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Research & innovation for a sustainable livestock sector in Europe

Suggested priorities for support under Horizon 2020 to enhance innovation and sustainability in the livestock production sector of Europe's food supply chains.

An Animal Task Force white paper

February 2013

Executive summary

The livestock sector contributes substantially to the European economy (€130bn annually), supports food security, the development of rural areas and ecosystem services. The sector encompasses both farmed animals in agricultures (meat, dairy and egg production) as well as in aquacultures (seafood or fish production). As part of a bio-based economy in Europe, the livestock sector also has major opportunities to contribute to a more sustainable, smarter and more competitive Europe. Research and innovation has made Europe's livestock sector as competitive and efficient as it is today. Continuing support is needed for research and innovation in the livestock sector if the new challenges of ensuring the supply of safe and healthy food, reducing the emissions of greenhouse gases, making better use of resources, meeting the needs of consumers in ways that are appreciated by society and contributing to a viable economy are to be met.

This position paper presents the ideas of the **Animal Task Force** about priority areas for Horizon 2020 support to the livestock sector. It is not a final statement, but rather a spur to develop dialogue with all relevant parties.

The key areas for research and innovation for contributing to a 'Better Society' and 'Competitive Industries', identified in this position paper are:

- **Resource efficiency** – resource management, better use of livestock residues, alternative feed resources.
- **Healthy livestock and people** – prevention and control, the microbiome, food and feed safety.
- **Responsible livestock farming systems** – environmental impact of livestock, robust livestock systems, animal welfare, health properties of animal products, role of livestock in society.
- **Knowledge exchange towards innovation** – precision livestock farming, implementation of 'omics' tools, knowledge exchange with farmers towards innovation.

The paper also identifies major opportunities for fundamental investments in '**Excellent Science**':

- Host-microbiome interactions.
- Long-term effects of environmental effects in early life.
- Enabling the predictive understanding of phenotypic expression.
- Immune regulation at mucosae.

The Animal Task Force

The Animal Task Force (ATF) promotes a sustainable and competitive livestock sector in Europe. We are a leading body of expertise linking European Technology Platforms and research providers for developing innovation in the livestock sector.

The members of the ATF are research providers from twelve Member States of the EU (Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Poland, Romania, Spain, Sweden, UK) and industry representative bodies that support the interests of Europe's livestock industries (EATIP, ETPGAH, EUFETEC, FABRE-TP). We work together to identify actions that are needed to foster knowledge development and innovation for a sustainable and competitive livestock sector in Europe.

For more information please visit **www.animaltaskforce.eu**.

To support research and innovation in livestock to contribute to a sustainable, smart and competitive Europe, adequate research infrastructures are essential. Priorities for research infrastructures identified by the Animal Task Force are:

- Facilitating pan-European sharing of expensive experimental research facilities.
- Developing high throughput phenotyping infrastructures – physical and virtual.
- Investment in biobanks.

PART 1

The importance of research and innovation support for a sustainable livestock systems for Europe

Introduction: the importance of supporting innovation, sustainability and competitiveness in Europe's livestock sector

Livestock's role in realising a bio-economy for Europe

Through contributing €130bn annually to Europe's economy, being 48% of total agricultural activity and creating employment for almost 30 million people, Europe's livestock sector is a major part of our economy. Livestock products make important contributions to a healthy diet and are in increasing demand globally. This creates additional export opportunities for Europe, in terms both of products and of expertise. Europe's livestock sector can play a central role in realising food and nutrition security worldwide.

In many parts of Europe the livestock industry is inextricably linked with the vitality of rural social infrastructures, but at the same time the livestock sector can present challenges to the environment and, arguably, some aspects of human health. While the livestock sector offers multiple opportunities for contributing to a smart, sustainable and competitive Europe, it will need imaginative and innovative system approaches to implement the knowledge, technologies and know-how that will equip the sector to meet Europe's challenges for the future.

Food production is a major part of the bio-economic system. Some of the challenges to be overcome call for a better understanding of how animal production can contribute more effectively to the bio-economy, deliver ecosystem services and improvements in the food chain. We need to know how we can better select for and manage animals as biological entities ('animals AS systems'); other challenges call for improvements in the design and management of the production systems and food chains of which animals are just one part ('animals IN systems'). These production systems should fit to the social, economic and technological challenges of today's society.

Research and innovation

Research, development and innovation (RD&I) has made Europe's livestock sector as competitive and efficient as it is today. This investment in RD&I must continue in the future. Creating a supportive environment for research and innovation in the livestock sector can lead to ways of production that ensure the supply of safe and healthy food, reduce the emissions of greenhouse gases and other emissions to the environment, improve the utilisation of resources, meeting the needs of consumers in ways that are appreciated by society, contribute to a viable economy, and will be an example for the world. Based on this recognition, we strongly recommend a heightened support for the livestock sector in Horizon 2020.

This position paper

This position paper addresses some important research and innovation opportunities that will make the livestock sector central in contributing to a smart, sustainable and competitive Europe. These suggestions are the shared view of all of the ATF members.

We first shortly address the priority issues to support a sustainable, smart and competitive Europe, and how these fit within the Horizon 2020 programme and the conditions needed for effective research and innovation. In Part 2, we describe the suggested research and innovation areas for topics within these issues in more detail.

Livestock in agriculture and in aquaculture

Livestock includes both animals farmed in agriculture and aquaculture. Aquaculture has rapidly developed from a pioneer sector cultivating wild fish breeds with general fish feeds into a professional mature stage of fish production based on selective breeding, customised feeding and preventive health control. Many of the topics that we suggest for support apply nowadays equally to 'livestock' in agriculture and in aquaculture. *The association EFARO has recently identified more specific key topics for scientific support to the European Aquaculture Strategy.*

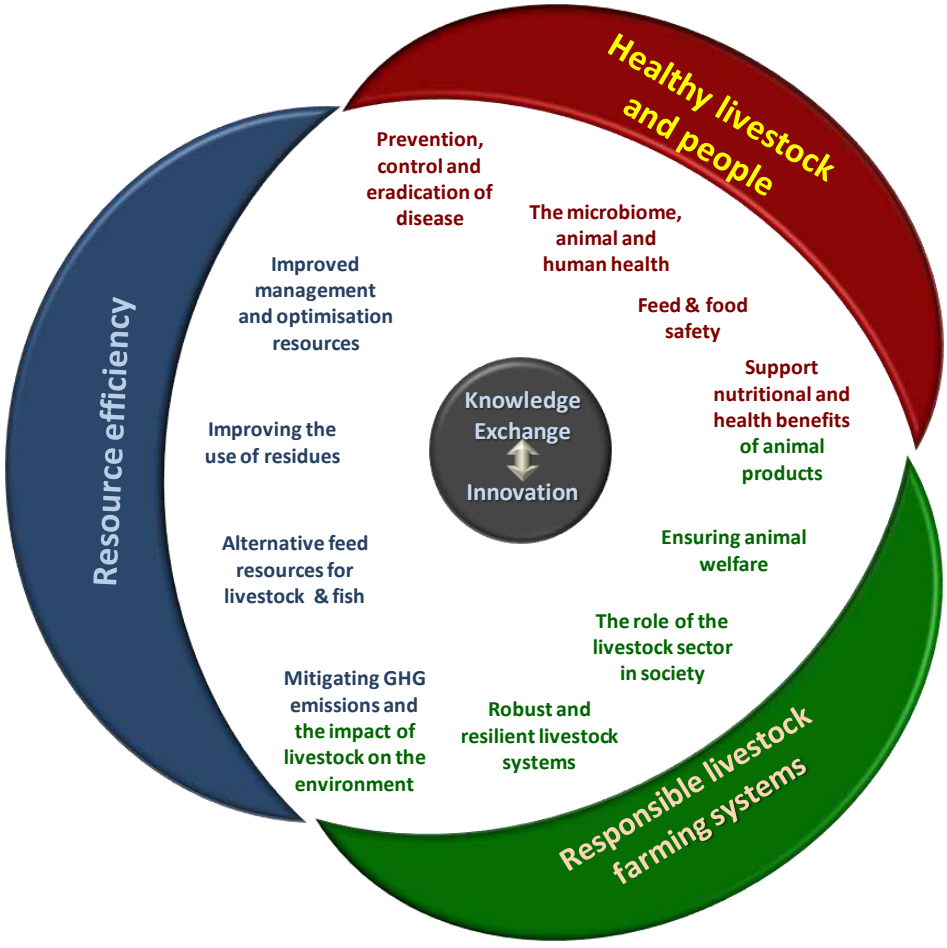
Priority issues to support a sustainable, smart and inclusive livestock economy under Horizon2020

In considering the livestock sector's contribution to a smart, sustainable and competitive Europe, we see the need for supportive action from science to enable:

A number of these issues will depend, for real progress, on developments in more fundamental understanding in a number of areas. Therefore we present a fifth issue:

In the next sections we identify the main topics to address these five issues. The hyperlinks will direct you quickly to the selected section.
For each of these topics we sketch out the background rationale, specific goals, how the goal(s) can be achieved and a comment on potential impact. These are preliminary drafts but could readily be fleshed out if it is felt to be helpful for the next stages of discussion and development of the Horizon2020 Work programme.

