Where Is the Livestock Future – Plate- or Land-Based? The Potential of Knowledge-Based, Holistic Grazing Concepts for Altering Grazing Livestock Systems

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Where is the livestock future – plate- or land-based? The potential of knowledge-based, holistic grazing concepts for altering grazing livestock systems

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Abstract

In those days, livestock production heavily depends on feed grown on arable land. Pork production needs most of arable land to gain one kilogram of human-edible protein, followed by chicken, beef production and the dairy sector. In many European countries there is a sharp decline in livestock grazing. Many dairy farms are under pressure to maximize the total annual milk output per cow resulting in increased herd sizes by occupying a minimum of land and feeding of conserved forage of silage and concentrates. Such practices reinforce the competition for arable land for animal feeding as well as grassland intensification by heavily fertilization and frequent cutting to feed the non-grazing cows. This intensification results in unfavourable changes in species composition, loss of biodiversity and important ecosystem services. Moreover, development and widespread adoption of precision farming technologies for grazing systems has been stagnated for many years. The shift towards well-balanced, sustainable grazing systems, that produces more and impacts less, is not easily feasible. Indeed, achieving such grazing systems implies several scientific, technical and socio-economic challenges. These challenges need to be solved in a holistic way in order to facilitate systems integration and transformation into practise. Moreover, the transition requires disruptive innovations for improved pasture utilization by precisely timed grazing pressure for optimizing plant recovery, reducing emissions and maintaining or even recreating structural, biological and functional richness.Thus, an integrated framework combing innovative technologies and concepts is required. The inter-disciplinary project GreenGrass focuses on the development of innovative grazing systems by using novel technologies such as virtual fences and remote sensing in order to bring cows back to pasture and to use the grasslands potential in an efficient and sustainable manner.

Keywords: livestock systems, precise spatiotemporal pasture management, precision farming, holistic framework

Introduction

In those days, we are confronted with an immense and emotionally charged plate debate. In recent decades, the keeping of monogastric species (pork, poultry) has obviously overtaken the role of ruminants (cattle, sheep). The global demand sharply increased over the last thirty years and is projected to increase further to the end of this decade, highest for poultry and pork. (OECD/FAO, 2020). Livestock systems negatively act on environmental processes and services by competing for land use with arable land, by greenhouse gas emissions, and by increasing the risk for further intensification and homogenization. The continuous intensification of agricultural systems led to considerable losses in species richness (Gossner et al., 2016) and ecosystem services (Allan et al. 2015). The sharp increase in poultry and pork production is most concerning as they mainly depend on feed grown on arable land as their ability to utilize nutrients from roughages is limited (Martens et al., 2012). However, also dairy cow systems are largely detached from grazing land. Today, feed intake of dairy cows heavily depends on silage and concentrated feed (Schingoethe 2017) from intensively managed pasture and arable land. To counteract the dependence on arable crops and to exploit grasslands' potential, we recommend bringing cows back to pastures in a sustainable manner.

For sustainable grazing systems and harmonization of trade-offs in livestock productivity and ecosystem services, precision farming technologies for managing grazing animals and delivering timely and precise information about the complex animal-plant system on the pasture are required. Although, precision farming technologies has entered the cropping industry for many years, those are still rare in managing grazing livestock. However, current advances in development of novel smart farming technologies have the potential for such precise grazing livestock management. Actually, no conceptional framework exists that adequately integrate technologies in precision livestock farming (PLF), precision grassland monitoring (Schellberg et al. 2008), information and economic evaluation and marketing concepts into a system that can be used to monitor and manage the driving factors within the grazing system and to make its outcome appropriately verified, recognized and rewarded. The shift to viable and sustainable grazing livestock systems needs a holistic, multi- and interdisciplinary framework. The project GreenGrass aims to develop a framework that assesses the potential of innovative precision sensor technologies such as virtual herding and remote sensing, information technologies, and marketing and transformation concepts for their integration into a holistic concept. Such a holistic framework needs to enable the re-connection to sustainable and viable grazing systems for the future.

Materials and methods

We evaluated scientific articles (reviews and original research) in Web of Science and databases of livestock production systems and the dairy sector to indicate the current trends. Furthermore, we searched for scientific articles for innovative precision farming technologies for pasture management. Overall, the literature research resulted in a dataset containing information of feed intake and efficiency, land-use, production and emissions for European countries and ten regions around the world, four livestock species (cattle, small ruminants, pork and poultry), and three products (milk, meat, eggs).

Results and Discussion

Pork production needs about 128 m² of arable land to gain one kilogram of human-edible protein, followed by 36 m² of arable land for chicken, 30 m² for beef production and 17 m² for dairy milk. The feed intake of pork and chicken depends mainly on maize (30% and 34%), wheat (for both 18%) and soy meal (13% for pork and 21% for chicken) all grown on arable land. Both, pork and chicken production only rely on very small amount of conserved forage. Feed grown on grassland contributes to 89 m² of grassland for beef production and 25 m² for milk production (Fig. 1). Globally, the feeding basket of the dairy cows mainly consists of roughage (67%), whereas cereals (9%), compounds (12%) and by-products such as soy meal (11%) make up a smaller feeding fraction. However, in several countries the role of pastures for cattle grazing has dramatically decreased. In those, zero-grazing and housing in tie-stalls are common for the dairy cows exceeding 50% of the dairy systems in Germany, Denmark, Italy and Spain. Whereas in Denmark, Germany and Austria fresh forage from pasture contributes only up to 7% of total feed intake, maize and grass silage complete the feeding basket up to 70% , followed by cereals, soymeal and compounds (FAO, IDF & IFCN 2014; Flachowsky et al., 2017). Grain-feeding in terms of wheat and barley and maize as well as compound feeding is generally low in e.g. New Zealand, Switzerland and the UK, but exceeds 30 % of the total feed ration in e.g. Canada, Israel, Japan, Korea and South Africa. Soymeal is widely distributed within feeding systems in e.g. France, Germany, Korea and South Africa.

