SmartCow

an integrated infrastructure for increased research capability and innovation in the European cattle sector

SmartCow

An integrated infrastructure for increased research capability and innovation in the European cattle sector

Newsletter – Issue 6, TNA special issue

Images © SRUC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730924.

Summary

Introduction to Special Issue Newsletter on Transnational Access

As we enter the final stages of the SmartCow project, we are taking the opportunity to review and update on the Transnational Access (TNA) programme with reports from several completed and ongoing projects in this Special Issue Newsletter.

The TNA programme makes available facilities of SmartCow partners for research by academic or industry colleagues. The first criterion for projects is that the research team must be mostly from a different (mainly EU) country (hence 'trans-national'). Successful bidders receive funding to cover the operating costs of facilities. Projects with dairy or beef cattle should be in the main areas of interest for SmartCow, including digestion and nutrient metabolism, greenhouse gases, and animal behaviour and welfare. There is also a strong interest in development of less intrusive experimental approaches through use of biomarkers and animal mounted sensors. The TNA programme had a €1.5 million budget to provide around 10,000 cow-weeks of access to facilities, including both animal production studies (production, reproduction, health and behaviour) and some more detailed studies of underlying digestive and metabolic processes (such as GHG emissions using respiration chambers, digestibility and nutrient flow measurements). Calls for proposals, evaluation of proposals and monitoring of ongoing projects are all conducted within the SmartCow project. We have evaluated 47 proposals submitted to four funding calls (from 2018 to 2020) and expect to support 24 projects. Projects that have already completed their work, including studies of diet effects on rumen functioning, effects on cheese quality, multi-species sward effects, amino acid nutrition, and sensor technologies for both feed evaluation and assessment of cow stressors.

Is the low enteric methane emission of dairy cows reflected in their rumen microbiome and immune response? – by Angela Schwarm, Puchun Niu, Phil B. Pope (Norwegian University of Life Science, Norway) and Ulrike Gimsa, Björn Kuhla (Leibniz Institute for Farm Animal Biology, Germany)


Angela Schwarm


Puchun Niu


Ulrike Gimsa


Phil B. Pope


Björn Kuhla

The aim of our TNA-project was to delineate interactions between enteric methane (CH4) emissions, rumen microbiome, and immune function in early and late lactating cows (Figure 1). Low CH4 emissions were associated with higher feed conversion efficiency, but also with impaired immune response of cows probably lacking the energy to sustain an adequate immune response (Meese et al. 2020). In addition, how does microbial community structure reflect low or high CH4 emissions? We hypothesized that (1) low and high CH4 emitting cows differ in the rumen microbiome; and that low compared to high CH4 emitters are (2) characterized by a higher feed conversion efficiency and milk production efficiency and (3) a lower immune response.

