Research Priorities

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Integrating Activities for Starting Communities

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

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Project ID: 730924

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Table of contents

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1 Context and issues for cattle production and research in Europe

Livestock production is vitally important for Europe's future (€130 billion to the EU economy - 48% of the agricultural sector, employment for nearly 30 million people), with a projected 70% increase in worldwide demand for meat and dairy products by 2050, even though European consumption is likely to remain constant or fall slightly. This gives the European livestock sector great opportunities - either by increasing production within Europe or by exporting the technology and know-how in animal science for sustainable livestock systems. However, much criticism has also been aimed at the livestock sector due to both environmental concerns and issues with animal health and welfare. Ruminant production systems have been singled out, with red meat in particular targeted as being environmentally unfriendly. Indeed, enteric methane represents 39% of greenhouse gases emissions from livestock, expressed in CO2-equivalents, and the livestock sector represents 14.5% of world emissions of greenhouse gases of anthropic origin (Gerber et al., 2013). However ruminant systems provide many interlinked benefits (Dumont et al., 2016): in addition to red meat and dairy products, they are producers of leather, cosmetics and pet food. Ruminants, can convert non-edible feeds (grass, by-products) into milk and meat of high nutritional value for humans, and grass-fed ruminants contribute to carbon sequestration in grasslands, use marginal land unsuitable for crops, maintain traditional landscapes and provide employment in remote areas.
The need to improve resource use efficiency, reduce anthropogenic GHG emissions and improve animal health and welfare has been highlighted by the EU (H2020, FACCE JPI, AnimalChange FP7 project, SusAn ERA-NET, GAS ERA-NET, Standing Committee on Agricultural Research-SCAR, EFSA), the Animal Task Force-ATF (European public private partnership), the FAO, the Global Research Alliance on Greenhouse Gases (GRA GHG), and by the recent outcomes from the COP 21 meeting in Paris.

Europe is a leader and exporter of top-level expertise, technologies and know-how in areas that are crucial for developing sustainable dairy and beef production. Indeed, European production systems are acknowledged to be amongst the best in terms of their environmental impact and respect for animal health and welfare. This leadership is also true for research outputs where Europe's position remains unique (ca. 40% of research papers on cattle in agriculture and veterinary sciences in the last 15 years). However, developing countries' research is increasing rapidly (ca. +90% papers from Asia and South America between 2000 and 2015) in line with their increase in production of meat and dairy products. There is therefore a major challenge for the EU cattle research community to maintain its global scientific leadership. In this context, coordination, harmonisation and access to European research infrastructures are essential to support research and innovation for cattle, and to contribute to a sustainable, smart and competitive Europe.

2 Scientific challenges that SmartCow project will address

2.1 Global challenges

Research on farm animals needs to address global issues such as sustainable production, food security, climate change and consumer acceptance. The Animal Task Force outlines four key challenges and cross-cutting issues (ATF, 2016) for cattle research that SmartCow will address:

- *Efficient use of biomass – food security*: by producing food using human inedible agro-products as animal feed, by efficient and robust animals adapted to new European feed resources, by precise management of animals, and by appropriate management of manure and animal by-products.
- *Sustainable competitiveness of livestock farming systems*: by taking into account consumers' perceptions and expectations about livestock production systems and consumptions of animal products, minimising potentially harmful emissions of animal production (and in particular, GHG emissions), by improving the competitiveness and adaptability of livestock farming systems facing global changes, improving ecosystem and social services provided by livestock production systems.
- *Healthy livestock for healthy diets and healthy people*: through prevention and control of diseases, by integrated management of animal welfare and health, improvement of the product quality, increases in food and feed safety.

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- *Improving infrastructure for research and innovation*: by the creation of EU research infrastructures with large populations of farms used in combination with research herds, developing ICT/infrastructure to promote exchange of data between stakeholders, developing knowledge exchange with farmers and industry towards innovation.

2.2 Adopting a holistic approach

A key issue in tackling these challenges is the need to adopt a holistic approach, considering all aspects of the production systems for dairy and beef (Baumont et al., 2014). For example, improving animal efficiency involves improving both feed and nutrient efficiency, thereby reducing emissions intensity. Health and welfare aspects play a crucial role in resource efficiency, as approximately 20% of animal production is lost due to morbidity and mortality (World Organisation for Animal Health http://www.rr-africa.oie.int/en/news/index.html). All these aspects are crucial for the sustainability of both the dairy and beef cattle sectors. More efficient and, healthy animals, able to express their natural behaviour and managed to high welfare standards are part of the vision of cattle husbandry that SmartCow will promote by offering the European Research Area a coordinated set of high-level RIs dedicated to these issues.