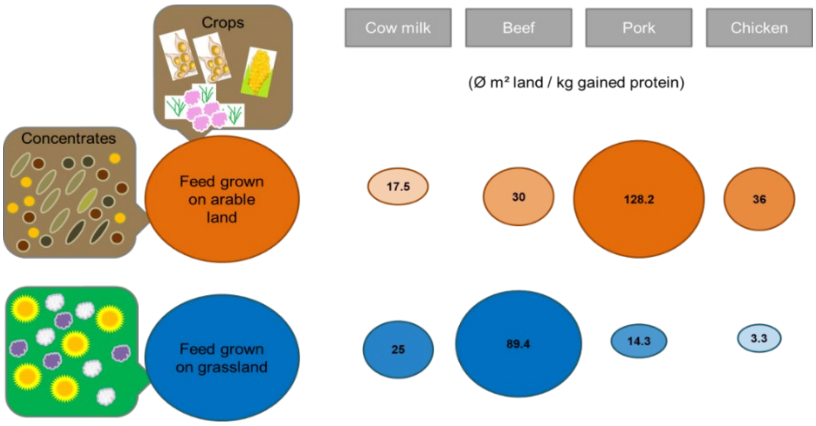

Figure 1: Land use of arable land and grassland for feeding dairy cows, beef cattle, pigs, and poultry (m^2) needed to gain one kilogram of protein (data derived from FAO, IDF & IFCN 2014; Flachowsky et al., 2017).

Perspectives for grassland management

In order to reduce the environmental risks of further expanding and intensifying the fodder production on arable land for feeding cows, sustainable grazing land-based systems with ruminants offers a good chance. Precise and efficient pasture management throughout the grazing season has the potential to largely meet the nutritional needs of cattle through fresh grass while reducing the amount of supplementary feed. To do so, the farmer needs precise spatiotemporal information on the available biomass and quality on the pasture to sufficiently feed the cows and to optimize plant recovery through precise animal distribution. However, precision farming technologies for managing grazing livestock have been stagnated over many years. Our literature research indicates that precision technologies for measuring and improving inter- and intra-paddock efficiency of pasture systems as well as for management of grazing cows are rare. Cow management is restricted to automatic milking and walk over weighing systems, herd management software and electronic cow identification systems (Gargiulo et al., 2017; French et al., 2018). However, new technologies are getting more and more available now. Actually, advances are being made in automated technologies of virtual fencing for controlling and monitoring animal movement and behaviour and remote sensing for monitoring and evaluation of grasslands biomass and habitat structures. Concerted development, combination and integration of these two techniques embedded in a holistic framework is particularly promising. Here, the GreenGrass project started to build the holistic framework for innovative and sustainable grazing concepts for the future. Recent advances in remote sensing with constantly improving sensor technology allow the spatial distribution of habitats and plant communities as well as the biomass and quality of forage crops to be recorded in high spatial and temporal resolution (**Landscape**). The data flood from remote sensor is automatically processed in a multi-level information system and simulations of the agronomic and ecological outcome of different pasture management scenarios can be performed a priori (**Information**). So, the farmer can choose his pasture management for today. Through the virtual fencing technology the farmer implements his chosen management options from his desk by setting the virtual fences within his grazing land via satellite images on his PC or smartphone. Virtual fences control the accessibility of certain pasture areas for the grazing animals at certain times. Information about virtual fences set on the farmland is forwarded to the cow through a virtual fencing collar on her neck. Depending on the purpose of land use, the fences can be set variably; biodiversity can be maintained and promoted, and at the same time, adequate quality food can be offered in appropriate quantities. Moreover, the farmer can easily and quickly adopt his management strategy through the high flexibility for setting virtual fences (**Grazing Systems**). Today's pasture utilization and habitat protection or recreation are documented via interfaces in the information systems and ensures transparency to consumers and authorities. Furthermore, marketing and pricing options for premium products and public goods are evaluated (**Market**). All relevant **Stakeholders** along the whole production chain are involved in the design and development of such an innovative grazing system facilitating its transfer into practice.

Conclusion

The grazing of ruminants is socially desirable and has a high potential to ensure the nutritional supply of animals. A knowledge-based grazing regime might be able to reduce conflicts between agricultural production and environmental protection. Modern techniques of 'smart precision farming' must be used to support the development of economically and environmentally sustainable pasture systems in a multi- and interdisciplinary approach. The project GreenGrass has recently started to develop novel and sustainable pasture concepts with ruminants under the development of innovative technologies in a transformative and integrative approach and evaluation of their practical potential.

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