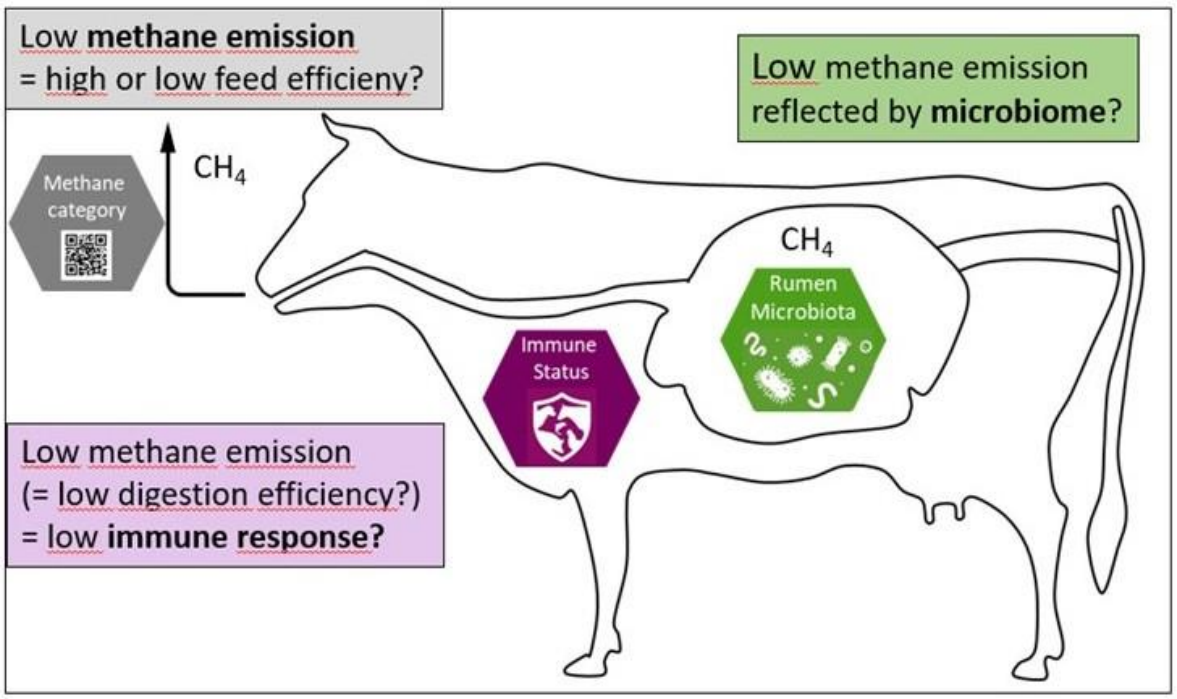


Figure 1

Dry matter intake (DMI), body weight (BW), milk yield and constituents and CH4 production in respiration chambers (Figure 2) were studied in early (n=20, 31 days in milk, DIM) and late (n=14, 390 DIM) lactating, multiparous Holstein cows. Immune response to concanavalin A (ConA) and phytohaemagglutinin (PHA) was studied in vitro using whole blood and peripheral blood mononuclear cells (PBMC). Analyses of 16S rRNA in rumen fluid (oesophageal tubing) and TNAα in supernatants are underway. Statistical analyses were performed within lactation stage with SAS 9.4.

Figure 2. Respiration chambers at the Leibniz Institute for Farm Animal Biology (FBN), Dummerstorf, Germany (Pictures © FBN)

Cows weighed 545 to 917 kg, had 9 to 24 kg DMI/d, 16 to 51 kg energy corrected milk (ECM)/d, 363 to 751 g CH4 production/d and PBMC proliferation indices (PI) of 1.9 to 5.5 (ConA) and 1.4 to 3.8 (PHA). As hypothesized, cows producing less CH4 (g/d) were characterized by a higher feed conversion efficiency (ECM/DMI; early lactation: p=0.002, late lactation: p = 0.055), and by a higher (p = 0.045) milk production efficiency (ECM/BW) at the late, but not early lactation stage (p = 0.9). The CH4/d, CH4/DMI, CH4/ECM and CH4/BW were not correlated (p > 0.1) to immune response (PI). Accordingly, cows retrospectively grouped into low and high emitters (CH4/d, CH4/DMI, CH4/ECM, CH4/BW) did not differ (p > 0.1) in immune response (PI), except for low compared to high CH4/DMI emitters in early lactation who showed lower PI (p < 0.052). Preliminary results confirm that greater CH4 emissions are related to decreased feed conversion efficiency yet improved immune function in early lactation.

Meese et al. (2020) J Dairy Sci, 103:4367-4377

Report on the TNA project "From grassland biodiversity and grass conservation to the animal's microbial ecosystem, and to milk and cheese quality" – by Joel Berard (Agroscope, Switzerland)