The first three main issues (Resource efficiency; Healthy livestock and people; Responsible livestock farming) are quite closely inter-connected. As a result some actions aimed at each one have relevance to the others. You will therefore find a level of repetition in the description of the topics. In order to give a complete overview of each of the topics, we have not eliminated this repetition at this stage.



The figure illustrates the main topics and sub-topics that we suggest as prime areas for further research. Some of the inter-linkages are immediately obvious.
All sub-topics are described in part 2 of this white paper.

Fit with Horizon2020 structure

The Animal Task Force recognises the three different pillars of the Horizon2020 programme. We see the need for investments in research, development & innovation support for the livestock sector in each of the Horizon2020 pillars of 'Better Society', 'Competitive Industries' and 'Excellent Science'.

The majority of the topics suggested in this position paper fall within the '**Better Society**' pillar of the proposed structure for Horizon 2020. While these are predominantly within societal challenge of *'Food security, sustainable agriculture, marine and maritime research, and the bio-economy*', the main topics we propose also overlap with the societal challenges of '*Climate action, resource efficiency and raw materials*', '*Health, demographic change and wellbeing'*, and '*Inclusive, innovative and secure societies'*. For each of the proposed topics we identify their fit with the Horizon2020 structure.

Many of the suggested topics demand concerted action between industry and research providers to target outcomes for a more competitive industry. The Animal Task Force uses an industry-driven approach by working closely together with relevant livestock industries to have science directed by industry. Some of the topics suggested in this position paper fall within the pillar '**Competitive Industries**' and concern new *Key Enabling Technologies* (KET) and the multi-disciplinary, knowledge and capital intensive approach needed for the development of these new KET. In several cases we would expect an industry lead in the development of RD&I actions.

For success, some specific topics will need underpinning through more fundamental research. These might be considered to fall under the '**Excellent Science**' pillar, regarding *Future and Emerging Technologies* (FET), but we would argue that science done to create a better society should be no less excellent than any other science in its quality and robustness. Nonetheless we identify some key themes that we feel stand out as being essential to fill gaps in scientific understanding to underpin actions to deliver 'Better Society'.
The adequate research infrastructures we consider necessary for research and innovation are addressed in a separate paragraph below.

Fit with other European policy

In addressing Better Society, the Animal Task force also endorses:

- The overall objectives of **CAP reform** to increase the productivity and competitiveness of the agricultural sector through knowledge creation and innovative approaches, and to improve the sector's performance with regard to the environment, mitigation of greenhouse gases and adaptation to climate change.
- The concepts for implementing the **European Innovation Partnership** whereby multi-actor groups at the local or regional level will link livestock and multifunctional farms with research and extension and other actors, to define problems and promote innovative and sustainable solutions.
- The **Smart Specialisation of regions** under the structural funds which will promote the emergence of a diversity of competitive livestock production systems, and provide economic resilience for Europe for the future, and as well as sustainable technologies and solutions which can be applied elsewhere in the world.
- The completion of the **European Research Area** which will enhance research cooperation in animal sciences and reduce unnecessary fragmentation and overlap, as well as promote researcher mobility and research as a career. In this respect also Animal Task Force values the emphasis given to the Marie Curie mobility support actions in Horizon 2020 and fully supports in particular the concepts of training networks and support for exchanges between research institutes and enterprises.

The proposals presented here fully adhere to:

- The **EU strategy on Innovating for Sustainable Growth**: A Bioeconomy for Europe by supporting the agenda of " creating a more resource efficient society that relies increasingly on renewable biological resources to satisfy consumers' needs, industry demand and tackle climate change".
- The EU Aquaculture Strategy to give new impetus to the sustainable development of aquaculture in Europe.

A stratified approach (re-search, research and implementation)

There is a danger that, in looking to the future needs for research and knowledge development, we forget the results of research activities that have already been completed, but not adopted. There are also risks that research topics are developed without a thorough assessment of the potential for impact or for potential trade-offs between developments in one area and impacts on others (in the context of integrated systems of production, or food chains). We therefore suggest that consideration is given, in the development of the Horizon 2020 programmes, to a three strata approach that includes actions in:

- *Appraisal*: Desk studies to assess current conditions (*do we know the current state of play?*), risks, gaps in knowledge provision and application, and the potential of new developments to make a difference (*what are the limits?*), considering various future scenarios and governance options and the possible trade-offs between social, environmental, economic and health objectives
- *New Research*: Technical studies and biophysical experimentation and demonstration to address specific challenges
- *Integrative design and evaluation*: Systems studies and integrative assessment of the impact of new (technical, social and economic) developments in the context of the systems or chains in which they operate. Designing, testing and demonstration of sustainable solutions, management regimes, and socio-economic models in practice, and in different climatic and demographic circumstances.
  Such evaluation will need to take account of different scales (i.e. farm-level, local and regional food chains, and European and global markets) and societal settings in order to create optimal and sustainable business models

Research infrastructure needs

We identify needs for improvement in research infrastructures, both material and virtual, for efficiency of delivery and to ensure European resources that are up-to-date and fit for foreseeable purposes. Livestock research facilities (including facilities at farm system level and high containment facilities with BSL 3-4 contingencies) are notoriously expensive to equip and maintain. There is a need to create synergies between different facilities across Europe, and, bearing in mind the range of different production systems and animal breeds, to increase research output of units e.g. by fostering transnational access and shared use. A linked network of demonstration or pilot units supported by modern ICT would greatly speed up the implementation of new technologies and practices, particularly when linked on a regional basis to groups of farmers.

Whilst high throughput phenotyping has been developed for plants and laboratory rodents it is still in its infancy for farm animals whether it be “deep” phenotyping i.e. large number of measurements from a small sample of animals or “broad” phenotyping small number of measurements on a large sample of animals. Investment in physical research infrastructure is needed both to link existing facilities and to develop new platforms for deriving relevant phenotypes. Investment also needs to be made to develop common data acquisition and storage protocols in order to facilitate sharing between European partners or between projects.

The genetic diversity of European farm animals is an invaluable resource that needs to be safeguarded through investment in biobanks of animal tissue. With the application of ‘–omics’ methodologies, such materials also provide new opportunities for understanding mammalian biology, including that of human medical significance.

Part 2

Description of research and innovation topics to support a sustainable, smart and competitive Europe under Horizon 2020

1. Resource efficiency

The main challenge for the world is feeding 9 billion people within the carrying capacity of planet earth. In the next decades, on the one hand we expect an increased demand for animal products, because of growth of the global human population, growing incomes and urbanisation. On the other hand we face land scarcity, increasing greenhouse gas (GHG) emissions and limited resources. This is a double challenge: the *efficiency* of the *use* of resources (e.g. energy, N, P, water) must increase whilst at the same time improvements in the *way we produce* these resources must be made, so that the environmental footprints for inputs are reduced and the requirements for production (e.g. health, welfare, social acceptance) are fulfilled. The livestock sector is a valuable component of the bio-economy (in food and non-food functions).

For finding ways to enhance food security in a sustainable way, we will need to pay greater attention to the efficient use of all associated resources, so that we minimise the need for resources, prevent avoidable losses ('wastes'), re-use unavoidable losses as feed wherever possible, and use manure as a valuable residual. Closing the nutrient cycles and re-use of valuable resources are central in this issue.

We will focus on four main opportunities for improving resource-use efficiency:

a) Assessing current situations and future options.
b) Improved management and optimisation of resources.
c) Improving the use of residues from livestock production.
d) Alternative feed resources for livestock and fish.

1a. Assessing current situations and future options

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Background

There are many results from past research activities that have been completed but not yet adopted or applied in practice. There is also a lack of objective assessment as to the potential for improvements that, realistically, can be made. A yield-gap analysis identifies potential for improvement and gives insight into the difference between the theoretically achievable production in diverse agro-ecological environments and the actual production.

Goal

To identify future options for a higher resource-use efficiency in livestock production. This includes:

- The development of an integrated European approach for the assessment of current resources (including food losses), risks and opportunities;
- Evaluation of options to better achieve 'sustainability' goals through better use of existing resources;
- Development of strategies to ensure long-term availability of resources that are at risk.

