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NOVEL SELECTION CRITERIA WILL BE REQUIRED FOR REDUCTION OF NEW ZEALAND'S NATIONAL GREENHOUSE GAS EMISSIONS INVENTORY THROUGH DAIRY GENETICS

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SUMMARY

The objective of this study was to estimate the reductions in national methane emissions from the New Zealand dairy industry arising though current genetic trends. Based on recent genetic trends, the emissions intensity per milk protein equivalents was calculated to be reducing by 0.43% per year reflecting production efficiency gains. In contrast, emissions per hectare was calculated to be reducing by only 0.03% per year, and this reduction is critically dependent on the assumption that genetic gain in milk yield potential is not exacerbating intensification of dairy farming systems. Novel selection criteria will be required to achieve national reductions in methane emissions from the New Zealand dairy industry.

INTRODUCTION

The Productivity Commission of New Zealand estimated in 2018 that the methane emissions from livestock need to be reduced by 10-22% of the amount in 2016, i.e. 2.8-6.1 million tonnes by 2050. Along with efforts from other sectors, New Zealand would therefore contribute a fair share towards maintaining the current global warming levels. Genetic improvement is one possible tool that could assist the New Zealand dairy industry to achieve this goal while still maintaining the critical role of the industry in export revenue and rural livelihoods.

Previous studies have concluded that methane emissions in dairy cattle were strongly correlated with dry matter intake (DMI) (Pickering *et al.* 2015). Therefore, we applied in this study a methodology which quantifies methane emissions from changes in DMI due to unit genetic changes. This method was applied to traits in the national breeding goal for the New Zealand dairy industry, Breeding Worth (BW).

The objective of this study was to compare how current genetic trends in key dairy production traits are impacting on a range of emission metrics so as to evaluate whether the current breeding strategy would need to be modified in order to help meet the national methane emissions reduction policy.

MATERIALS AND METHODS

The methane emissions were estimated as their carbon dioxide equivalents (CO_2-eq) as a direct conversion from feed intake energy, i.e. kg DMI × 0.583 kg CO_2-eq/kg DM (Fennessy *et al.* 2015). Feed energy consumed by a breeding cow, and her replacement both on and off the milking platform were estimated. We proposed 3 measurement definitions to describe the impact of genetic trait changes on methane emissions as follows:

Gross methane emissions. The gross methane emissions as CO_2-eq emitted by a breeding cow in a year prior to genetic change (E) was estimated as a product of number of animals, feed intake, and the conversion coefficient described above.

Methane per hectare (ha). The gross CO_2-eq emissions per ha of grazing land (EH) was expressed as a ratio of E and the total number of ha for grazing land required per cow per annum (H).

Methane intensity on an animal product basis. The emission intensity (EI) was calculated as a ratio of the E and total number of product outputs per cow. Here all types of animal product outputs were converted to milk protein equivalents (milk protein-eq) using a revenue ratio.

The changes of *E*, *EH* and *EI* due to genetic improvement were denoted as gross value (*GV*), emission value on a ha basis (EV^h) and emission value on an animal product basis (EV^m) and were calculated by obtaining the first derivative of each of the 3 equations with respect to an unit change in one genetic trait (*g*) at a time following Amer *et al.* (2017).

Response to index selection. Genetic trends averaged over the past 5 years were accessed from New Zealand Animal Evaluation Ltd (NZAEL). Trait-wise annual responses in *E*, *EH* and *EI* from index selection were calculated as a product of *GV*, EV^h or EV^m and genetic trend and aggregated over all breeding objective traits.

RESULTS AND DISCUSSION

The emission values for each of the traits within the breeding objective are listed in Table 1. By achieving a 1-unit increase in trait genetic merit, the associated annual gross emissions per breeding cow were estimated to increase for all traits except Residual Survival and Fertility. Similar patterns were observed for emission per ha. In contrast, emission intensity values per unit of milk protein-eq were estimated to decrease for Milk Fat, Milk Protein, Residual Survival, Fertility and Body Condition Score (BCS) as genetic merit improves. Liveweight and Milk Volume emission intensity values were estimated to be positive but on a much smaller scale compared to other traits. A negative emission intensity value for any trait indicates that the increase in gross emissions associated with that trait is proportionally smaller than the increase in either ha or animal product output.