Equipe Marcenat © INRAE

Since a few years, a group of researchers and friends wanted to test an interesting but at the same time challenging hypothesis. What are the effects of grassland biodiversity and grass conservation on the animal's microbial ecosystem, and the consequences on the milk and cheese quality? A PhD student had been working on this issue for some time at the ETH Zurich in Switzerland, and her enthusiasm and initiative convinced us that she was the right person to answer these questions, but the challenge was not yet won… Where and how to realise such an ambitious project that needed the production of different forages, used pastures with gradients of plant biodiversity, and required the production of cheese under experimental conditions? The SmartCow TNA program came to our attention and revealed us a great opportunity to realise our project. After a few videocalls and many emails across tree nations, the full-project proposal was written and submitted to the Consortium for evaluation. The answer came just a few months later: our project was approved. As it is often the case in these situations, the excitement quickly gave way to the awareness that it was time to roll up our sleeves and work on the detailed experimental plan and to organise our stay in the Massif Central in order to follow the experiment.

Our journey has begun at the INRAE Herbipôle research facility in Marcenat (France) in early 2019 with the first contacts with the research facility manager Matthieu Bouchon to organise the upcoming harvest of the forages needed for the experiment. The experimental part of the project took place from May until End of July 2019. We profited of the experience of the Herbipôle research engineers and technicians and the very straight collaboration with the research scientists of the UMR (French acronym for "Joint Research Unit") 'Herbivores' (Theix, France) and 'Fromage' (Aurillac, France) to conduct an experiment with the aim to investigate the effects of grassland biodiversity and herbage conservation method on the sensory properties of milk and cheese and related microbial communities. The late snowfall in the beginning of May did not discourage the entire team from harvesting the forages in order to start the experiment as planned. The rapidly increasing sum of degree-days in the following weeks did the rest. In late May 2019 grass from the same plot was conserved either as hay or as silage. During 3 months, 48 Holstein and Montbéliarde cows were involved in the experiment, and divided into four groups fed either on pasture or indoors with fresh grass or conserved forages. During 3 weeks in June 2019 and 2 weeks in July 2019 we were daily involved in milk samplings for cheesemaking and several samplings of the microbial environments (soil, bedding places, grass, rumen, faeces, teat skin surface,…), and of the forages. The milk was daily transported to the cheesemaking facility in Aurillac for cheese production under the lead of Isabelle Verdier-Metz and to the laboratory of sensory evaluation led by Cécile Bord at VetAgro Sup (Lempdes, France) for the evaluation of raw and pasteurised milk. After 2 months of ripening, the sensory properties of the cheeses were evaluated in the same laboratory. Massimo De Marchi and colleagues from the Università di Padova (Italy) analysed the mineral composition and coagulation properties of the collected milk samples, whereas Marilena Musci and her students from the Università di Parma (Italy) analysed the volatile compounds of the experimental cheeses. Physicochemical analyses on the cheeses were performed at the UMR Herbivores. The Cantal-type cheeses derived from fresh herbage were creamier and exudative, and had a stronger barnyard and dry fruit flavour. Cheeses derived from conserved forages had a more intense lactic odour. The influence of the herbage conservation method (haymaking or ensiling) on the cheeses' sensory properties was rather limited coinciding with the only few differences found in the volatile compounds of the cheeses. Furthermore, cheeses derived from cows fed fresh herbage indoor had a lower global flavour intensity than those derived from grazing cows. The results were recently published in the Journal of Dairy Science (Manzocchi et al., 2021; doi:10.3168/jds.2020-19738). Furthermore, these results were also presented at the virtual conference The Science of Artisan Cheese in August 2020 to a large international public of cheese specialists. A poster with preliminary results was presented also at the 74th conference of the German Society of Nutrition Physiology. A second paper dealing with the differential ruminal biohydrogenation of dietary fatty acids according to the herbage conservation method was submitted to the Journal of Dairy Science. Further analyses concerning the microbial fluxes from the grassland to the cheese in relation with grassland biodiversity and herbage conservation method are currently ongoing. Last but not least, this project allowed us to investigate some methodological aspects related to replication and repeatability of measurements in cheesemaking, that will be very useful for the design of future experiments dealing with the effects of farming practices on cheese sensory properties.