How to achieve this

This involves collation of databases from across the EU and the development of novel approaches to testing and constructing indexes of performance to capture resource-use efficiency and resource scarcity at an EU level. The aim is to derive measurable indexes of progress towards goals related to innovation and efficiency. Parts of these assessments should focus on potential consequences of actions to enhance 'efficiency' on more holistic aspects of livestock systems such as challenges to animal welfare and environmental management.

Impact

This work provides a valuable baseline against which to assess the potential impact of future investments. It provides, perhaps for the first time, both an assessment of the *status quo* and the potential for future change. By making the invisible losses visible, motivation to develop novel systems to reduce the losses will emerge.

1b. Improved management and optimisation of resources

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Background

While it is well known that efficiency of feed production and of feed use by livestock ('feed efficiency' for short) have major effects on the environmental impact of livestock production, we do not necessarily exploit individual differences in feed efficiency nor match inputs to needs as they change with time (and the animal's physiological state). Selection for improved genotypes can enable increased efficiency of resource-use within animals, provided that management systems are able to advantage of this gain in efficiency.

Livestock plays an important role in utilising co-products from food-, beverage and biofuel industry but this resource use gain may be at the cost of performance efficiency. Optimising strategies is needed.

Optimisation of resources also involves reducing livestock losses through disease, reproductive and metabolic failures, post-natal losses, 'failure to thrive' and premature culling. These losses are not desirable both an ethical and a resource-use efficiency point of view. Management systems, that minimises losses and match inputs to needs combined with breeding for improved resource-use, feed efficiency and traits such as longevity, health, good (e.g. non-stereotypic) behaviour, reproductive success are needed.

Grass-based systems, allow ruminants to produce very high quality proteins for human consumption from resources that are not in direct competition with humans. Ruminant-derived products remain in high demand within Europe, and globally the demands are growing. Such systems, though, have mixed benefits with regards to the delivery of environmental goods. Increased attention should be given to maximising the 'ruminant advantage' by developing grass-based systems, including improved crop rotational systems, which are productive and more environmentally acceptable.

For fish production the development of customized fishfree feeds is of utmost importance.

Goal

The development of systems of production that combine improved management to optimise feed (and other resource) use with improved genotypes and to minimise losses through disease and reproductive failures. The development of grazing systems that meet production, welfare and environmental goals.

How to achieve this

Research on the interaction between genetics and nutrition will generate new possibilities for improved feed utilisation. New practical feeding systems should be developed that take advantage of new models of variations in response to nutrient profiles together with genetic and genomic information, knowledge of temporal patterns of changing nutrient demands and host-microbiome interactions. Sensing (and other) technologies should be developed to enable precision management for feed use efficiency (so called 'precision feeding'), without the addition of unwarranted costs. Appropriate phenotypes, and appropriate indicator traits, that reflect improved resource-use efficiency need to be identified, recording methods developed (if necessary) and selection strategies designed that realise gains. Interactions between gains in resource-use traits and other important traits must be quantified.
With ruminants, research should be directed on developing diets that lower energy losses as methane, and at the same time finding strategies for improving efficiency of nutrient use that will also lower the incidence of metabolic diseases and increase fertility.

Options to combine management strategies with genetic selection to improve health and reproduction traits (including reproductive failures, post-natal losses and 'failure to thrive') should be addressed.

Development of grazing systems for ruminant that are cost effective, environmentally sound and manageable is essential in the context of the development of large scale dairy enterprises with high productive animals and in the context of remote rural areas that need to be grazed for landscape maintenance for recreation. Integrated approaches that combine improved management skills, innovative management systems and techniques and genetic improvement should be evaluated in the context of different systems of production.

Impact

The benefits impact on food security, sustainability, reducing climate change effects and realising a bio-economy. There will be improvements in biological and economic efficiency with reduced waste and emissions. Optimal solutions will recognise potential trade-offs between efficiency gains and welfare, or other important losses. Identifying 'win-wins', or at least clarifying key trade-offs will enable better decision-making.

A greater proportion of ruminant production will be delivered from grass-based systems with reduced demands on land that can be used for other purposes. The environmental impact of grazing systems will be improved (in relation to climate-changing emissions and biodiversity goals). Competition for land that can be used for purposes other than grass production will be reduced.

1c. Improving the use of residues from livestock production

Fit with Horizon2020 Structure

Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Competitive industry: Key Enabling Technologies

Background

A future livestock agriculture requires that a larger fraction of the feeds produced is converted into human edible food, and losses in the feed and livestock industry (including feed storage such as silages) are minimised so that the maximal amounts of the primary inputs are retained within the feed cycle. In areas with intensive animal production more effective manure management is needed so that, manure is turned into a valuable resource (especially of N, replacing artificial fertilisers with their high associated energy costs and of P which is a first limiting resource for all plant production and which is in very limited supply globally) instead of a residual burden. Recapturing N and P from manures will both increase resource use and restrict pollution and eutrophication of ground waters. The price of fossil fuels is expected to increase; new solutions for on farm energy production should be supported. More research is needed to further reduce the ammonium nitrogen footprint of farms.

To make progress, there is a necessity for a holistic approach where system analysis is used to assess the total effects of different practices.

Goals

More efficient recovery and recycling of food, feed, water and animal waste, including P losses and N emission reduction. Reduced energy costs across livestock farming.

How to achieve this

For better translation of resource inputs for animal feed production:

- Analysis of the feed production and utilisation chain by using Life Cycle Assessment techniques and state-of-the-art nutritional models.
- Improved feed evaluation systems for optimal animal nutrient utilisation.
- Controlling losses in the feed production chain, in particular wet feed storage systems.
- Efficient recycling of nutrients in manure and the effects of feeding management on manure quality.
- Assessment of the potential risks for re-circulating infectious agents and evaluate different disinfection and mitigation strategies in order to provide a sustainable use of residual resources.
- Assessment of scale and local systems organization to improve the efficiency of anaerobic fermentation systems of manure and other food/farm wastes.
- Assessment of the efficiency of different products from manure (from pure minerals to organic matter fractions) for closing the mineral loops.

For manures: treatments leading to the production of normalised fertilisers that can be exported from high density livestock territories to arable land; evaluation of the geographic scale that is needed for optimal effects in nutrient dispersion.

Impact

New ways of efficient resource-use at system level that reduce wastes in the feed and food chain; improvements in the re-use of nutrients in manure, and of energy stored in carbon connections, less negative environmental impact. Potential addition of high value added products from manure for other industries.

1d. Alternative feed resources for livestock and fish

Fit with Horizon2020 Structure

Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Background

Especially for Europe the development of alternative protein supply strategies that minimise reliance on imports is of strategic importance (i.e. soybean and fishmeal). There is also a need to find alternative sources of energy at large due to growing competition for energy feedstock, to allow the farming sector to continue fulfilling its primary mission, i.e. production of food and feed. Alternative feed sources such as the use of former foodstuffs need to be further investigated as well as new technologies to improve yield for feed production.

New crops, for example miscanthus, potentially can double the production of green mass per unit of arable land but generally require industrial processing in biorefineries in order to produce components that can be used for feed, food, fibre, energy and raw materials for other industries. More efficient technological approaches to achieve this are needed.

Goals

Better understanding of the quality and potential of feeds for animals, especially feeds that cannot be used for human nutrition; the development of viable systems for meeting the protein needs of livestock with much reduced imports into Europe.
Optimising the use of by-products from the human food chain for use in livestock systems, to reduce wastes.

How to achieve this

Alternative protein sources (alternative crops, insects, algea) need evaluation and development for practice... The feed sector should intensify research for those available feedstock resources that may be used 'more and better' in order to reduce its dependency on e.g. native cereals for its energy supply. This will include specific technological treatment for meeting the EU feed safety requirements, (e.g. for food products no longer destined for food use); optimising the feed use of current and emerging resources such as co-products from non-food industry (biofuels). New and better ways are needed to convert by-products from the food industry into valuable feed resources. Certain resources may contain anti-nutrient factors or contaminants at low levels. Detoxification techniques should be developed to allow safe use of these new resources in animal feed, thus reducing the pressure on agricultural resources.

Close collaboration with plant breeding research is necessary to develop new plant production systems and new crops with much higher productivity. Considerable research inputs are needed to develop efficient bioprocessing systems and develop products that ensure efficient animal production systems.

Impact

Delivery of the best strategies to develop alternative feed resources; reduced protein imports into Europe, and reduced competition between feed and food production.

Introduction of new crops, combined with biorefineries can lead to a complete new European industry, as the basis for self-sufficiency in animal feed (energy and protein), the provision of raw material for industry and bioenergy and material for human food.

2. Healthy livestock and people

We suggest a '*One Health*' approach to realise a healthy livestock sector for and ensuring feed and food safety for people.