2.3 Improving ethics in animal production and in animal science

Animal production and research in animal science (involving experiments on animals) are also challenged by society in terms of ethics (Ferdosian and Beck, 2011; INRA-CIRAD 2015). A better consideration of the welfare of experimental animals, the implementation of the 3R principles (Replace, Refine, and Reduce), and a broader evaluation of the cost/benefit of experiments on animals which integrates the societal demand for a more ethical animal production is essential. SmartCow will consider ethics in animal science as a crosscutting issue and will develop and promote high ethical standards in research on cattle.

2.4 Developing new and more complex animal traits and increasing phenotyping capabilities

Until recently, animals were selected only on the basis of easily measured production traits. This has led to animals that can function in only very specialised production systems. The consequences are that some important traits for welfare, most notably disease susceptibility, have been neglected, reducing the welfare status of some farm animals in specialised production systems. The industry now requires far more complex animal traits than previously (for example: the concepts of feed efficiency, robustness and sensitivity to health disorders are more difficult to include in selection indices than simple productivity traits) and they need to be assessed under a range of conditions. Studies of these traits will bring new knowledge on the links between environment (including feeding), phenotypes and genotypes. This has been recognised by the EC which has just accepted for funding a project dedicated to the study of robustness and efficiency in cattle (GenTore).

2.4.1 Utilisation of new tools: smart technologies, rapid analytical methods, ontologies

At the same time, new tools become available; these include: smart technologies (e.g. sensors, automatic recording systems) that provide continuous and precise measurements of physiological and behavioural traits, rapid analytical methods such as mid infrared (MIR) and near infrared (NIR) spectrometry that allow rapid assessment of chemical and biological parameters in several matrices (e.g. milk, tissue, faeces, urine) and powerful analytical methods such a isotope ratio mass-spectrometry (IRMS) for detecting very small differences in isotopic natural abundances across diets and between individuals. Moreover, an ontology for cattle i.e. a standard language that unambiguously defines phenotypic traits so as to serve as a reference for any possible user (e.g. geneticist, physiologist, biochemist, modeller, producer) has been developed (Golik et al., 2012; Animal Trait Ontology for Livestock, ATOL and Environment Ontology for Livestock, EOL) and is now available on the web (http://www.atol-ontology.com/rb/en/1). It is now time to look for means to investigate complex animal traits using smart technologies and in a standardised way applied in many contexts. Addressing complex animal traits will require multidisciplinary approaches combining animal nutrition, metabolism, animal behaviour, molecular and quantitative genetics and system analysis. This objective requires the critical mass of staff expertise and facilities that SmartCow will draw together across RIs.

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2.4.2 Integrating and opening access to cattle research infrastructure

At the same time, livestock RIs are notoriously expensive to equip and maintain. No individual partner can provide sufficient resources to set up such large-scale integrative experiments. There is now a pressing need for a coordinated network of RIs combining leading facilities in the key areas of animal science and the range of production systems and cattle breeds at the EU level. Several recommendations for an improvement in the coordination of RIs have been published, but they have not yet been implemented for the cattle sector. Integration of the facilities and competencies proposed by SmartCow will enable synergies and will therefore increase research outputs e.g. by fostering transnational access and shared use. With 14 partners from 9 countries and 11 complementary RIs for both basic and applied research, the SmartCow consortium is tailored to tackle these challenges as it offers high level experts, excellent complementary facilities and services, and the appropriate biological resources to enable innovative, full-spectrum research opportunities in a coordinated approach (Figure 1).

