BRIEF COMMUNICATION: Rate of Genetic Gain for Methane Emissions in a Maternal Production Flock

F Booker*, McEwan, JC & SJ Rowe

AgResearch Ltd, Invermay Agricultural Centre, 176 Puddle Alley, Mosgiel,
*Corresponding author email: fern.booker@agresearch.co.nz

Abstract

Global warming attributed to methane emissions from livestock presents a significant global challenge to the agricultural sector. Although opportunities exist in intensive systems for feed additives, the only proven tool for permanent mitigation at a national level, across sectors, is animal breeding. It has been reported that enteric methane emission is a heritable trait, and that breeding is an effective mitigation strategy. The impacts of incorporating methane into existing breeding schemes are less understood. Selection for reduced methane emissions (measured by portable accumulation chamber; PAC) along with increased productivity (NZMW+FEC+DAGS+MEAT index) was implemented in 2017 in the Woodlands 2638 flock. The economic weighting for methane was NZ$100/tonne GWP100 CO2e. The economic weights for existing traits were unchanged. Breeding value trends per year for flock 2638 and the Dual Purpose industry average for born 2018 to 2023 progeny were estimated as -0.95 vs -0.01%, -0.2 vs 0.06%, 0.18 vs 0.12kg, 133 vs 89 cents, and 185 vs 110 cents for PACCH4gBV%, PACCO2gBV%, LW8gBV, NZMW and NZMW+FEC+DAGS+MEAT indexes respectively. Gene flow calculations suggest that methane emissions could be reduced by 27% by 2050 while increasing per head productivity by $51.80. Continuation with current industry progress would achieve a 2.8% reduction in methane emissions and $30.80 increase in per head productivity. In summary, methane emissions can be reduced while also increasing productivity faster than current industry progress.

Keywords: methane; breeding; sheep; PAC

Introduction

Methane (CH4) emisions from ruminants is one of the largest sources of anthropogenic CH4 globally (Schaefer et al. 2016). The New Zealand government has set a target of a 10% reduction in methane emissions by 2030, with further reduction of 24-47% by 2050 (Paris Agreement 2015). There are opportunities in more intensive farming systems to reduce methane emissions through the use of feed additives, but in New Zealand's extensive pastoral-based system these additives are less useful. Methane emissions from sheep determined using Portable Accumulation Chambers (PAC) have been shown to be moderately heritable (Jonker et al. 2018), giving a permanent and effective mitigation strategy.

Research suggests that breeding for lowered methane per kg DMI does not have negative effects on other production traits, and may in fact have a positive impact on some other traits such as fleece weight (Hickey et al. 2022). To date, there is very little known about the effects of incorporating methane selection into breeding schemes whilst still selecting for genetic gain in other production traits.

Materials and methods

Sheep Improvement Ltd (SIL) Flock 2638 is a maternal genetics research flock based at AgResearch Woodlands, Southland, consisting of 750 ewes plus replacements. It uses 20 rams per year, of which 2 are repeat matings and 4 are link rams from other flocks. The flock began primarily as a Coopworth flock, but over recent years has developed into a maternal composite. Production traits on this flock have been collected and recorded as per the SIL Best Practice Guide (Beef and Lamb Genetics 2016). Methane emissions were measured through PAC as per the protocol described by Jonker et al. (2018). Flock 2638 has been selected on a custom economic index incorporating methane, commencing with born 2017 lambs. The index is NZMW+FEC+DAGS+MEAT+PAC. (Anon 2022). To incorporate PAC breeding values into an economic index, methane has been given a cost of $100 per tonne of GWP100 CO2 equivalents. This results in a cost of $6.82 per gram/day of PAC methane breeding value (PAC CH4 gBV g/d) or $0.51 per percent reduction when expressed as PAC CH4 gBV%. Average breeding values and indexes for the born 2017 to 2023 progeny for flock 2638 and all dual purpose flocks were retreived from SIL in June 2024 (Job No 41674) and the genetic trends and averages estimated by linear regression.