The theme covers topics linking chemical and microbial contamination of the environment to problems concerning animal health and welfare, public health and the total food chain. Options should be pursued for developing integrated strategies for disease prevention or control and approaches for the evolution of agricultural production systems that are in tune with targets for improved consumer health and protection.
Mutual development of knowledge to improve human and animal health and wellbeing (risk assessments; diagnostics; epidemiological approaches; long-term consequences of dietary and other environmental impacts on health and welfare; zoonoses) is at the core of a 'One Health' approach with challenges at all levels of science, from discovery to implementation. The evolution of agricultural systems that promote holistic approaches to human (individual and social), animal and environmental health will demand multi-disciplinary approaches. Improved understanding of ecological and epidemiological drivers of disease emergence, persistence and spread, and applications for improved disease control through integrated strategies requires transnational as well as local actions that, again, pose challenges for multi-disciplinary effort.

By minimising disease, we also improve resource-use efficiency so these topics add to this section (above) as well as being important in their own right. Actions under this heading could build on progress made in the DISCONTOOLS project and at the same time adhere to the EU animal health strategy 'Prevention is better than cure'.

Within the One Health theme, we focus on three specific topics:

a) Prevention, control and eradication.
b) The microbiome, animal & human health.
c) Feed & food safety.

2a. Prevention, control and eradication

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Health, demographic change and wellbeing'

Background

Secure animal health is of utmost importance for human health, animal welfare and for the efficiency of production. Food safety, zoonotic diseases and the responsible use of pharmaceuticals such as antibiotics all have potential impacts on human health and wellbeing. The control of the notifiable diseases (FMD, swine fever) is of utmost importance to safeguard the trade in animals and animal products. Europe has made significant progress to prevent, control and eradicate diseases. However, new diseases arise regularly and continue to do so. Continuous risk assessment, disease prevention, control, eradication and coordinated action remains an important topic for research and knowledge development.

The possibilities to use genetic selection for improved disease resistance have been under-researched, partly because of lack of unequivocal phenotypic parameters for health and disease resistance. Also the sources of variation in the incidence of endemic or production diseases, despite apparently similar control regimes, need analysis to improve control systems.

Goal

To create operating networks and paradigms and to apply them for the appraisal of risks to European livestock (at national, transnational and local levels) and human health of endemic, exotic and emerging diseases. To develop both elements of control systems (e.g. management procedures / biosecurity; vaccines; disease resistant genotypes; feeding systems, etc.) and approaches that combine these elements into integrated systems for disease control that can be applied cost-effectively.

How to achieve this

Current surveillance networks, data bases and diagnostics need critical appraisal for adequacy in the light of current and foreseeable disease challenges. Strategies and technical approaches to overcome weaknesses/deficiencies should be developed and applied transnationally and linked to local actions. Key risks, once identified should be the target for specific measures to reduce risks, and improve prevention and control.

Necessary actions include more rapid and precise diagnostics, vaccine development (especially for diseases that modify immune responses), selection strategies for the delivery of disease-resistant or disease-tolerant (depending on the disease) genotypes and feeding systems. Genetic approaches will depend on identifying easy-to-measure phenotypic markers of health that can be assessed in large numbers of animals. A major effort should be directed at manipulating gut microbiota ('the microbiome') for enhanced immunity. This last element will require significant effort in fundamental aspects of microbiome-host interactions resulting in methods to regulate microbial populations.

Specific actions are needed to control notifiable and zoonotic diseases, and the control of the development of resistance to pharmaceuticals such as antibiotics and anthelmintics. This includes research on the mechanisms of development and selection of resistance markers, and their transfer between animals and from animals to humans. Significant effort is also needed to explore the combined impacts (and trade-offs) of combinations of these individual approaches. This should be done through simulation and, for promising strategies, evaluations in practice.

An integrated systems approach is needed for the development of customised strategies to reduce the incidence and severity of endemic animal diseases taking into account the characteristics of the pathogens, the animals, the farms (open / closed) and their environment (e.g. farm density).

Impact

Improved disease control systems and practical ways to combine actions for disease control. Reduction in the growth of antibiotic resistance; livestock genotypes and livestock systems that are more resilient to disease challenge; reduced risks to human health; reduced losses and improved resource-use. This work enables the free trade of animals and their products throughout Europe.

2b. The microbiome, animal and human health

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Health, demographic change and wellbeing'
Excellent Science

Background

In recent years it has become abundantly obvious that the microbial communities in the guts of animals and birds interact with host physiology in many ways. Interactions with immune and nutritional signalling are amongst these. Managing 'gut health' is an important part of managing health and productivity of the whole animal (or person). Optimising gut health is also of paramount importance to reduce the use of antibiotics and prevent antibiotic resistance. Specific action in this area with respect to animal and human health is needed to develop approaches for improved health in animals and man. We also identify this generic area of science as one that merits significant fundamental effort (see also 5a 'Host -microbiome interactions', proposed under Excellent Science for a more fundamental approach to this topic).

Goal

To enhance understanding of how diet interacts with gut microbes, the immune system and host genetic background, with a view to identifying routes for the implementation of this knowledge in the management of health in both humans and livestock.

How to achieve this

By using an interdisciplinary approach to develop and combine profound knowledge on food/feed science, nutrition, genetics, bioinformatics and microbiology with different targeted and global '-omics' techniques it should be possible to identify the microbial, genetic and nutritional factors and mechanisms underlying health and welfare. Research is needed to evaluate the interaction between physical properties of feed, nutrient balance in feed, and microbial populations in the gut. Associations between gut microbiota, nutrients and mechanics of immunity and increased resistance of animals to pathogens merit exploration. With access to specific biomarkers we can objectively evaluate the impact of external factors, related to specific gut diseases, environment and climate, on animal health, productivity and welfare.

Impact

Better control of feed use by animals and new understanding of the interconnected biologies of gut microbiota and the animal/human host leading to novel strategies for sustaining health and immunity. Development of new strategies to direct the microbial population in the gut.

2c. Feed and food safety

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Health, demographic change and wellbeing'

Background

Consumers are increasingly aware of the importance of having access to food that is both wholesome and safe to eat. Reputational damage to both the internal (EU) and export markets for food from animals carries heavy threats of economic loss and, in the extreme, to the sustainability of industry sectors. From both a societal and economic view it will be essential to improve safety aspects of food provision throughout the food chains that link animals to people.

Goal

The provision of tools and practical guidelines to ensure supplies of food and feed that are microbiologically and toxicologically safe.

How to achieve this

Efficient control of microbial and chemical hazards to man in the dairy and meat production is the goal of the 'One Health' approach assuring and promoting food security. Studies are needed to improve the efficient control of hazards to man. Tools and methods should be made available that will lead to a further reduction of the risks and dangers of food-borne and antimicrobial resistant pathogens in the food chain. Despite many efforts infections of known and emerging food-borne pathogens from the animal reservoir occur at high frequencies. This leads to a high human burden of disease, social unrest and great economic damage. Producers and consumers of dairy and meat thus have an interest in detecting, preventing and controlling outbreaks of food-borne pathogens. An array of tools and methods must therefore be developed and optimised to reduce the risks and dangers of pathogens in the food chain. The research in this area must follow a comprehensive approach:

- Inventory: What are the risks of particular pathogens for humans? For example, further research on the effect of low-level contamination, like mycotoxins, should be addressed.
- Measuring: What is the incidence of particular agents and toxins? Improved techniques must be developed for the control of microbiological contamination of feed and food (in particular but not only Salmonella and Clostridia).
- What is the human exposure in terms of disease burden?
- What are the transmission routes of pathogens, antibiotic resistance markers and contaminants between animals and farms? For that purpose research in technologies for an optimised measurement and prediction of substance-specific carry-over is crucial to minimise carry-over effects in feed mills.
- Attribution identification: What are the sources of infection and contamination for humans?
- Control: What are optimal methods of control and intervention? Special methods must be developed to reduce the adventitious presence of residues of coccidiostats or medicinal substances in feed for non-target species as a result of carry-over.
- Securing: How can monitoring checks be optimally carried out?

Impact

Improved animal and human health; safer food supply chains.

3. (Socially and environmentally) responsible livestock farming systems

Livestock farming systems generate valuable and desirable products for the human diet including some from resources that cannot otherwise be converted into food (grass-based systems). They also support rural communities (especially in more remote areas), contribute to sympathetic management of some ecosystems and increase biodiversity (especially in uplands) and are in growing demand, globally, to meet changing dietary preferences for ever more affluent communities. But they also pose challenges to the environment (through gaseous emissions, pollution and ecosystem damage), human health (through zoonotic diseases) and for the welfare of animals within the systems. Future farming systems need to be developed to reap the potential benefits but also to be responsible for meeting societal expectations for environmental control, human health and animal welfare.

