4.1 - Mechanistic modelling of enteric CH_4 production

Jointly supported programme: NZAGRC & SLMACC

Objective Leader – Dr David Pacheco (AgResearch)

The development and evaluation of methane mitigation strategies requires a mechanistic understanding of the processes influencing methane formation in the rumen. The ability to predict responses in methane formation from NZ ruminants will improve inventory and accounting of GHG, and is fundamental to inform research and policy.

Responding to global interest in climate change and environment impact, existing mathematical models of ruminal digestion and animal metabolism have been enhanced in recent years to include prediction of methane production. The two major research efforts in mathematical modelling of methane formation[1] in the rumen have a common paradigm of methane formation. Namely, methane formation is a function of excess hydrogen resulting from reactions in which hydrogen is produced and reactions in which hydrogen is utilised. Such reactions have been more or less adequately described for dairy cattle only, with predictive models for other ruminant stock classes less well described. In addition these models have been parameterised using diets that are untypical of the forage dominant diets consumed by New Zealand ruminants.

This project will focus on two areas for improving the prediction of methane production. Firstly, we seek to identify the sensitivity of methane prediction to the digestion and metabolic processes currently represented in models of rumen metabolism, particularly in relation to forage based diets and how these processes are likely to vary among ruminant species. This step aims at improving the "top-down" approach currently used in models of methane production. Thus, the critical aspects of rumen digestion on hydrogen production and utilisation are parameterised for relevant stock classes and dietary conditions in New Zealand. Secondly, advances in the understanding of methanogen metabolism, growth and population dynamics create the opportunity for improving the prediction of methane from "the bottom up" by including a better representation of the mechanisms controlling hydrogen utilisation by methanogens. Outputs from this research will include an improved mechanistic representation of methane production across a range of ruminant species, which can be used to improve current whole-animal models.

4.1 – Progress in 2009/2010

A series of workshops were organised by AgResearch researchers with key national and international researchers working in the area of methane modelling.

[1] The Dutch-Canadian model based on the work of Bannink, France, Kebreab, Dijkstra and Mills; and the American whole-animal model "Molly" based on the work of Baldwin, and later improved by McNamara and Hanigan.

The first workshop was held on March 25, 2010, in Hamilton, New Zealand. This workshop established the current state of methane modelling in New Zealand and cemented the establishment of the working group for this Objective.

A second workshop was held on April 9 and 12, 2010 in Hamilton, New Zealand. This workshop included the participation of Dr. André Bannink, (Animal Science Group, Wageningen University). We identified and prioritised key processes that need to be adequately described for forage diets and animal species to achieve the goal of a multi-species mechanistic model of rumen methane formation.

The third workshop was held on April 20, 2010 in Sydney, Australia to discuss trans-Tasman collaboration and funding opportunities with Australian researchers from NSW and Victoria.

These workshops have moved our thinking from trying to re-parameterise current models to fit New Zealand diets, towards reviewing and quantifying key processes underpinning methane formation in the rumen, which may or may not be necessarily represented in current mechanistic models.

4.1 – Progress in 2010/2011

A review of the key ruminal processes involved in methanogenesis has been completed. A key finding is the identification of outflow rate as a central and influential process in all models. Thermodynamic principles are also critical for a mechanistic understanding of the processes of fermentation (e.g. VFA production) and subsequent methanogenesis in the rumen. However, their implementation in a modelling framework depends on suitable estimations of pool sizes and substrate concentrations, which in turn are affected by the outflow of solid and liquid material from the rumen. These data are not currently well estimated for forage fed ruminants.

The main goal of this exercise was to identify the processes that have a strong influence in the prediction of methanogenesis in the rumen. Now that this has been completed we are well placed to define the key areas we will concentrate on for this modelling project and undertake future experimental work based on a 'first principles' approach.