Results and discussion

Selecting for reduced methane

Figure 1 shows the means and change that has been made in the PAC methane emission gBV% in flock 2638 relative to all dual purpose recorded sheep since 2017. Starting from similar values, flock 2638 has been declining by -0.95% per year on a per animal basis while for dual purpose animals the decline has been only -0.01% per year. For the production component of the selection index (NZMW+FEC+DAGS+MEAT) flock 2638 born 2017 progeny averaged 2937 cents in 2017 compared to 1347 cents for the average dual purpose animal. Over the next 6 years the trend was an increase of 185 cents per year for flock 2638 compared to 110 cents per year for the average dual purpose animal. A difference in the rate of productivity gain of 67%.

Many New Zealand dual purpose sheep are selected only on a simplified production index, New Zealand maternal worth (NZMW) incorporating reproduction, survival, growth and adult size traits. When comparing these traits, flock 2638 born 2017 progeny averaged 2294 cents in 2017 compared to 1256 cents for the average dual purpose animal. Over the next 6 years the trend was an increase of 133 cents per year for flock 2638 compared to 89 cents per year for the average dual purpose animal. A difference in the rate of gain in favor of flock 2638 of 49%. The current PACCH4gBV (grams of methane emitted per day per animal from PAC data)is expressed on a per animal basis rather than a per kg of dry matter intake (DMI) basis so changes in CO_2 emission breeding values (a reflection of intake) and liveweight are also of interest. A common industry statement is that selection for lower methane emissions will simply result in smaller animals.When comparing carbon dioxide emission breeding values, flock 2638 born 2017 progeny averaged -1.4% in 2017 compared to -0.1% for the average dual purpose animal. Over the next 6 years the trend was a decrease of -0.2% per year for flock 2638 compared to an increase of 0.06 per year for the average dual purpose animal. Although part of this difference could be changes in digestability, it suggests feed efficiency is unchanged or perhaps slowly improving. In contrast, when growth in the form of breeding values for liveweight at 8 months of age (LW8gBV) are examined, flock 2638 born 2017 progeny averaged 4.08kg in 2017 compared to 3.86kg for dual purpose animals. Over the next 6 years the trend was 0.12 kg per year for flock 2638 compared to an increase of 0.18kg per year for the average dual purpose animal. This suggests a modest decrease in the rate of gain in liveweight by the inclusion of not only methane but also the disease traits FEC and DAGS and MEAT in the flock 2638 selection index. However it did not result in a decrease in liveweight.

In summary the results indicate that it is possible to select for a reduction in methane emissions, while still maintaining genetic progress in other production and health traits at a rate greater than the industry is currently acheiving. The reasons behind this are not simply measuring methane via PAC, but also include the use of genomic selection, better breeding scheme design and greater emphasis on the selection index when selecting flock replacements.

Selective breeding to hit emissions reduction targets.

We next investigated if the rate of reduction in methane emmissions that has been seen in flock 2638 over the past 6 years was sufficient to acheive New Zealand's targeted reductions by the year 2050. Assuming the rate of reduction of –0.95% /year as has been shown in the flock so far will be maintained, and accounting for the genetic lag for use of rams in commercial flocks, this would result in a 27% decrease in commercial flocks methane emissions by the year 2050 while increasing per head productivity by $51.80. Continuation with current industry progress would achieve a 2.8% reduction in methane emissions and $30.80 increase in per head productivity. In summary, methane emissions can be reduced while also increasing productivity faster than current industry progress. While this analysis does not account for all factors it indicates that genetic selection, if appropriately applied, could contribute a substantial proportion of the currently proposed reduction in methane emissions from the sheep industry while also improving their productivity at a rate faster than currently being acheived and without any change in ewe numbers. The fact that these results have been obtained from a SIL recorded flock and using the current industry breeding evaluation system adds strength to the fact that this is possible using existing industry tools available to all New Zealand breeders. The challenge is its rapid adoption by the industry.