Within this theme we focus on six topics:

a) Societal and economic expectations of the livestock sector: current situation and future options.
b) **Mitigating GHG emissions and the impact of livestock on the environment.**
c) Robust and resilient livestock systems.
d) Ensuring animal welfare.
e) Dietary aspects of animal products: support nutrition and health benefits of animal products.
f) Role of the livestock sector in the society.

3a. Societal and economic expectations of the livestock sector: current situation and future options

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'

Background

Before working on solutions for a socially, economically and environmentally responsible livestock sector, there is a need to have a sound overview of the current situation and future options. What does European and global society expect from livestock in the future? Where will livestock products feature in future diets? What are the expectations for animal welfare, alongside expectations for 'efficient' and environmentally benign production systems? Where and what are the trade-offs? We need clarification on these social perspectives as well as better quantitative data – for example for greenhouse gas (GHG) emissions (e.g. methane, ammonia and nitrous oxide) that originate from livestock production systems. Reliable data are also needed on other environmental aspects such as water consumption, acidification, eutrophication, biodiversity, the emissions of odour, particulate matter and pathogens.

Goal

Feasibility assessments, development and evaluation of technological options, assessment of social, economic and environmental consequences of innovative production systems; assessment of obstacles and options to enhance adoption.

How to achieve this

Careful analysis of future demands for livestock products, and socio-economic appraisal of expectations of the 'means of production' is needed alongside technical exploration of options for production systems. Life cycle and system analysis are sound methodologies for a complete chain analysis and focus on a set of environmental impacts. The LCA requires further development and application to support scientifically sound methodological choice enabling a harmonised assessment of improvement options for the environmental performance of the livestock sector. This, and other methods for multi-criteria assessment of livestock systems and food chains, need to be refined and applied, alongside inventory data and other relevant statistics to provide robust analyses of current situations and how they have been changing.
In order to achieve maximum impact, there needs to be strong cooperation between industry and research partners as the tools that are developed could be used for strategic management, selection of improvement options as well as corporate social responsibility reporting. The whole approach needs to be developed in the context of social expectations. A focus on those areas where options and consequences may be most challenging, e.g. upland systems of livestock production is warranted.

Impact

Overview of the opportunities for change; identification of existing research results that can be put to practice; clearer understanding of the current state-of- play and options for improvement.

3b. Mitigating GHG emissions and the impact of livestock on the environment

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Background

The livestock production sector has a clear impact on the environment: emissions to air (ammonia, greenhouse gases), soil (accumulation of phosphorus and heavy metals) and water (nitrate and phosphate leaching). Recent studies stow the significant contribution to Europe's greenhouse gas (CH_4, N_2O and CO_2) emissions and the need to reduce them. Mitigation of GHG emissions is linked to the production of feed, to the physiology of animals, especially the contribution of enteric flora in ruminants, to the way of managing animal manure, the use of energy in all parts of the production chain and to the capture of carbon in pastures. Improving nitrogen use efficiency in feed production and improving feeding strategies to reduce the required feed per kg of product are key. New animal breeding goals offer opportunities to contribute to an environmentally positive livestock sector.

Changes in manure management (e.g. manure production per animal, liquid vs. solid manure, manure composition, manure application technique) aimed to reduce the emission of a particular gas may result in higher emissions of other gases. It is therefore important to consider greenhouse gas emissions through the whole manure chain to avoid pollution swapping. Reducing nitrogen contents of manure by optimising animal nutrition is an effective way to reduce nitrogen losses from storage. Special attention has to be paid to mitigation of NH_3 emission as it also has an impact on public health.

The water-use efficiency requires a thorough analysis, especially in the drier regions of Europe, where irrigation water is used to produce feed.

Goal

Better understanding of and new ways to substantially mitigate the GHG emissions and the water footprint of the livestock sector and the development of integrated approaches to achieve GHG emission mitigation at system level.

How to achieve this

- Improve resource-use efficiency, with a focus on nitrogen-use efficiency in feed production and on the feed conversion rate in animal nutrition to reduce the environmental impact of all livestock types and systems.
- Develop improved breeding programmes for implementation of novel traits and methods, and the use of new tools and methods (e.g. genomics) to improvement of resource efficiency and reduction of environmental impact.
- Increased understanding of animal variation is a key for development of methods to mitigate enteric methane production from ruminants. Apply and/or develop new technology to monitor data (from e.g. feed intake, live weight changes, feeding pattern, greenhouse gas emissions) and combine these data with rumen microbiology and animal genetics to produce practical methods to decrease methane production without jeopardising the ruminants' unique ability to convert grass to valuable food. To make progress, there is a necessity for a holistic approach where system analysis is used to assess the total effects of different practices. Life cycle analysis (to assess system impacts of species, breeds and genotypes), improved multi-trait selection strategies (including genomic options) and better systems for data sharing and exploitation will be needed.

- Increase the knowledge about the processes responsible for greenhouse gas emissions from manure management (handling and storage of manure inside or outside animal houses, manure application into the field), in order to reduce greenhouse gas emissions by using appropriate manure management techniques.

Impact

New smart ways of mitigating GHG emissions can lead to a reduction of 20%. New traits and breeding programs that will ensure more efficient animals with a lower environmental impact.

3c. Robust and resilient livestock systems

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Background

Robust and resilient livestock systems are systems in which animal health and welfare is optimally guarded. Climate change has its effects on livestock production: climate change results in more extreme climatic conditions with longer periods of high ambient temperatures and more variation in climate during and within the season. Climate change also brings new diseases and uncertainties in feed provision. To be able to respond to the needs of consumers, the livestock sector should invest in adapting to the climatic changes and uncertainties. In current systems animals are exposed to critical transition periods like weaning in pigs, onset of lactation in dairy cattle and the early post incubation period in poultry. During these critical transitions periods the animal's adaptive capacity is hampered resulting in substantial short (e.g. diarrhoea, lung problems, metabolic diseases) and long term effects (e.g. tail biting, feather pecking, early culling) on health and welfare. A novel approach is to create robust and resilient livestock systems that aim at more gradual management transitions to help animals through these periods.

Goal

New strategies to be adaptive to the effects of climate change and secure a sustainable food supply.

How to achieve this

- Development of livestock production chains that are more resilient to large variations in feed supply from own land, but also from imported feed and co-products. The solution can be found on farm level, but also on a higher level, from regional to EU. This solution is especially important for landless monogastric systems.
- Breeding of robust animals: Development of new selection traits. New traits reflecting changing demands of clients, consumers and society at large with regard to health, welfare and longevity of animals, ecological footprint of animal production and food safety need to be developed and implemented. This includes systems of feedback of information from the production chain into the breeding programs through novel means such as automated data collection and genetic linking through genomics tools.
- Besides breeding also (feeding) management and farming systems can substantial contribute to robustness and resilience of animals. E.g. systems that promote early feed intake after incubation of chickens has shown to have long lasting positive effects on health, welfare and performance. A systematic approach to identify key factors that hamper robustness during critical transition periods is needed to find new approaches to cope with these transitions.
- Exploiting adaptive capacity of herbivores to make better use of marginal land (land on which the only thing that will grow is grass). This would mean a better understanding of adaptive capacity (genetics, early life experience, ability to cope with environmental fluctuations). Also, the need to manage this adaptive capacity, i.e. matching animals to environments, getting the right blend of animals with different capacities in a herd (leads to the notion of the adaptive capacity of a farm), and tailoring management to best exploit adaptive capacity.
- The changing climate might require adaptive systems for different climate zones (microclimates) that will allow animals to select that climatic environment that fits them best at various outside climatic conditions. Alternatively we can focus on adaptive animals that are able to withstand climatic variation (especially heat stress) by early life thermal programming of animals.

Impact

Robust and resilient livestock systems that ensure a sustainable supply of food to Europe.

3d. Ensuring animal welfare

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'

Background

Animal welfare is an increasingly important topic in Europe and in other parts of the world. Consumers are concerned about the welfare of farm animals and are prepared to make food choices on the basis of that concern. At the same time there are pressures to make livestock systems and food chains more resource efficient, safer and environmentally sound.
Addressing these aspects collectively is important to realise a socially responsible and sustainable livestock sector. Food chain actors believe that in certain circumstances, improving the welfare of farm animals above legal standards can be an added-value of product quality and therefore a mechanism for trade advantage or for assuring customer fidelity. An animal-centred view of animal welfare puts the animal at the heart of the issue, raising possible challenges to the consumer-centric view.