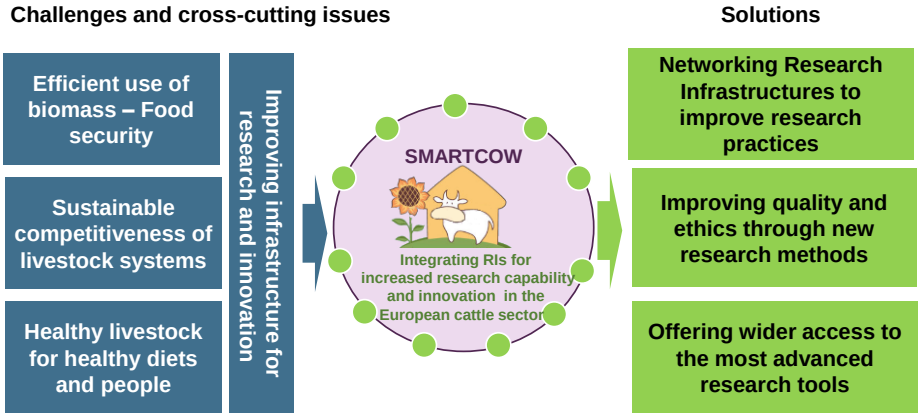

Figure 1. Overall concept of the SmartCow project

3 Research priorities for Transnational Access calls

Transnational access (TNA) calls are aimed to provide to the academic and the private sector an efficient and easy access to a wide range of cattle types (dairy, beef, different breeds and genotypes), husbandry and feeding systems (indoor and outdoor, grass or maize-based diets, use of by-products and alternative feeds…), and to the most advanced animal science technologies applied to cattle in the fields of nutrition, physiology, ethology and animal husbandry. All relevant topics and scientific disciplines that can contribute to the scientific challenges addressed by SmartCow at the animal level, are eligible to the TNA calls. The first consultation of academics and industry stakeholders leads us to highlight the following priorities:

3.1 Efficient use of feed resources

Reducing the feed/food competition in cattle production remains a priority. The full exploitation of the unique ability of cattle to convert biomass resources not directly edible for human (forages, by-products) into high-quality protein sources (milk and meat) has to be better exploited. New feed processes and feed additives are of interest to that respect. Projects that will contribute to improve the utilisation of existing non-human-edible feed resources or to test the utilisation of new by-products and new protein rich feeds will be encouraged.

3.2 Mitigation options to reduce GHG and other emissions

The down-side of the ability of cattle to valorise non-human-edible biomass is the production of GHGs, in particular methane. Projects that will contribute to reduce GHGs emissions by cattle will be encouraged. A particular attention will be paid to mitigation options aiming at reducing simultaneously GHGs and other animal based excretions (ammonia, phosphorus, particles…) and to studies addressing the trade-offs between animal performances and reducing GHG emissions.

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3.3 Efficient and robust animals, adaptation to climate change

Understanding the components of feed efficiency and robustness is necessary for an efficient selection and management of animals. How feed efficiency can be explained by intake, fermentative, digestive and metabolic processes according different animals and diets remains challenging. Understanding adaptation and resilience of animals to different feeding and management strategies but also environmental changes (as climate change) is also challenging. For example, identification of types of diet to reduce heat production during digestion, or animals that resists to heat stress are challenging questions. Integrated studies that will contribute to progress in these fields will be encouraged.

3.4 Animal health and welfare

Health and welfare of livestock animals is a major societal challenge, but also a component of production efficiency. Housing conditions, nutritional and rearing management of animals play important roles on animal health and welfare. Studies aimed at improving animal health and welfare through husbandry and feeding management will be encouraged.

3.5 Product quality

Safety, nutritional and organoleptic quality of milk and meat is also a major challenge for the sustainability of cattle production. Studies aimed at assessing and/or improving the different component of product quality in cattle through nutritional management in particular will be encouraged.

3.6 Precision cattle farming

As a cross-cutting issue, studies focussing on precision nutrition and rearing management of cattle taking advantage of the advanced technologies and the diversity of husbandry situations available in SmartCow RIs will be encouraged.

3.7 Basic science for applied and integrated approaches

3.7.1 Phenotyping and monitoring tools: biomarkers, sensors

Sophisticated methods to assess feed conversion rates in cattle as a phenotype are a prerequisite to identify efficient production environments and genotypes. Reference methods ("Gold standards") available in SmartCow RIs are expensive in terms of labour, consumables, and equipment, are sometimes problematic from an animal welfare point of view but are required for the assessment and improvement of nutrient use efficiency and reducing emissions associated with the different management systems and genotypes used in the EU.

Thus, there is a need to develop alternative methods that are easy to implement, less invasive for animals and less costly. However, their applicability at a large scale, particularly for individual phenotyping (and genetic evaluation) and monitoring, remains to be evaluated. Research activity in SmartCow will focus on the most promising proxies to predict components of feed efficiency, assessing their range of applicability across diets, and individuals. Infra-red techniques (MIR and NIR) on different matrices, mass-spectroscopy and the use of sensor-data for cow nutrition, health and behaviour monitoring will be tested. Complementary studies aimed at developing biomarkers and sensors for phenotyping and monitoring purposes will be encouraged taking advantage of the large range of breeding situations provided by SmartCow RIs.

3.7.2 Comprehensive behavioural, digestive and metabolic physiological studies in cattle

Understanding the interactions between the diet, the animal (the host) and the microbiome and their consequences on animal behaviour, feed intake and various functions (production, reproduction, immune system, welfare…) remains a scientific challenge. Further insights in the comprehension of these interaction and the underlying mechanisms will help to prepare efficient and robust cattle for the future livestock systems. Comprehensive physiological studies taking advantage of the advanced technologies available in SmartCow RIs will be encouraged.

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