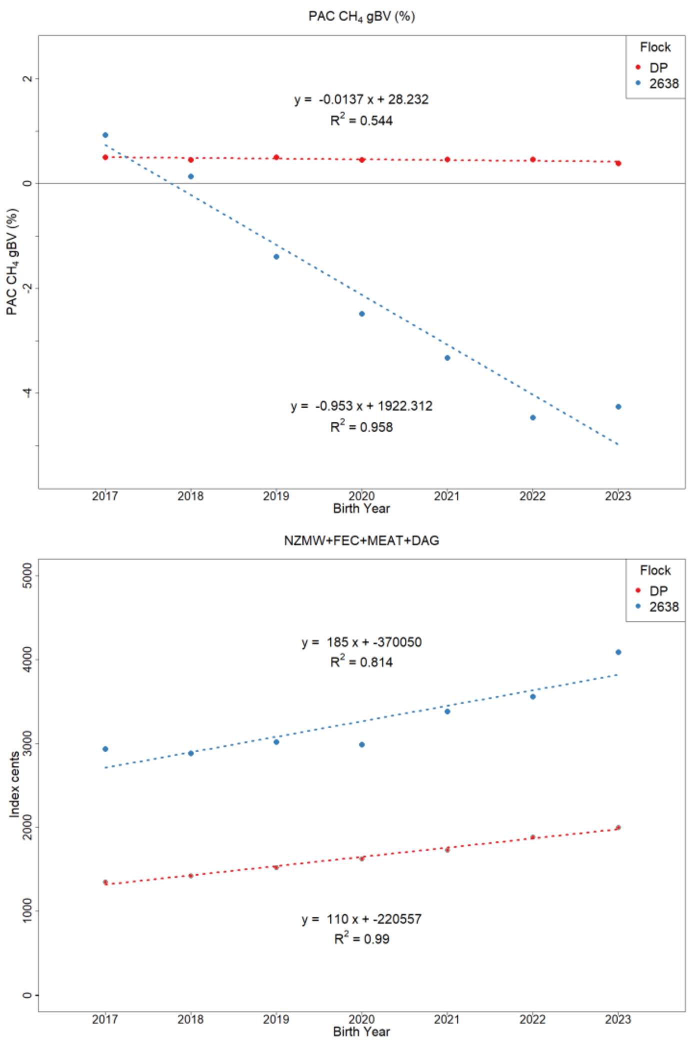

Figure 1. Plots of percentage change in average PAC CH4 breeding values (PACCH4gBV%) and NZMW+FEC+DAGS+MEAT index values (cents, NZMW+F+D+M) by birth year for flock 2638 and the New Zealand dual purpose flock average (DP).

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References

Anon. Sheep industry Breeding objectives 2022 Available at https://www.sil.co.nz/files/1661310874929.pdf [accessed 21 June 2024]

Beef and Lamb Genetics 2016 Best Practice in Performance Recording for SIL Genetic Evaluations, Beef and Lamb Genetics https://www.sil.co.nz/technical [accessed 8 October 2024]

Hickey SM, Bain WE, Bilton TP, Greer GJ, Elmes S, Bryson B, Pinares-Patiño CS, Wing J, Jonker A, Young EA, Knowler K. 2022. Impact of breeding for reduced methane emissions in New Zealand sheep on maternal and health traits. Frontiers in Genetics 13: 910413.

Jonker A, Hickey SM, Rowe SJ, Janssen PH, Shackell GH, Elmes S, Bain WE, Wing J, Greer GJ, Bryson B, MacLean S. 2018. Genetic parameters of methane emissions determined using portable accumulation chambers in lambs and ewes grazing pasture and genetic correlations with emissions determined in respiration chambers. Journal of Animal Science 96(8): 3031-3042.

United Nations / Framework Convention on Climate Change. 2015 Adoption of the Paris Agreement, 21st Conference of the Parties, Paris: United Nations

Schaefer H, Fletcher SEM, Veidt C, Lassey KR, Brailsford GW, Bromley TM, Dlugokencky EJ, Michel SE, Miller JB, Levin I, Lowe DC. 2016. A 21st-century shift from fossil-fuel to biogenic methane emissions indicated by 13CH4. Science 352: 80-84.