Production circumstances and consumer perceptions differ considerably across European cultures. Achieving 'good lives' for animals may require a variety of approaches. Maintaining a 'level playing field' will only be possible if we develop standards of well-being on the basis of animal-based indicators, and not solely on the *inputs* (or circumstances) we offer our livestock. Despite the growing awareness of animal welfare, and the increased scientific knowledge about animal-based welfare assessment (e.g. Welfare Quality®), monitoring and practical implementation is proving to be more difficult. However, several welfare schemes, retailers, farmer organisations and other stakeholders aim to implement (part of) such systems. Uniform strategies are needed to improve implementation and new research has an important role to play to improve monitoring of animal welfare outcomes.

Goal

To evolve techniques and new concepts to provide a level playing field regarding monitoring of animal welfare, in combination with other sustainability aspects (profitability, environmental load, etc.) in a global perspective. To deliver innovation of production systems to give animals good lives and to comply with the pallet of sustainability requirements. To enable the achievement of high standards of animal welfare across local production and societal circumstances.

How to achieve this

1. Support for decision-making and risk management should be developed, addressing all sustainability issues collectively, for instance by integration of animal welfare in life cycle analyses.
2. Further develop standardised practical indicators for animal welfare to be able to confirm that policies are having the desired effects at food chain, farm and animal levels. Collaboration between animal and social sciences to analyse driving forces in necessary transitions and define governance options and alternatives.
3. A toolbox of standardised health and welfare outcome indicators to be collected at suitable stages within the production cycle. Promote the establishment of methods for linking new and existing databases for future quantitative risk assessment of animal welfare. Access to such data will also open possibilities for research determining the strength of the links between specific housing and management inputs (space, use of pasture, feeding systems) and animal-based welfare outcome indicators (of nutritional status, behaviour and lifetime production).
4. Improved husbandry conditions, fostering species specific animal behaviour will require innovative thinking to include behavioural, physiological and health status considerations. Breeding, climate control, barn design and feed can contribute to the reduction of certain animal welfare challenges. For example, consider the role of diet and satiation in the social behaviour and ethological welfare of animals, improving vitality and reducing early losses, the relationship between diet and the footpad

quality of poultry and increasing the longevity and lifetime production of dairy cows, sows and laying hens.

5. Breeding robust animals is an essential element in improving animal welfare: the development of improved tools to speed up the identification and introduction of important genomic and phenotypic welfare characteristics will be a key factor in improving welfare outcomes simultaneous with other traits important for a sustainable livestock sector.
6. Research to support endeavours of production chain partners to incorporate welfare quality assurance based on performance parameters; investigation into how to communicate the benefits to consumers and society to achieve the potential added-value for the supply chain.

Impact

Better implementation of locally applicable solutions for animal welfare, whilst promoting a level playing field through a common welfare improvement. Better implementation of animal welfare monitoring and integrated product information addressing all sustainability aspects by using integrated approaches across the livestock sector. Improved animal welfare in Europe.

3e. Dietary aspects of animal products: support nutritional and health properties of animal products

Fit with Horizon2020 Structure

Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Health, demographic change and wellbeing'

Background

Animal proteins are an essential part of a healthy and balanced diet[1]. Some minerals and vitamins (e.g. zinc and vitamin B12) are only present in animal-derived food, and cannot be replaced by plant-based sources. The nutritional value and the function of animal products in a sustainable diet need to be promoted and be further improved.

Some properties of animal products, though, are not ideal for a healthy diet. Certain types of meat, are regarded as a high contributor of saturated fatty acids or cholesterol. Improvement of the fatty acid profiles of animal prooducts requires a lower proportion of saturatef fatty acids, a lower proportion of n-6 poly unsaturated fatty acids (PUFA) and a lower ration n-6:n-3 fatty acids. Options to address these issues lie in changing animals (e.g. through breeding) or their management (through feeding) to improve primary products. It has been demonstrated that the fatty acid profile of feed as a direct impact on the fatty acid profile of animal products.

Goal

To improve the nutritional value and health promoting properties of food of animal origin in sustainable production system (e.g. the fatty acid profile of animal products, the amount of essential trace-elements such as iodine or selenium and also critical nutrients such as calcium, zinc, or folate).

To assess the impact of new feed resources on the nutritional value of animal products.

How to achieve this

- Optimisation of genotypes to produce high quality products of animal origin e.g. selection strategies on animal and system robustness.
- Assessment of the impact of the nutritional composition of feed, in particular emerging feed materials on the nutritional value of animal products, in particular the proportion of n-3 PUFA, n-6 PUFA and saturated fatty acids, as well as calcium, zinc and folates.
- Analysis of the food system to support the development and evaluation of measures that will contribute to socially and environmentally responsible livestock production. This includes opportunities to translate consumer demands and information collected along the food chain (in terms of quality of food products (e.g. milk composition or boar taint)) into food system innovations including improved management and breeding practices at farm level (from consumer to farmer). Social and technological consequences of innovations need to be assessed in order to focus on those areas where options and consequences may be most challenging, e.g. upland systems of livestock production.

Impact

Improved nutritional profile of animal products contributing to healthier diets.

[1] Animal products are an important source of minerals (iron, zinc, magnesium, phosphorus and selenium), contain a range of B-vitamins (B1, B2 B3, B6 and B12), and an important source of fat-soluble vitamins: Vitamin E, Vitamin D and Vitamin A.

3f. Role of the livestock sector in the society

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'

Background

Food production is not the only function of the livestock sector. Livestock systems are an important part of a rural infrastructure, communities, landscape, and recreation. Do we really know how important livestock systems are to the resilience of community structures in different parts of Europe? Can we use better understanding to target research on livestock better for (local) community benefits?
By considering biodiversity as both a resource and an output in livestock systems, agro-ecology put foods and ecosystem integrity at the same level of priority; it can thus provide alternative dual-benefit solutions through stimulating natural processes for input cost reduction and income gain.

Farming system must meet and cope with the dynamics of consumers and citizens' concerns and demands. The quality of products should be better controlled and predicted in order to adapt products to the markets and increase their health properties. Citizens also form broader expectations regarding farm products and farming systems: impacts on landscape, on biodiversity, on animal welfare, etc. All these issues shall be addressed in an integrated way at the same time to design and develop sustainable farming systems.

Goal

To understand the contribution of livestock systems to community sustainability, or fragility, in Europe, in terms of other values than food products and to include this in the development and evaluation of production systems, for example the possibility to use livestock farms in 'green care', for recreation, for education, or for the development of rural areas.
Optimisation and implementation of traceability system on the entire production chain in animal production from farm (feed, genotype, housing system) to final products (food safety/consumers).

How to achieve this

Analysis of the impact of the presence, absence or reduction of livestock agriculture on local/regional rural communities. The importance of livestock farms for the green infrastructure and biodiversity should be quantified so that effective grazing strategies can be developed. Traditional livestock breeds could also play a role in multi-purpose production systems; thereby improving the management of domestic animal genetic resources.

In reflexive design projects involvement of stakeholders contributes to a better understanding and design of complex adaptive farming systems. Complexity in multi-level, multi-stakeholder and multi-contextual situations will be crucial for further development of livestock farming systems.

Impact

Better appreciation of the impact of livestock systems on rural communities. Better informed policy making for rural development.

4. Knowledge exchange towards innovation

Innovation has been at the heart of agricultural developments and the sector's successes in the past. Technical developments in the livestock sector for example, have made it possible for farmers to keep large herds of animals at lower labour costs, reduce wastes and emissions, reduce diseases. New technological developments and innovations will be essential for success in the future: they will ensure the sector becomes more sustainable and remains competitive.
One of the main opportunities for the future are 'tailor-made' solutions. New techniques allow for a highly specialised management systems on the farm, that can make the livestock sector one of the most technological advanced sectors in the world. ICT, precision livestock farming and 'omics' are promising new technological developments that should be invested in.

For innovations and technological developments to be successful, it is important that these are developed together with the farmers and industry. Their knowledge greatly contribute to making scientific findings valuable in practice.

Two promising emerging technological developments deserve to be highlighted:
a) Precision livestock farming.
b) Improving systems for the implementation of 'omics' tools.
c) Knowledge exchange with farmers and industry towards innovation.

4a. Precision livestock farming

Fit with Horizon2020 Structure

Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
'Climate action, resource efficiency and raw materials'

Competitive industry: Key Enabling Technologies

Excellent Science

Background

Much of European livestock production uses intensive systems designed to maximise profits. However, in recent years animal welfare and environmental concerns, matched with policy responses, has called for multi-dimensional assessment of system 'success'. Sensor-driven livestock technology offers potential solutions. Precision Livestock Farming (PLF) develops management tools aimed at continuous automatic monitoring of animal production, environment, health and welfare in real-time. Sensor technology integrated in monitoring systems allows farmers to follow the animal's status, to observe their performance or detect diseases at an early stage and to monitor the environment. With the help of this technology, farmers and veterinarians can continuously, and automatically, collect and manage the information needed to assure citizens that livestock production is safe, humane and environmentally sustainable. ICT technology can help, for example, to measure individual differences for management (e.g. of resource use) or phenotyping in support of new breeding goals.

