

Title	Refining direct fed microbials and silage inoculants for reduction of methane emissions from ruminants
Countries Involved	New Zealand (AgResearch), Ireland, France, Netherlands
Objective	This proposal is focused on implementing the use of lactic acid bacteria (LAB) as an approach to reduce methane emissions from ruminant livestock. The goal will be to refine current on-farm LAB technologies such as direct-fed microbial supplements and/or silage inoculants, currently used to increase production and improve health of animals, with a methane-reducing benefit.

Title	Reducing hydrogen and methyl-compound production to mitigate rumen methane
Countries Involved	New Zealand (AgResearch), Japan, USA
Objective	To target microorganisms that produce the hydrogen (H ₂) or methyl (CH ₃)-compounds which serve as primary substrates for methanogenesis, with the aim of finding specific ways to reduce their supply of substrates to methanogens via inhibition of their growth or enzymatic activities.

Title	Deep sequencing the rumen microbiome
Countries Involved	New Zealand (AgResearch), France, Australia, USA
Objective	Deep metagenomic and metatranscriptomic sequencing was carried out to identify the microbes affecting methane levels in sheep and cattle (low and high emitting animals). Data generated by the programme is being used in on-going CH ₄ mitigation work in the PGGRC and NZAGRC CH ₄ programme and new research projects. To target microorganisms that produce the hydrogen (H ₂) or methyl (CH ₃)-compounds which serve as primary substrates for methanogenesis, with the aim of finding specific ways to reduce their supply of substrates to methanogens via inhibition of their growth or enzymatic activities.

Title	Accelerated discovery of methanogen specific inhibitors
Countries Involved	New Zealand (AgResearch), Australia, Japan, USA
Objective	A high-throughput screening method for rapidly identifying novel anti-methanogen inhibitors was developed, based on the efficient testing of inhibitors against methanogens growing in 96-well culture plates. The

	technique is much simpler, cheaper and more robust than traditional techniques and has sped up the screening of compounds used in the PGGRC/NZAGRC methane emission vaccine research program.
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Title	Fast-tracking development of methanogen-specific inhibitors
Countries Involved	New Zealand (AgResearch), USA
Objective	The project successfully developed a small scale rumen fluid-based assay that is much simpler, cheaper and more robust to use than traditional techniques. This has sped up the screening of compounds that can then be transferred into the PGGRC/NZAGRC methane emission vaccine research program. The project also identified possible compounds that are still active in rumen fluid, which are now being tested as part of the vaccine programme.

Title	Vaccine to reduce methane emissions in ruminants
Countries Involved	New Zealand (AgResearch), Australia
Objective	Adjuvants (substances that trigger production of antibody responses to the vaccine) were identified that may produce a vaccine targeting methanogens in the rumen. A commercial partner can now be brought in with PgGRC managing this process.

Title	Good practice guidelines for enteric methane measurement methodologies
Countries Involved	New Zealand (AgResearch)
Objective	To update the existing 'Guidelines for use of sulphur hexafluoride (SF6) tracer technique to measure enteric methane emissions from ruminants' (2014); and develop a new guideline on new methodologies for measuring CH4.

Title	Enteric methane mitigation using nanobeads
Countries Involved	New Zealand (AgResearch)
Objective	The purpose of this project is to develop a cost-effective and nontoxic biopolymer nanobeads delivery system for reducing enteric methane emissions from ruminant livestock.

Title	The development of a rapid, low cost measurement system
Countries Involved	New Zealand (Dairy NZ)
Objective	To develop a fully automated, validated low cost system and protocol for routine high throughput estimation of methane emissions from dairy cattle that reflect emission differences between animals; along with a pipeline/protocol for analysis of these measures incorporating correlated phenotypes and predictors, a working document detailing system design, costs and results from initial testing, peer-reviewed publication(s).

Title	Using naturally-produced lovastatin to reduce methane emissions
Countries Involved	Led by Malaysia, New Zealand (AgResearch)
Objective	To demonstrate that the use of naturally-produced lovastatin is a viable mitigation technique to reduce enteric methane emission from ruminant production system based on the utilisation of crop residues, by carrying out an in vivo dose response study and a study on the effects of lovastatin on animal health and safety of the products.

