Editorial

Modeling of livestock systems to enhance efficiency

Leslie McKnight[†] and Eveline Ibeagha-Awemu[‡]

[†]Trouw Nutrition, Guelph, Ontario, Canada
[‡]Agriculture and Agri-Food Canada, Sherbrooke, Quebec, Canada

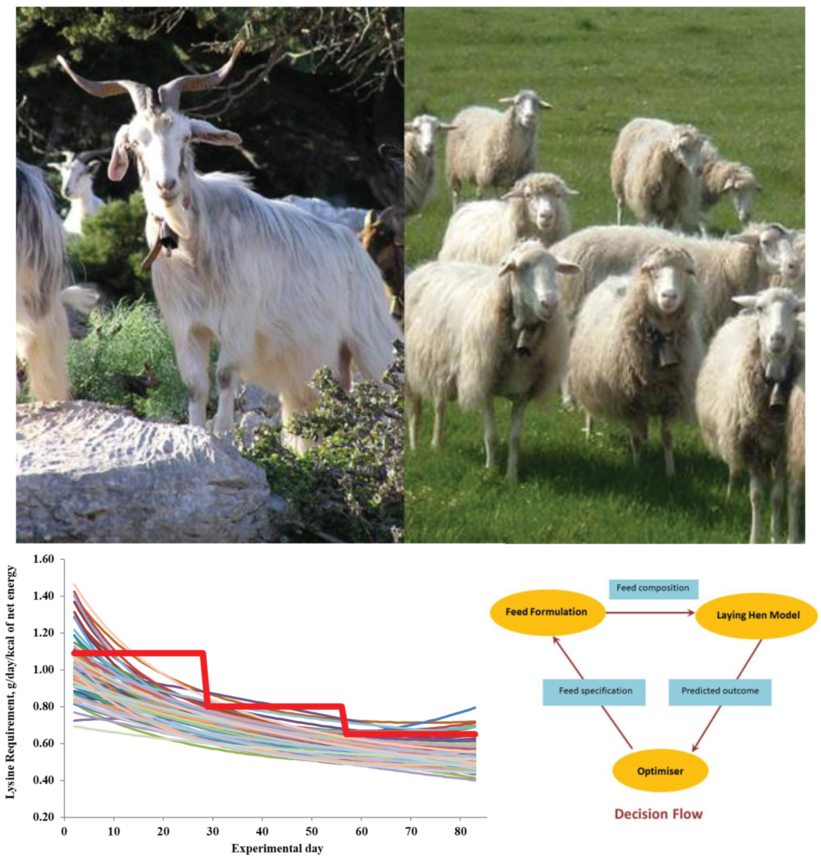

Figure 1. Example figures from this issue (provided by Cannas et al., 2019; Pomar and Remus, 2019; Sakomura et al., 2019).

By 2050, an estimated nine billion people will live on the planet. In order to feed the planet, we will need to increase food production dramatically. In parallel, the demands for animal products will surge, especially in emerging markets. In response, animal production systems must enhance efficiency at multiple levels in the face of many challenges, including a scarcity of resources, volatility in commodity prices, public concerns over food safety and animal welfare, antibiotic resistance, pressures to decrease pollution, and protect biodiversity. To be successful, animal production systems will need innovation that supports efficiency and sustainability.

Animal production systems are complex. To improve the efficiency of systems, there is a need to understand how the biology, environment, and management practices interact. Mathematical models enable the quantitative analysis and integration of data to describe these interactions and

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behavior of the system. Data come from many sources, yet there is rapid progression toward technologies that enable automation allowing for real-time data capture. In complement, the use of sensor technologies to collect large quantities of data on individual animals, broadly labeled precision livestock farming, is gaining in popularity. This "big data" approach is not without limitation. Machine methods learn from the data and use the data to make predictions without consideration of the underlying structure of the system. Mechanistic modeling, on the other hand, divides the whole system into its key components and analyzes the dynamic interactions (France and Kebreab, 2008). Assimilation of mechanistic and big data approaches represents an opportunity to optimize efficiency and profitability, while reducing environmental impacts.

This issue of Animal Frontiers, "*Modelling of Livestock Systems to Enhance Efficiency*," focuses on how mathematical models and data analytic technologies are being applied in animal production systems to improve the efficiency of production. Piñeiro et al. (2019) describe the digital technologies and how the data generated is integrated into swine management systems. Such systems transform information to guide decision-making in modern pig production. The authors illustrate these concepts with a focus on solutions for sow production, from management of the individual animal to the entire farm. Pomar et al. (2019) explain how precision feeding is an emergent practice in modern pig production. Adjusting dietary intake in real-time to better reflect nutrient and amino acid requirements can improve profitability on the farm.

Liebe and White (2019) provide a critical evaluation of data analytic tools being applied in dairy cattle management, using automated individualized feeding as an example. Although such systems are thought to optimize herd performance, in practice the benefits are not always apparent. The authors describe higher-level data analytical frameworks, including principle component analysis, neural networks, and machine learning, which can be employed to generate better predictions of feed intake to guide on farm decision-making. Kebreab and colleagues (2019) outline a new dairy cattle whole-farm modeling framework comprised of integrated modules including animal, manure, soil and crop, storage, water, energy, and economics. In this article, the animal module, which integrates animal life cycle, nutrition and production and management and facilities, is highlighted. The modeling system is comprehensive and will inform and support farm-level decisions. Finally, Sauvant (2019) defines the concepts of efficiency and robustness in dairy cattle. The author provides an in-depth examination of published empirical and mechanistic models that predict dry matter intake, digestion, and metabolism of individual nutrients.

Moving from dairy cows to small ruminants, Cannas et al. (2019) explain the key metrics of production efficiency in sheep and goat production with emphasis on how these metrics differ from dairy cattle production, "*sheep and goats are not just small cattle*." A comprehensive assessment of the evolution of nutrition models for sheep and goats used across the world is provided. The authors note that predictions of energy and nutrients for sheep and goats need improvement. An emerging strategy to improve predictions is the integration of nutrition models with data analytics, yet the limitations of big data and machine learning must be considered.

The article by Sakomura et al. (2019) is focused on optimizing the nutrient requirements of laying hens by modeling egg production. The authors apply the model using simulations of flocks of laying hens and broiler breeders providing dynamic representation of nutrient requirements. The aim of model application is to optimize economic returns on farm and facilitate decision-making.

About the Authors

Leslie McKnight is a research scientist at Trouw Nutrition and Director-at-large, Industry on the Canadian Society of Animal Science executive board. She completed her PhD at the University of Guelph and worked as a post-doctoral research fellow at the Centre for Nutrition Modelling, University of Guelph prior to joining Trouw Nutrition. Her current research focuses on the evaluation of feed ingredients and feeding systems that optimize the efficiency and health of dairy cows, poultry, and swine.
Corresponding author: leslie.mcknight@trouwnutrition.com

Eveline Ibeagha-Awemu is a research scientist with Agriculture and Agri-Food Canada at the Sherbrooke Research and Development Centre, and 2019 president of the Canadian Society of Animal Science. Her research focuses on 1) the study of genetic markers and epigenetic marks (DNA methylation, histone modifications, chromatin remodeling and noncoding RNA regulation) associated with disease and production traits in dairy cattle; 2) the role of nutrients in the genetic and epigenetic regulation of production and health traits of cattle; 3) gut microbiota manipulation to stimulate early microbial establishment, immune development, growth, and productivity of dairy animals; and 4) the role of probiotics as alternatives to antibiotic use in animal production.

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