Goal

To develop and implement future options for innovation in livestock systems that will make Europe's livestock systems more efficient and sustainable. To achieve integration of knowledge between biological, veterinarian, social, economic, engineering and ICT scientist. To combine research and development with product and service development by matching academic and industrial communities.

How to achieve this

Better support tools that combine information on individual animals with ration formulation and management routines should be developed to achieve optimal productivity and simultaneously avoid wastage. Sensors and models that can detect irregularities in such things as drinking and feeding patterns (to detect disease), social behaviours (to detect oestrus), activity (to detect disturbances in climate control), and locomotion (to detect lameness) are needed to improve the control of unwanted behaviours, and to improve the precision of management for the delivery of quality products, health, welfare and environmental outputs. Automated phenotyping technologies need to be further developed and applied to enable real-time management and to provide data for the delivery of new breeding goals.

The objective is to convert data from these tools into useful information and decision support systems for farmers and service providers like veterinarians to better manage the individual animals and the herd both on a short term basis (early detection of infections or metabolic disorders, precise feeding considering animal responses, regulation of environmental condition in building) and a medium term (improving the practices from clear historical information). This requires the development of mathematical decision support modelling (e.g. data mining and artificial intelligence), (wireless) sensor technology, ICT-infrastructure (web based, databases), standardisation (e.g. RFID) and user-centric design methods to evaluate the interest of cumulating data from different origins (biological, behavioural) and to improve the quality of the diagnosis and support. The choices for the farmer will touch the socio, economic and technological integration and discussions and should be addressed in the Horizon2020 programme.

Impact

New technological developments as described above will make the management of farmers and service providers more efficient, and allow for farming practices that reduce wastes, reduce emissions, give early detection of irregularities and improve welfare and health. However, the biggest social impact is that farmers will be supported in giving care to individual animals that are part of groups, and taking care of the circumstances in which these groups have to function. This will be a system innovation. Further development of precision livestock farming will make Europe's agricultural sector an example for the world.

4b. Improving systems for the implementation of 'omics' tools

Fit with Horizon2020 Structure
Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy'
Competitive industry: Key Enabling Technologies
Excellent Science

Background

The first achievements of the 'genomic revolution' are currently being implemented. Starting three years ago, breeding companies began to use genomics to select reproducers. Additionally farmers (mainly cattle), are on the edge of using '-omics' measures as a herd management tool. An important challenge is to relate the increasing amount of 'omic' data to 'on farm collected phenotypes':
i) Structural variation (e.g. SNP, CNV) from whole genome sequences to predict the breeding value (expected genetic performance of progeny) of animals across the range of breeding goal traits;
ii) other 'omic' measures, (e.g. metabolites, protein, RNAseq) as biological markers of phenotypes, possibly collected with the precision farming approach (see above in 4a).

Goal

The 'omics'- approach has the overall goal to improve knowledge of the genetic and genomic control of traits in order to assist in breeding decisions and in herd management. A major goal is better understanding and use of the potential of 'omics' in creating a more sustainable livestock sector.

How to achieve this

New tools need to be developed to deal with the 'omic' data explosion, methods and models need to be developed for use of genomic information in breeding programs and in farm livestock management (e.g. diagnostic tool, management of population inbreeding and population genetic variability). Breeding programs and farm management need to be re-designed to make best use of the new 'omic' era.

Impact

The availability of tools able to deal with 'omics' measures will shift the overall animal sector to a higher technological level, enhancing collaboration of European SME (as currently ongoing) involved in breeding and in farmers advising. Indeed this will increase their competitiveness and economic potential. The development of 'omics' based tools will strengthen the research-industry interaction.

4c. Knowledge exchange with farmers and industry towards innovation

Fit with Horizon2020 Structure

Better Society: 'Food security, sustainable agriculture, marine and maritime research, and the bio-economy' (and the European Innovation Partnership on Agricultural Productivity and Sustainability)

Competitive industry: Key Enabling Technologies

Background

It is generally recognised that the barriers to implementing new technologies or new management methods are best overcome by involving the end-user (the farmer in this case) in the research and development activities, and/or in defining the objectives in the first place. Agricultural innovation (i.e. the translation of research results into practical socio-economic benefit, added-value or profit) thereby moves from the traditionally linear innovation model to an interactive and participatory process of knowledge exchange, involving farmers, together with other intermediaries and stakeholders (e.g. farm advisors) to create new knowledge and innovation. Approaches that may work in one area (geographical or sectoral) may not work in others. While it cannot be expected that adoption of new or different approaches will ever be uniform across the wide spread of cultural, regional and other backgrounds that are such a rich source of diversity in Europe, there are likely to be significant opportunities for better promotion of 'best practice' or more effective local adoption. The challenge is to identify hurdles to adoption and to explore opportunities to overcome them.

Since new technologies and new types of information - such as those referred to in 4a and 4b – also open up new ways of doing things, it is important to evaluate (a) how new developments impact on existing business practices and (b) what new opportunities arise for developing more competitive and sustainable business models, considering the individual farm, the local society and the food chain or sector as a whole.

Goal

To ensure that new technologies are developed in a context which improves the uptake of research results into practice, and allows for (a) a positive impact on farm incomes and (b) the exploration of new business models within systems of production and consumption

How to achieve this

The Animal Task Force endorses the approach of the European Innovation Partnership to support the establishment of multi-actor groups at the regional level. Such groupings acting in a coordinated manner across European provide an excellent opportunity to act as 'test beds' for new technologies, on-farm management methods and new business models, taking account of the full range of livestock production systems (including multifunctional approaches), different geographic settings and bio-diversity. 'Test beds' can realised for example as 'focus groups', as on-farm participatory research or as experimental or demonstration farms with outreach to farmers. The integration of various data and information streams into practical decision support systems is seen as a key enabler to the uptake of new technologies, particularly considering remote sensing, measuring and recording, and making full use of robotics and the future internet. The linkage of facilities which are appropriately equipped to accurately monitoring resource inputs and animal performance will be necessary to carry out measurements on a large number of animals in order to derive relevant phenotypes and to take full advantage from the 'genomic revolution'.

Impact

Better cooperation between agricultural research organisations and farmers, improved uptake of new technologies and methodologies, improved farm incomes and more sustainable systems of production and consumption.

5. Opportunities and needs in 'Excellent Science'

A number of issues above will depend, for real progress, on developments in more fundamental understanding in a number of areas. Specific ones that we wish to highlight are:

a) Host-microbiome interactions.
b) Long-term consequences of environmental effects in early life.
c) Enabling the predictive understanding of phenotypic expression.
d) Immune regulation at mucosae.

5a. Host-microbiome interactions

Fit with Horizon2020 Structure
Excellent Science

Background

75% of the immune cells in the body are connected to the gastro-intestinal tract. Gastro-intestinal epithelial cells are constantly monitoring the content of the gut and communicate with the underlying immune cells. Intestinal microbes have a strong impact on this crosstalk. There is convincing evidence that intestinal microbes influence host immune development, immune responses, and susceptibility to intestinal diseases. Conversely, host factors affect the composition and metabolic activity of microbes, which in turn modulate disease susceptibility. Thus there is an intimate interaction in the gastro-intestinal tract of animals between host epithelial cells (= host genotype), the residing microbes, and the animal feed.

The innate immune system is responsible for early recognition of pathogens and pathobionts and for driving the innate and adaptive immune system in the required direction. The most dominant organ where immune development and immune recognition occurs is the gastro intestinal tract.

The intestinal microbiota of mammals is largely symbiotic in nature. In recent years it has become obvious that the intestinal microbiota profoundly influences host biology and imbalances in the microbiota composition have been linked to several intestinal diseases and events in early life may have long-term effects on the host. Functions of the gut microbial community, such as methane production (especially in herbivores) has also been shown to be dependent on the host.
Disentangling the myriad of processes that underlie these events, the factors that influence them (e.g. food or feed consumption by the host; host genotype) and the subsequent synthesis into forms of understanding that will allow this new knowledge to be applied to benefit livestock management, and human health, are at early stages. Significant support is needed for scientific initiatives that will throw more light on this area of fundamental relevance to both livestock science and 'One health' approaches to the management of health and disease.

