Challenges and headaches in modelling animal adaptive response

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Application
This study highlights how modelling approaches in animal science have evolved due to the developments of data collecting methods. With the availability of new monitoring technologies, the use of hybrid models combining concept-driven and data driven approaches makes it possible to characterize and rank animals for their robustness. This characterization helps breeders to select for new criteria such as animal adaptive capacity faced with special perturbations, or more generally for their robustness faced to any perturbation.

Introduction
In the current context of changing environments and an expanding human population, breeding for animal robustness and adaptive capacity becomes an important challenge to ensure that livestock production remains (or: becomes again) robust (Nguyen-Ba et al., submitted). Breeding for robustness is difficult because robustness is a complex trait to phenotype that requires knowledge of dynamically adaptive mechanisms at different levels within a living organism. Nowadays, new technologies make it possible to collect data at different levels of organisation at a high frequency and at a modest cost. For example, data at the animal level (e.g., feed intake or body weight) can be collected using automatic feeders while, at lower level, ruminal pH can be measured continuously using a pH bolus. This progress in collecting data will help animal scientists to better understand the animal's response when facing to environmental perturbations. Therefore, it will open new perspectives and horizons to quantify the adaptive response and, subsequently, rank and select animals based on their robustness. The objective of this article is to explain how mathematical models have adapted to the technological revolution of data collection. In this study, the focus is on data collected with novel monitoring technologies used in precision livestock farming, with the main objective to quantify the animal's adaptive capacity when it is facing environmental perturbations of known or unknown origin.

Materials and Methods
Mathematical models are useful tools to decipher the relationship between data collected at different levels of time or space, to describe different animal functions, and to predict the animal's response to different perturbations. Since the seventies of the last century, several mechanistic models have been developed to study the effect of feed composition and frequency on animal performance. These models are typically based on concepts of nutrient partitioning and the efficiency of nutrient utilization (i.e., input-output relationships). Fewer models consider also environmental factors, which may be caused by the difficulty to characterize the environment (e.g., in the cases of health stressors) and/or the multiple traits with which the animal responds to changes in the environment (e.g., the response to heat stress). The common denominator of these mechanistic models is that they are concept-driven.
With the rapid progress in monitoring technologies, there is a move towards models analysing large amount of data, using statistical tools, with minimum information of the underlying mechanisms. Moreover, with technologies such as machine learning and data mining, processing huge datasets to detect periods of perturbations has become possible (Liako et al., 2018). This data-driven approach has become an alternative to the mechanistic concept-driven approach and the question arises to which extend these approaches can be or become complementary.

Results
Two cases of data recording and possible models associated to quantify animal's adaptive response will be presented to demonstrate that the frequency of data collection and the diversity of data recording at different levels of organisation will guide the modelling approach.

Conclusion
The results showed the necessity of concept driven approach, of data driven approach and also of combining these approaches to quantify the animal's adaptive response.

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References
Codrea MC, Højsgaard S and Friggens NC 2011. Journal of Animal Science. 89(10), 3089–3098.

Liakos K, Busato P, Moshou D, Pearson S and Bochtis D 2018. Sensors. 18(8), 2674.

Nguyen-Ba, H, Van Milgen, J, Taghipoor, M Submitted. Animal.