© E. Manzocchi

© INRAE

Besides the purely scientific aspects of this project, we highly appreciated the collaborative form and the opportunity to work with keen researchers in this domain, with whom our collaboration is still ongoing and got even closer. We are grateful to the SmartCow Consortium for the unique opportunity we got with this TNA program to continue and strengthen our international collaboration with several partners and profit of the excellent skills and infrastructures of the experimental farm in Marcenat, as well as of the magnificent landscapes of the Massif Central!

Reference: Manzocchi E, Martin B, Bord C, Verdier-Metz I, De Marchi M, Bouchon M, Constant I, Giller K, Kreuzer M, Berard J, Musci M, Coppa M. 2021. Sensory characteristics and composition of milk and uncooked pressed cheeses from cows fed hay, silage or herbage on pasture and indoor. Journal of Dairy Science 104.In press. https://doi.org/10.3168/jds.2020-19738



© Images E. Manzocchi: Fig. 1 Montagne, Fig. 2 cheesemaking, Fig. 3: cheese

SmartCow project on the impact of physically effective fiber in lactating dairy cow – by Ruth Heering (University of Hohenheim, Germany) and Florence Fournier (INRAE, France)

© Florence Fournier

An experiment was conducted within the scope of the TNA SmartCow project at Les Cèdres research station of the Herbipôle Unit of INRAE Clermont Auvergne Rhône-Alpes from mid of January 2020 until the beginning of June 2020. During this time, the doctoral candidate Ruth Heering from the University of Hohenheim spent three months as a visitor at INRAE Site de Theix, where she worked together with researchers as well as technicians and staff of INRAE to execute the SmartCow experiment. The experiment aimed at unraveling the processes underlying the effects of an increased concentration of dietary peNDF in diets of high-producing dairy cows on their chewing behavior, rumen fermentation, digesta passage rates, the efficiency of rumen microbial protein synthesis (MPS), and partitioning in nitrogen (N) excretion. Offered diets were isonitrogenous and isoenergetic and varied solely in their peNDF concentration adjusted by the mixing time of the total mixed ration (TMR) in the feed mixer wagon (i.e. 60, 45, 30, and 15 min).

Results showed that nutrient intakes, apparent total tract digestibility of organic matter, total chewing time (sum of eating and rumination times; min/d) as well as amount (g N/d) and efficiency of MPS (g N/kg dry matter intake) responded quadratically to increasing peNDF concentration with greater values for 45 and 30 min of mixing time. However, liquid and solid digesta passage rates as well as rumen pH, as well as concentrations of volatile fatty acids and ammonium-N in rumen fluid were similar across TMR mixing times. The proportion of ingested N excreted via urine or secreted via milk differed depending on the duration of the mixing (Table 1), whereby the proportion of ingested N secreted via milk was lower and that excreted via urine greater for TMR mixed for 45 and 30 min.

Table 1. Partitioning of nitrogen (N) excretions (g/100 g N intake) of lactating dairy cows fed a diet varying in mixing time in the feed mixer wagon.

Variable g/100 g N intake	Mixing time				SEM[1]	*P*-value	
	15 min n = 4	30 min n = 4	45 min n = 3	60 min n = 4		Linear	Quadratic
Milk N	31.3	27.5	28.6	29.3	2.01	*ns*[1]	*<0.01*
Urinary N	23.8	29.4	30.8	27.3	2.31	*0.04*	*<0.01*
Fecal N	44.0	42.4	40.2	42.9	2.94	*ns*	*ns*

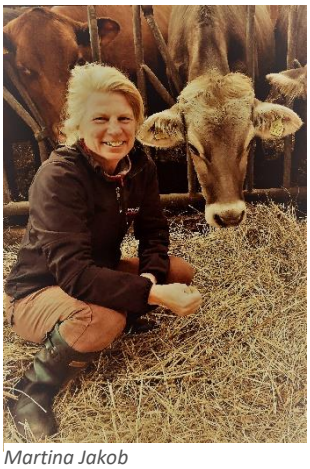
[1]*ns* = not significant (*P* ≥ 0.05); SEM = standard error of means.