Goal

To gain an understanding of the symbiotic functions of key members of the microbiota, their metabolism and ecology. Predictive understanding of the factors that affect interactions between the gut microbial community (and lung microbial immunity) and host function, and the means to exploit this understanding for practical benefit.

How to achieve this

Studying the effect of (genetic, environmental, nutritional) factors on immune competence and intestinal health adds a new and important dimension to the current research on the gastro-intestinal tract, which is mainly focused on the effects of feeds, feed ingredients, pro-, and prebiotics on the functionality and immunity of intestinal tissue. With regard to immune competence, research should focus on genetic, environmental and nutritional factors that influence microbiota colonization and immune development. As it is known that there is significant variation in intestinal functionality and health between animals, there is much to gain in this respect. For example, in small scale experiments so-called high and low immunological responders have been identified that differ from each other in their quantitative immunological response against different pathogens and probiotics.

Action to enable prediction of the effects of external (e.g. food and feed characteristics; physical environment) and host (genotype; physiological state) factors on the form and function of the gut microbiota. Exploration of interactions between gut microbiota, cellular function at the gut-lumen interface

and subsequent physiological signalling. The creation of European network(s) to enable integration of effort, data management and subsequent synthesis.

To investigate the impact of the microbiome on the host using transcriptomics and metabolomics and the influence of external factors (e.g. food and feed characteristics; physical environment) and host (genotype; physiological state). The effect of key species and their components or metabolites on host signalling and immunity will be investigated using automated high-throughput microscopy and specific cell pathway reporters. This approach will be complimented by the construction of metagenomic libraries and functional screens to identify new bioactive molecules which can health properties and therapeutic applications. The creation of European network(s) to enable integration of effort, data management and subsequent synthesis.

Impact

Better management of livestock for environmental, health and production benefits. Better management of human health and disease. The discovery of novel probiotics and microbial products to prevent disease and promote the health of livestock animals.

5b. Long-term consequences of environmental effects in early life

Fit with Horizon2020 Structure
Excellent Science

Background

It is more and more recognised that the pre- and peri-natal environment the animals are exposed to has large effects on performance, health and welfare of animals in later life. E.g. perinatal effects are found of nutritional state of the mother or incubation conditions in broilers effecting development and health. Furthermore thermal programming of chickens during incubation have shown to affect postnatal heat stress tolerance. Postnatal early rearing conditions have been shown to be important in the development of behavioural vices as tail biting and feather pecking. Also early nutrition seems to have long term effects on the development of the immune system. At this moment we are at the start of understanding how large the impact of early life conditions is on long term health, welfare and productivity. Research is partly hampered by the fact that different links in the production chain are not yet realising the impact of their work on the next step in the chain.

The microbiota that colonise the gastro-intestinal tract during the neonatal period play a crucial role in shaping the immune system and determining the immune competence of the animal, which in turn, determines immune responses and immune tolerance later in life. The neonatal period is therefore crucial for both local and systemic innate and adaptive immune responses later in life. Colonisation of the gut (and the development of immune competence) is dependent on external factors such as management and feed, but also on the host genotype.

Goals

1. Better understanding of key environmental factors that impact later life.
2. Quantify the relative impact of early life conditions on later health, welfare and performance.
3. Develop a chain approach to integrate this new knowledge in an integrated chain approach.

How to achieve this

Actions to improve understanding of early life impacts particularly on lifetime psychological, behavioural and reproductive outcomes. Action to promote fundamental understanding of the mechanisms governing sex differences in response. Exploration of the ability of postnatal environmental conditions to mitigate the impacts of early life challenge. The development of European-wide network(s) to bring together research in rodent and human models with livestock research to help translate basic understanding from rodent models to livestock species, and to explore the scope and limitations of early life events to alter lifetime development.

Impact

Better management of livestock to reduce losses and improve healthy development; better advice for healthier lifetimes in people.

5c. Enabling the predictive understanding of phenotypic expression

Fit with Horizon2020 Structure
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Background

A core aim of much of animal science is to understand how animals function so that it may become possible to predict what they will do if treated in certain ways. In other words: we are trying to understand how an animal of a certain genotype will respond when exposed to a particular environment, or a change in its environment. Examples include how an animal 'performs' when it is offered specific feeds, or how an animal responds to exposure to a particular pathogen, or how an animal will change its behaviour in response to some challenge. In yet other words a core aim of animal (or livestock) science is the enable the prediction of phenotypic expression.

The '-omics' revolution has delivered massive capability to describe functional processes in huge detail against a backdrop of well-defined genotypes. We have developed capability to describe phenotypes at many levels of detail. This presents, at least in theory, the potential to use information from different levels of detail to improve understanding, and subsequently to predict, phenotypic expression. Research into 'Systems Biology' is developing rapidly in the biomedical area, as well as in some model species, but it is hardly developed for livestock species. Europe has the potential to lead in developing and applying Systems Biology tools farm livestock if it can combine resources across its many research providers. No one provider, and probably no one Member State has the capacity to do all that is needed.

Goal

To create capability across Europe for the development of theory and applications to deliver predictive understanding of phenotypic expression in mammals and birds.

How to achieve this

Create a virtual network of relevant institutions across Europe to agree protocols and operating structures for standardising the collection, collation and management of relevant data. Develop the necessary data infrastructures. Support a network to develop theory and methods to combine data from different levels of detail to enable interlinkage of 'fine' and 'course' phenotypic descriptions. Identify key areas for focal development of predictive models of phenotypic expression; develop and test such models. Develop a network of physical infrastructures for recording phenotypes of functional relevance.

Impact

By creating the capability to combine information from different levels of exploration and using it to develop models of phenotypic expression, Europe will take a world lead in enabling understanding of animal function and the translation of fundamental research into practically meaningful actions.

5d. Immune regulation at mucosae

Fit with Horizon2020 Structure
Excellent Science

Background

Development of novel vaccines to prevent infectious diseases among animals and humans is a desirable application of the advances made in biotechnology and immunological understanding. Moreover, many new vaccines are urgently needed. Although the vaccine R&D path is long, the scientific advances in the past decades have made it sound to expect that new vaccines can be developed against infections which have not previously been amenable to prevention by vaccination, including endemic diseases that are responsible for large antibiotic use and production losses. It is thus realistic to expect new vaccines that i) induce longer lasting immunity, ii) provide rapid protection, iii) provide sterile immunity, iv) induce immune responses that allow a parallel surveillance of the distribution of the infection by Differentiating Infected from Vaccinated Animals (DIVA), v) can easily be applied by mass application methods, for example by mucosal routes, vi) are safe under all circumstances, and that vii) can be given to maternally immune animals.

Goal

To ensure a preventive animal health care allowing a responsible use of medicines and antibiotics.

How to achieve this

This area requires investments in knowledge development on

- Immunological Correlates of Protection, in particular protection at mucosal surfaces: It is imperative to identify protective immune mechanisms and to know which immunological or other host-related laboratory read-outs are associated with immunity and which are inevitably linked with clinical end-points.
- Antigen Discovery: The rational use of bioinformatics must lead to selection and synthesis of antigens with optimal possibility to induce protective immunity. This could e.g. employ analysis of microbial genomes with B- and T- cell epitope. Optimized design of antigens would allow protection by eliciting a multi-serotype immunogenicity. In cases where vaccines need an associated DIVA test, DIVA antigen discovery also needs to be factored in. Emphasis should also be given to non-peptide antigens such as lipids or carbohydrate antigen recognized for those diseases, such as tuberculosis, that require cell-mediated immunity.
- System Vaccinology: To accelerate a new generation of vaccines. It is imperative to develop and apply state of the art methods, for example host transcriptome analysis or proteomics in combination with bioinformatical systems of systems biology. All analyses need to be related to clinical endpoints of protection such as absence of pathology, pathogen shedding or absence of clinical signs or survival of challenge.
- Adjuvant Development: The increased knowledge on immune activation and the interplay between innate and adaptive immune responses advertises the possibility to develop adjuvants with tailored induction of preferential immune responses most suited to provide efficient immunity, including specific induction of mucosal immunity with killed vaccines.
- Genetics: Genetic factors that determine the variable response to vaccination include the highly polymorphic leukocyte antigen system, which is involved in antigen presentation. Other, but less polymorphic pathways involved are the Toll-like receptor pathway, which is involved in antigen recognition and stimulation of the immune system, and the cytokine immunoregulatory network. Knowledge of such factors may direct vaccine development towards vaccines that are effective in genetically diverse populations.

Impact

Continued development of improved and novel vaccines is the only way to secure a healthy and sustainable expansion and improvement of animal production and welfare in developing countries. Furthermore, improved and novel vaccines will have the potential to reduce contamination of animal products with zoonotic infectious agents and thus improve food safety. Vaccine R&D holds a strong potential for small or medium sized industries.