Title	Rumen bacterial taxonomy project
Countries Involved	New Zealand (AgResearch)
Objective	The purpose of this project is to agree the nomenclature for current groups of rumen bacterial 16S rRNA gene sequences from taxa identified as being abundant in the rumen. This will include analysing datasets generated in the earlier Global Rumen Census project as well as datasets from international collaborators and those being generated in various domestic methane mitigation programmes.

Title	SheepFeed
Countries Involved	New Zealand (AgResearch)
Objective	To contract the purchase and validation of a SheepFeed system, such as the identification of naturally low and high emitting sheep for use in selective breeding. A SheepFeed system validated to pastoral grazing systems and available for use by New Zealand researchers would benefit the overall research programme.

Title	Identification of low methane emitting phenotypes
Countries Involved	New Zealand (AgResearch)
Objective	Achieved the expansion of a strong international interest group (the Animal Selection, Genetics and Genomics Network) and a “white paper” on reducing methane emissions from ruminants; identified a number of chromosomal regions and pathways possibly affecting methane emissions or methane yield; and showed that genomic selection for methane emissions is achievable and viable.

Title	Global Rumen Census
Countries Involved	New Zealand (AgResearch)
Objective	742 rumen and foregut samples of 32 different animal (sub-)species originating from 35 countries and next-generation massively parallel bar-coded sequencing methods were used to survey the global diversity of rumen bacteria (via 16S rRNA genes), methanogens (via 16S rRNA genes), and protozoa (via 18S rRNA genes). Rumen microbial communities were broadly similar, despite the range of ruminants, diets, and geographic locations.

Title	SF6 tracer technique best practice manual
Countries Involved	New Zealand (NIWA), Argentina, Australia, Brazil, Canada, France, Ireland
Objective	Best practice guidelines and protocols for the measurement of methane emissions by individual animals using the SF6 tracer technique have been developed, ensuring comparability of global methane emissions research results.

Title	CH4 chambers technical manual
Countries Involved	New Zealand (AgResearch), Australia, Belgium, Denmark, Germany, Spain, Switzerland, UK
Objective	A comprehensive technical manual of alternative CH4 respiration chambers designs, their performance and operation has been developed, ensuring comparability of global methane emissions research results.

Title	Global database of rumen methanogens and homoacetogens
Countries Involved	New Zealand (AgResearch)
Objective	A global database of rumen methanogens and homoacetogens from rumen samples obtained from a diverse range of locations and farming situations but analysed using an agreed common methodology has been developed. This database will aid further research into methane emissions by identifying the methanogens that are commonly present in the rumen of various species.

Title	C-Lock methane measurement system
Countries Involved	New Zealand (Dairy NZ)
Objective	The development and calibration under New Zealand conditions of an existing automated CH ₄ measurement system (C-Lock/GreenFeed system) for rapid estimation of emissions from cattle at low cost has been carried out. A further project is currently underway to upgrade these units.

Title	Development of a rumen bacterial taxonomy
Countries Involved	New Zealand (AgResearch)
Objective	The taxonomy for bacteria suitable for analysing rumen microbial community sequence data has been developed. Canada and the United States were also involved.

Title	A rumen sub-model to capture system productivity benefits of methane mitigation
Countries Involved	New Zealand (AgResearch), Australia
Objective	Australia: to use a pre-existing rumen model and link it to animal production. New Zealand: to test the existing model and revised forms against the New Zealand datasets to identify diet and animal situations in which the model performs well or poorly and so identify aspects of fermentation in the model needing to be modified to improve performance.

Title	Understanding the development and control of stability in the rumen microbiome as a basis for new strategies to reduce methanogenesis
Countries Involved	New Zealand (AgResearch), Ireland, Spain, Belgium, Germany, UK, France
Objective	The project identified and exploited long-term effects of short-duration dietary treatments on methane production, rumen function and responses to methane mitigation interventions at a later stage. The focus was on manipulations in early life, when the rumen community is developing, but also work on other diet transitions.