Evaluation 'Robustness of animal production systems: concept and application' (WP-065)

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Introduction

Livestock production systems (LPSs) changed dramatically during the last five decades in western societies like Europe by incorporating new knowledge and technology, after food security policies focused on higher agricultural production quantities, low food prices and high food quality (EU policy framework). As a result, agricultural systems were able to improve production quantity and quality significantly, backed by governance measures and enhanced knowledge and technology. The intensification and optimization in livestock production systems, and the global trade of feedstock and animals, have put a major pressure on animal welfare and the environment. Social acceptance of intensive livestock production systems is therefore decreasing. The currently common way of keeping and managing livestock has also proved to be vulnerable to outbreaks of infectious diseases. This has fuelled the demand for more sustainable LPS, or in other words the development of production systems that fulfil economical, ecological and social demands (EES; also called People, Profit, Planet) of all stakeholders involved.

Various approaches exist for quantifying the level of sustainability of LPS by means of sustainability indicators (SI) that cover aspects of the whole range of EES demands. Little attention has been given to variation in time and space of the SIs of LPS, particularly when faced with perturbations inside and outside the LPS. The predominant strategy in LPS to maintain sustainability and avoid unwanted variation is to control conditions and keep out perturbations. Robustness of a system is the ability to maintain sustainability in the presence of perturbations.

The objective of the project is to develop the concept of robustness of livestock production systems at various system levels and apply these concepts in practice.

Research

A PhD student worked for two years and three months, before leaving the position. His first and second work package focussed on current and new strategies for designing LPS for robustness. Livestock production systems are complex systems consisting of biological, ecological, technical and social subsystems. He reviewed approaches to dealing with perturbations and dynamic environments in each of these types of systems and distinguished the resilience approach in ecological and social systems and the robustness approach in biological and technical systems.

The third work package focussed on quantifying robustness. Robust engineering design appeared to be a promising approach to measure robustness and compare concepts and configurations. The PhD student spent four months with one of the pioneering groups of robust design to adapt the methods for LPS and analyse a set of livestock production data.

The fourth work package focussed on designing for robustness. The objective was to design and implement an experiment with a commercial hatchery for configuring the incubating and hatching settings for minimal variation in chicken quality.

Main results

Livestock production systems are hierarchical structures of nested systems. Lower system levels are biological systems and ecosystems (animals and micro-organisms), intermediate levels are predominantly technical systems (pen, barn and herd) and higher levels are social systems (production chain, livestock production sector). To enhance robustness of livestock production systems for sustainability, a specific approach is needed for each system level and these approaches should be integrated and balanced.

Resilience theory is the model for maintaining system features in the presence of perturbations in ecosystems and social systems. It is merely a descriptive approach, due to the low level of design and human control in these systems. Robustness theory is an equivalent model to describe and understand the maintenance of system features in biological and technical systems.

Robust design theory distinguishes concept design (choice of concept, components and materials), parameter design (optimal configuration of control factors given the concept design) and tolerance design (eliminating causes of variation). Technical systems of current livestock production systems are heavily based on tolerance design, but an interesting opportunity for new designs is to utilise the animal's intrinsic adaptation capacity and incorporate concept design and parameter design for over-all robustness. Concept design strategies for robustness include diversity and heterogeneity of components, functional redundancy and modularity.

A fourth level of design, called hierarchy design, is needed to ensure that higher system levels support lower system levels of livestock production systems for optimal robustness.

The only experiment is on hatching setting of brooding eggs for minimal variation in chicken quality. The results will be obtained at the final stage of the project and will be published, as well as the study on robust engineering design which is focused on parameter design.

Meaning for TransForum

This project elaborates on a change of perspective when designing more sustainable livestock production systems. The current focus is often on a higher level in standardized conditions with minimal variation in the dynamic conditions of the real world.

This project yields a generic approach to designing for robustness through concept design, parameter design, tolerance design and hierarchical design. Parameter design yields the parameters to quantify robustness. New designs should seek to utilise the intrinsic adaptive capacity of animals and prepare animals for inevitable changes that they otherwise perceive as stressful. This is the basis of livestock production with minimal clinical symptoms of disease and minimal use of medication in the presence of ubiquitous pathogens. This improvement at the lower system (animal) will allow improved robustness at the higher systems even until the production sector.

Implications for Metropolitan Agriculture

Sustainable LPSs are very important for application in or around metropolitan areas. Not only closure of all kind of cycles and minimization of logistic movements are important in order to improve sustainability of MA but also animal welfare and change of sensitivity to disturbances followed by controlling these variables with medication. It is important to listen more carefully to society in order to adapt LPSs to these wishes of society. Robustness design theory can be used in the different LPSs to understand more (natural) maintenance features of biological and technical systems. This robustness design theory has to be tested and translated to all kind of animal production systems, always starting with the animal. Based on that understanding it can be better determined where, what and how the best can be produced.

Implications for Connecting Values and Agro-Innovations System

The present LPSs are more and more unacceptable in society. So, new designs of robust animal production according societal standards will bring added value if marketing is able to make the client more sensitive for these aspects. It is observed that last few years, despite economic crisis, organic products sale has increased tremendously. In other words, the consumer is not always looking for the lowest price if sustainable animal production can be sold as an important quality trait. So, examples are needed to connect the values of robust sustainable design with altering behaviour in the whole chain. The invention of robust design followed by innovations in the different LPSs will be one of the crucial aspects of the agro-innovations system. Examples like "Rondeel egg" have to be made successful in order to change both behaviour of animal producers and consumers