Ruth Heering, her supervisors, Prof. Uta Dickhoefer and Dr. Natascha Selje-Aßmann (University of Hohenheim), and Dr. Rene Baumont (UMRH, INRAE) are currently working on a publication based on the results of the present experiment.
This SmartCow project was a great opportunity for Ruth Heering to have access to INRAE's cattle infrastructure and to complete the last experiment of her doctoral dissertation on the effect of peNDF on protein metabolism in dairy cows. Moreover, this project was a great opportunity to exchange expertise between two scientific groups. The visits prior to the start of the experiment as well as the stay of Ruth Heering and regular meetings after each experimental period were important and contributed to the successful outcome of the experiment.



Images 1 and 2 © Ruth Heering; Image 3 © Florence Fournier

Pilot study of a carotenoid skin sensor. Measurement of carotenoid content in cow's skin as part of SmartCow access to TNA – by Martina Jakob (Leibniz Institute for Agricultural Engineering and Bioeconomy, Germany) and Christina Umstätter, (Agroscope, Switzerland)


Martina Jakob

The carotenoid content of human skin can provide information about the health status and stress level. It can be measured by multiple spatially resolved reflection spectroscopy. A non-invasive, handheld device was developed for measurements on the palm of humans. The sensor is available on the market now and is continually improved. A pilot study was designed to find out, whether the same sensor can also be used to measure the carotenoid content of the skin of cows. Such a tool could be a useful basis for detecting health issues in the udder and could therefore enable farmers to respond early and prevent more severe courses of illness. Three on-farm trials in France, Ireland and Scotland were run to collect data on different breeds and feeding systems. In addition, different measuring points were tested on the udder. In France and Scotland, the measurements were focused on the teats whereas in Ireland the side of the udder was also measured. Overall, in France the measured values were higher than in Scotland and Ireland. The results varied for the teats, but feed and breed have shown a significant influence. Therefore, the pilot study results indicate that the sensor has potential to provide useful information for farmers. As the sensor is developed for human use, more research needs to be done. The calibration models need to be adapted for dairy cows as well as the tool needs adaptation to the specifics of the udder.


Sensor attached to an USB cable- © Martina Jakob

Parts of study were presented in autumn 2020 at the Conference:
22. Arbeitswissenschaftliches Kolloquium : Arbeit unter einem D-A-CH - Automatisierung und Digitalisierung in der modernen Landwirtschaft. Agroscope Science, 94, 2020, 1-168.

SRUCs GreenCow Facility – by Gemma Miller (SRUC, United Kingdom)

The GreenCow facility is sited at SRUC's Easter Howgate Farm. The farm is ideally suited to research with a range of production systems (rough hill, improved and lowland grazing as well as intensive housing facilities), as well as the largest suckler beef herd available for experimental use in the UK. The facility consists of two stand-alone but closely linked units – 1. Feed Efficiency unit and 2. Respiration Chamber unit.

The feed efficiency unit consists of a large shed with flexible penning configurations and capacity to allow accurate measurement of individual animal feed intakes for up to 150 animals (60 automated feed intake recording bins, HOKO, Insentec, Netherlands). The shed also houses an integrated cattle handling and weighing system with curved race leading to the crush which allows weights, measurements and samples to be obtained safely.

The respiration chamber unit sits a short distance from the feed efficiency facility allowing easy movement of animals between the two. The six open-circuit respiration chambers are complimented by six training pens of the same design as those within the chambers. These are used to accustom animals to being housed individually prior to entering the chambers, however the cattle maintain visual contact with at least one other animal whilst in the chambers through windows between adjoining chambers. The chambers and training pens are also equipped with HOKO feed bins, with the addition of canopy 'sniffers' fitted above the feed bins in the chambers which allow measurement of greenhouse gases emitted specifically whilst individual cattle are eating.