The Productivity Commission (2018) suggested a 10-22% target reduction of gross methane emissions by 2050 of that in 2016, equals to 2.8-6.1 million tonnes (Ministry for the Environment 2018). However, direct selection for reductions in gross emissions per animal would result in direct selection against efficiency improving traits (i.e. against Milk Fat and Milk Protein yield). A better overall outcome than direct selection for inefficiency would be to continue selecting for animal efficiency, but then use other policy mechanisms to reduce the total number of animals or hectare areas farmed (Quinton *et al.* 2017).

Table 1. Estimated effects of a 1-unit trait change in gross methane emissions (kg CO_2-eq emission/breeding cow/year, *GV*), emissions per hectare (kg CO_2-eq emission/ha, EV^h) and emission intensity (kg CO_2-eq emission/kg milk protein-eq, EV^m)

Trait	Unit	*GV*	EV^h	EV^m
Milk Fat	kg	3.57	0.04	-0.02
Milk Protein	kg	2.19	0.02	-0.02
Milk Volume	L	0.07	0.001	0.00004
Liveweight	kg	2.40	0.12	0.005
Residual Survival	day	-0.24	-0.32	-0.0007
Somatic Cell Score	score	0	0	0.04
Fertility	%	-6.28	-8.80	-0.04
Body Condition Score	score	22	26	-0.29

Table 2 shows the current (2019) values for gross emissions, emission per ha and emission intensity for all traits within the current breeding objective. The annual and 20-year change estimates for the aggregated genetic trend are also listed. On average, one breeding cow in New Zealand was estimated to emit 3.087 tonnes of CO_2-eq in year 2019. Over the years, the gross emissions are estimated to increase but emission per ha and emission intensity would reduce, and *EI* was estimated to reduce proportionally faster than the changes of *E* and *EH*.

Given there are 4.8 M dairy cattle in total across New Zealand (DairyNZ 2017), the country-wise gross CO_2-eq by 2050 would increase by 4.8 M animals × 9.95 kg/year/animal × (2050 - 2019) = 1.5 M tonnes, if there was no reduction in the number of dairy cattle. If the land area remained the same from 2017 with 2.4 M ha in dairy sector (Beef + Lamb NZ Economic Service statistics 2017), the country-wise gross CO_2-eq by 2050 would change by 2.4 M ha × (-2.31 kg/ha) × (2050 - 2019) = -171-k tonnes. This is less than 6% of the Productivity Commission 2050 target of 2.8 M tonnes.

Table 2. Aggregated genetic trend predictions for gross CO_2-eq emission (kg CO_2-eq/cow/year, *E*), emission per hectare (kg CO_2-eq/ha, *EH*) and emission intensity (kg CO_2-eq/kg milk protein-eq, *EI*)

	Total value at 2019 (kg)	Annual change (kg)	Annual change percentage (%)[1]	20-year change (kg)	20-year change percentage (%)[1]
E	3,087	9.95	0.32	199	6.45
EH	6,915	-2.31	-0.03	-46	-0.67
EI	9.27	-0.04	-0.43	-0.80	-8.63

[1]percentage compared to 2019.

In emissions per ha measurements, we have assumed that stocking rate gets adjusted as feed requirements per cow increases hence these measurements could adapt to intensive farming system. In another scenario, often dairy farmers in New Zealand increase supplements, e.g. concentrates, for higher genetic merit cows to milk more. This part could be assessed by sensitivity tests.

CONCLUSIONS

This study shows that under the current breeding objective, each New Zealand dairy cow was estimated to produce more gross methane emissions, but also to become more production efficient. Gains in emissions per ha are at best very modest and critically dependent on the assumption that future genetic gain in milk production potential will not encourage further trends towards intensification of New Zealand's dairy production systems. To reach the 2050 methane reduction goal, new selection criteria and a changed emphasis of selection beyond the current tightly defined goal of increasing farm profitability will be required.

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