the year of 2015, she began working as research assistant at the Uruguayan Secretariat of Wool (SUL), where worked with genetically resistant animals to gastrointestinal parasites and strategic supplementation for sheep. Currently, develops the final stages of his master's degree at the National Institute of Agricultural Research (INIA - UY), under the guidance of Ing. Agr. PhD Ignacio de Barbieri. The thesis is part of the SMARTER and Rumiar Project (INIA - UY), entitled "Consequence of divergent selection due to resistance to gastrointestinal parasites in sheep on residual feed consumption". Besides this work, she appreciates the training of dogs for working with sheep and at home presents a double purpose flock.



Fernando Amarilho Silveira (INIA)



Fernando Amarilho Silveira graduated in Animal Science at the Federal University of Pelotas in 2015. From 2016 to 2018, completed his master's degree in the area of animal breeding with emphasis on sheep breeding by the postgraduate program in Animal Science of the same institution. In 2018 entered the postgraduate program in Animal Science of the Federal University of Porto Alegre (UFRGS - BR) in the area of animal breeding with emphasis on sheep, scheduled to end in August 2021. His research activities are being developed with the National Institute of Agricultural Research (INIA - UY), within the SMARTER project in WP 7.2 and WP 7.4. His thesis will be titled "Inclusion of Producer Preferences in the Selection and Modelling Indexes for Feed Efficiency of Australian Merino and Corriedale Sheep Raised in Uruguay", under the guidance of Professor. Dr. Jaime Araujo Cobuci (UFRGS - BR) and PhD Gabriel Ciappesoni (INIA - UY).

Rodrigo López Correa (INIA PhD student - Universidad de la República (Uruguay) internship)



Rodrigo López Correa is a PhD student at INIA and Universidad de la República in Uruguay under the guidance of Ing. Agr. PhD Ignacio Aguilar, who did an internship at INRA (Castanet, Tolosan) from 4th September to 4th November under the supervision of Dr. Andrés Legarra (GenPhySE Research Director). The aim of his research was to apply metafounders methodology to fit unknown parent groups on genomic evaluations of livestock, and thus improve breeding values (EBV) predictions. Several scenarios were tested under different gamma matrix designs and EBV predictions obtained by single-step were then validated using the linear regression method (LR) developed by Legarra and Reverter (2018). Metafounders methodology proved to be a suitable approach to include genomic information in the national genetic evaluation of livestock in Uruguay. The outcome of the entire work is now being prepared so that it could be published in a peer reviewed scientific journal.

Masoud Ghaderi (UEDIN Post-doc)



Masoud is an applied mathematician who joined SMARTER project in August 2019. He completed his PhD in engineering has experience in statistical learning algorithms and computational methods. Masoud is involved in WP5 and WP3. In WP5, he works on developing genetic models to measure impact of environmental challenge on performance of animals. He uses statistical models in simulations to estimate and select for resilience and ultimately, to assess the response to selection under various circumstances. In WP3, he characterises new phenotypes using longitudinal data of animals which undergo environmental challenge. He will then use the result of WP5 to assess selection for the new characterised phenotypes.

SMARTER Participation to conferences and events (past and future)

2019:

- [ICAR 2019 - ICAR \(International Committee for Animal Recording\) annual conference](#), organized on behalf of the Czech Moravian Breeders' Corporation, and which has been held in Prague (Czech Republic), from 17th to 21st June. Jean-Michel Astruc made a presentation of SMARTER on 20th June during the Technical Session n°8 (New developments in Sheep, Goat and Camelids), under the title: SMARTER – A European project on selection of efficiency and resilience in small ruminants with strong ICAR commitment and implication.



- [EAAP 2019, 70th EAAP Annual Meeting \(European Federation of Animal Science\)](#) in Ghent, Belgium, from 26th to 30th August to 4th 2019. The partner INIA-UY presented two research approaches: “**Differences in growth between Corriedale sheep divergent lines for resistance to nematodes**” (session 62) and “**Evaluation of udder morphology and milk production in prolific and meat ewes**” (session 32). The first research, related with the SMARTER WP3, studied the association between genetic resistance of lambs to gastrointestinal parasites (GIP) with dry matter intake (DMI) average daily gain (ADG) and residual feed intake (RFI). For this, it was used sixty-four Corriedale lambs (357±14 days old), from divergent lines for resistance to GIP (27 resistant-R and 37 susceptible-S), developed by the Uruguayan Wool Secretariat. The preliminary results suggest a difference in growth pattern between R&S lines during the infestation period without effects on DMI. The second research is related to the SMARTER only partially (in the case of the Texel breed).
- **Fitter Livestock Farming Workshop**, Brussels, Belgium, 6th November 2019 afternoon. Carole Moreno made a presentation of SMARTER during the workshop: “What R&I can deliver to support climate mitigation and adaptation in livestock farming”, organized jointly by the Fitter Livestock Farming group, in association with ATF (Animal Task Force), EAAP (European Federation of Animal Science) and EFFAB (European Forum of Farm Animal Breeders). The workshop was held at the University Foundation. More information [on the website](#).

2020:

- [ICAR 2020, ICAR \(International Committee for Animal Recording\) annual conference](#) will be organized by the Dutch-Flemish cooperative CRV (Coöperatie Rundveeverbetering – Cooperative for Livestock Improvement) and held from 8th to 12th June in Leeuwarden, The Netherlands.
- [EAAP 2020, 71st EAAP Annual Meeting \(European Federation of Animal Science\)](#) in Porto, Portugal, organized by the Portuguese Association of Animal Science (APEZ), with the patronage of the Ministry of Agriculture, Rural development and Fisheries from the Portuguese Government. It will be held from 31st August to 4th September 2020.
- [IGA 2020 Eger, 13th International Conference on Goats](#) organized under the auspices of the IGA – International Goat Association - on behalf of the Hungarian Sheep and Goat Dairying Public Utility Association, Eger, Hungary from 14th – 17th September 2020.

SMARTER Scientific Publication peer-reviewed

2019

- **Behaviour of the Linear Regression method to estimate bias and accuracies with correct and incorrect genetic evaluation models.** F. L. Macedo, A. Reverter, and A. Legarra. Journal of Dairy Science, 2019. <https://doi.org/10.3168/jds.2019-16603>
- **Inbreeding and effective population size in French dairy sheep: Comparison between genomic and pedigree estimates.** S. T. Rodríguez-Ramilo, J. M. Elsen, and A. Legarra. Journal of Dairy Science, May 2019, Volume 102, Issue 5, Pages 4227–4237. (embargo period)
- **Genetic and nongenetic factors associated with the fate of maiden ewe lambs: slaughtered without ever lambing versus retained for breeding.** N. Mchugh, T. Pabiou, K. Mcdermott, E. Wall, D. P. Berry. Translational Animal Science, Volume 4, Issue 1, January 2020, txz156. <https://doi.org/10.1093/tas/txz156>



2018

- **Semi-parametric estimates of population accuracy and bias of predictions of breeding values and future phenotypes using the LR method.** A. Legarra, A. Reverter. *Genetics Selection Evolution*, 50, Article number: 53 (2018). <https://doi.org/10.1186/s12711-018-0426-6>



Ansdell Richard: a ewe with lambs and a heron beside a loch

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