The facility supported the UK's Greenhouse Gas Platform work to improve the national inventory of emissions and provide a baseline for diet and animal breeding approaches to reduce methane emissions. Since then, work has demonstrated the efficacy of various dietary manipulations and additives on methane emissions and animal performance. We have also identified relationships between methane emissions and rumen volume, measured using cutting-edge CT scanning. Over 700 individual measurements of methane emissions from beef cattle (and a small number of paired sheep) have been recorded at the unit to date.

The GreenCow facility is currently hosting one TNA project with an SME, which is utilising both the feed efficiency and respiration chamber units. Unfortunately, due to COVID restrictions, the User was not able to visit the site and so the Samples from the TNA and archived samples from previous trials have also contributed to WP6.

Chambre - © SRUC

UREAD TNA – by David Humphries (UREAD, United Kingdom)

© UREAD

Two TNA studies have been conducted and recently completed (2021) at UREAD. Both studies were conducted during 2020/21 and were affected by Covid-19 restrictions, the main impact of this was users were unable to visit the site while studies were running or contribute to the physical aspects of the studies (sample collection and processing). Both studies focused on improving dietary nitrogen and feed efficiency in lactating dairy cows, one through phased feeding of protein in early lactation and the second through the use of a liquid feed supplement to improve rumen function and digestive efficiency.

Study 1. User Nicolaj I. Nielsen, SEGES, Denmark:
"Increased N-utilisation from dairy cows by phase feeding of protein"
The objective of this study was to increase feed N-utilisation and milk yield in dairy cows by the targeted use of quantity and quality of feed protein during early lactation. 36 lactating dairy cows were used and were fed 3 dietary treatment regimens for 15 weeks. The expected outcome from this study was the foundation for new feeding and grouping strategies that will increase N-utilisation and milk yield in dairy cows. The results from this trial will form the basis for implementation of phase feeding on a number of commercial pilot farms in Denmark.

Individual daily dry matter intake measured using Calan Gates - © UREAD

Fig. 1: Milk yield recording and milk sampling – Images © UREAD

Study 2. User Georgina Chapman ED&F MAN (Liquid Products):
"Adding a molasses based liquid feed to the diet will increase whole tract fibre digestion, efficiency of nitrogen capture and improve animal performance"
This study evaluated a source of sugars in the diet through the addition of a molasses based liquid feed (MBLF) as Regumix. It was hypothesized that his would improve whole tract fibre digestion and the efficiency of nitrogen capture, and consequently animal performance would also be improved. Increasing the efficiency of nitrogen capture will potentially reduce the amount of nitrogen excretion via urine and faeces and as a result reduce the potential for pollution. Additionally, an increase in whole tract fibre digestion will lead to a greater efficiency of home-grown forage utilisation. The rationale for this project is based on supporting sustainable farming by increasing the efficiency of home-grown forage utilisation and so reducing the reliance on bought in alternatives. If positive results are obtained

further research will be conducted to determine the extent to which MBLF can enable lower protein concentration diets to be fed commercially.
A series of 4 replicated 4 X 4 Latin Square design experiments was conducted with 16 mid-lactation Holstein dairy cows, 4-week periods, and 4 diet treatments, including a control treatment. Total tract digestibility measurements were conducted on 4 cows in one of the Latin squares.

Cows being trained in the use of digestibility stalls and faecal collection chutes prior to the start of digestibility measurement - © UREAD

The TNA studies conducted at UREAD contributed samples and data for Smartcow WP6.

Being a facility manager of SmartCow – by Marta Terre (IRTA, Spain)

Methane measurements with the portable laser device - © Marta Terre

Learning has always inspired me, and it is what it happened being the TNA manager of IRTA dairy farm (EVAM) within the SmartCow project. I have had the pleasure to work with three different institutions with different working methodologies, from which good things can be obtained. Working with private companies shows you the importance of reporting and keeping them updated and also ready for last time changes. With public research institution the tempo is slower and more planned in some cases, and under construction, because research is pending of former results, in others. Whatever the case, in general, collaboration is a rewarding experience, and with SmartCow TNA it is a win-win experience.

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

Twitter: @cow_smart - Facebook: @smartcowproject