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Session B04 – Invited speaker

GrowPF – A new model for tracking growth and body composition in ruminants

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Abstract: Livestock production models are a valuable tool to help producers understand the complex interactions of animal and plant biophysical processes and the implications of their decisions on herd dynamics, sustainability, and profitability in the face of rapidly-changing markets and environments. However, to accomplish these goals successfully, models need to be able to consider multiple aspects from a whole-farm perspective. Fundamental to this is a solid understanding of animal growth and reproduction, and the ability to represent these in the context of modern systems and genetics.

Keywords: *Livestock, Crop Livestock Enterprise Model, metabolism, whole-farm, modelling, CLEM, ruminant nutrition, APSIM, Fat, Protein*

The Crop Livestock Enterprise Model (CLEM, Liedloff et al. 2025) has been developed to address these issues. CLEM is part of APSIM Next Generation (APSIM Initiative, Holzworth et al. 2018) and builds on previous work of the Integrated Assessment Toolkit (IAT, McDonald et al. 2019) and Northern Australia Beef Systems Analyser (NABSA, Ash et al. 2015) to create a whole-farm modelling approach capable of simulating livestock production systems, whether grazing or pen-fed. The model uses an individual animal-based approach, allowing users to explore the influence of individual characteristics and selection/improvement on system outputs, as well as the stochastic nature of breeding effects and mortality across herds. The model uses a modular approach allowing the user to determine the complexity required, and a flexible reporting system for visualization and analysis of results. These features made CLEM the ideal system for developing a new livestock growth model, Grow Protein and Fat (GrowPF).

The livestock growth model originally provided with CLEM is based on the work of Freer et al. (2007, 2012) and uses the model's monthly timestep. The new GrowPF model builds on this existing framework and incorporates several new features such as the ability to use a daily timestep and dynamic tracking of body composition to explore the cumulative impacts of changes in nutrition and relative maturity on fat and protein stores in the animal. Models using the approach of Freer et al. calculate daily change in liveweight, which is then partitioned into changes in protein and fat, but there is no cumulative tracking of these changes: i.e., if the model says an animal loses 50 grams of protein on a given day, the model has no way of knowing if the animal has that much available to lose, or how this would affect tomorrow's ability to gain or lose protein.

Our approach is to address these issues by explicitly modelling 3 pools: body protein, wool protein (where needed), and fat, with the change in liveweight defined as the sum of the changes in these pools over time. This method adapts the logic of Oddy et al. (2024), adding the ability for fat and protein to move in opposite directions. Previous models limited fat and protein to changing in the same direction: i.e., if protein went up, so did fat, albeit with different slopes. However, on-farm there are cases where animals will mobilise fat but not protein, or vice versa, such as in late pregnancy, early lactation, or at feeding levels near maintenance (Dougherty et al. 2022, Oddy et al. 2024). Instead, GrowPF allows fat and protein stores to change as functions of their own respective drivers for growth, as limited by the animal's nutritional state and metabolic demands. This provides full accounting of the flows of energy and protein through the animal from across its lifespan, including the feedback loops between existing protein and fat stores and the animal's intake and metabolism.

GrowPF also draws on Oddy et al. (2024)'s concept of defining mature size based on both standard reference weight (SRW) and target mature protein mass (Pmax). An individual's SRW is generally defined as their asymptotic mature weight once they have reached skeletal maturity, at a midpoint body condition score (BCS). However, breeds with the same SRW may differ in fatness at maturity, even when measured at the same BCS.

Pmax addresses this by creating a target for mature protein mass, representing a specific genotype's maximum potential for protein accretion and therefore the animal's target maximum total protein mass at SRW. Additionally, GrowPF tracks the highest proportion of Pmax previously attained: should an animal lose protein mass due to nutritional or metabolic restrictions, the animal will prioritise gaining protein back to its previous level once the restriction is lifted, thus representing the effects of nutritional restriction on composition of gain and overall body reserves. This feature is key to improving the linkage between body condition and breeding success. Other models using the Freer approach, including CLEM, use relative condition, based on the animal's weight, to predict breeding success, but this approach doesn't capture the fact that reproduction requires both sufficient fat and protein stores, or the differences in outcomes should one or the other be limiting. In GrowPF the animal's fat and protein stores will determine the outcomes of pregnancy and lactation, providing a better understanding of how quickly cows can rebreed after giving birth, how limits to energy vs protein supply affect lactation, and the effects of successive pregnancies and lactations on whole-body protein and fat reserves, allowing for more targeted herd management and improved understanding of reproductive potential.

Adding GrowPF to CLEM provides a new understanding of body composition and its implications for herd management, allowing users to better consider the effects of nutrition and management on animal growth, reproduction, and productivity from a whole-farm perspective. This updated growth model benefits from CLEM's tracking of individual animals to better explore the impacts of between-animal variation and selection for different traits on both individual performance and whole-farm productivity. The GrowPF model has been validated for growing cattle and sheep (Dougherty et al. 2024, 2025) and is currently being validated for grazing animals on native pasture. These improvements in simulating the effects of temporal variation in feed quality on long-term body reserves and reproductive cycling allows users to better represent livestock production systems, enabling them to explore the best management practices and strategies for their specific situations.

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