IS METHANE PRODUCTION LIKELY TO BE A FUTURE MERINO SELECTION CRITERION?

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SUMMARY

Selection index theory was used to model the effects of including feed intake and methane (CH_4) production in the breeding objective and having both, either or none of these traits as selection criteria on genetic responses in Merino production traits. A range of economic values (EV) were assumed for CH_4 production based on expected future prices for CO_2-e ($/tonne). The implicit price of carbon required to achieve desired gains of a reduction in CH_4 of 1% p.a. were calculated. The sensitivity of desired gains to changes in the correlations between production traits and CH_4 production were modeled as these correlations are currently unknown. If the correlations between production traits and CH_4 are positive (as expected) then it is very unlikely that CH4 production would be used as a selection criterion as an implicit carbon price of over $400/tonne CO_2-e was needed to achieve the desired reductions in CH_4 production. However, if the correlations are unexpectedly negative, the carbon price needed to achieve such gains was more likely at ~$30/tonne CO_2-e. The correlations need to be determined from research trials for informed advice about breeding for CH_4 reduction to be given to Merino breeders.

INTRODUCTION

Rumen methanogenesis results in the loss of up to 12% of gross energy intake (Johnson *et al.* 1993). Methane, a greenhouse gas, is estimated to contribute about 24% of anthropogenic global warming, second only to carbon dioxide (Houghton 1997). Most of Australia's agricultural emissions come from enteric emissions and 15% from sheep enteric emissions (Australian Government (AG) 2008). Sheep daily CH_4 production (~20g/d) is highest when the energy density of the diet is about 10.5 MJ/kg DM and diet digestibility about 70% (Pelchen and Peters 1998). Most current technologies to control CH_4 emissions are not cost effective (Keogh and Cottle 2009). While CH_4 emissions are greater on improved pasture with higher stocking rates, additional farm profit exceeds the potential cost of additional emissions (Alcock and Hegarty 2006). Development of CH_4 mitigation strategies, without causing negative impacts on production, is a major challenge for ruminant nutritionists (McAllister *et al.* 1996).

An alternate approach is to achieve small cumulative decreases in CH_4 production through sheep selection. Between-sheep variations in CH_4 emission have been observed in respiration chambers (Blaxter and Clapperton 1965) and under grazing conditions (Lassey *et al.* 1997; Pinares-Patin *et al.* 2003; Ulyatt *et al.* 1999), where ~85% of the variation in daily CH_4 production from sheep grazing temperate pastures was due to variation between animals.

The Australian government has committed to reduce carbon pollution by 5% of 2000 levels by 2020 (AG 2008). It is not considered practical to immediately include agriculture in a carbon trading scheme, however it is likely to be included after 2015. A final decision will be made in 2013, contingent on there being reliable and cost-effective methods of emissions estimation and reporting. The likely cost of carbon permits is $10-40/tonne CO_2-e (AG 2008).

This paper addresses the questions - if CH_4 production and/or feed intake were more easily measured, are they likely to be used as selection criteria in future breeding programs, and what (incentive) price of carbon is needed to achieve targets of 0 or 1% reduction in CH_4 /year?

METHODS

The selection index program, MTIndex, was used to construct the Sheep Genetics Merino 14% MP (medium micron premium) index with the addition of feed intake (kg/year) and CH_4 (kg/year) (Tables 1 and 2). The additional traits were included in the breeding objective using genetic parameters from the literature (e.g. Ponzoni 1986, Lee *et al.* 2002, Safari *et al.* 2005). Correlations between CH_4 and production traits were not available and were assumed after discussion amongst colleagues (e.g. P. Amer, pers. comm.). The EV of CH_4 production (kg/day) was calculated as $/tCO_2$-e * 21/1000, where 21 is the internationally accepted global warming potential of CH_4 in CO_2 equivalents (AG 2008). The EV of NLW accounted for predicted lamb offspring CH_4 production. The index was run unconstrained or with a desired gain of -0.16 kg CH_4 /ewe /generation/i (~1% p.a. CH_4 reduction) to calculate the implicit carbon price needed for this reduction. Sensitivity of calculated trait genetic gains to the assumed CH_4 correlations and EV were studied by randomly sampling 100 times within the normal distributions of these values with an assumed standard deviation (0.1). The impacts of including feed intake and/or CH_4 production as selection criterion on gains in all traits were calculated.

Table 1. Traits in the 14% MP index - assumed genetic parameters and economic values

Trait*	Units	σ_p	Heritability	Repeatability	Economic Value
YCFW	%	18.27	0.29	0.40	$0.29
YFD	µm	1.22	0.55	0.55	-$3.22
FI	kgDM/year	75.00	0.13	0.35	-$0.02
YWT	kg	5.56	0.35	0.50	$0.26
ACFW	%	14.16	0.44	0.60	$0.30
AFD	µm	1.41	0.60	0.60	-$4.14
AFDCV	%	2.24	0.35	0.60	-$0.83
AWT	kg	6.32	0.40	0.40	$0.04
NLW	No.	0.65	0.06	0.35	$36.49
CH_4	kg/year	1.46	0.25	0.40	-$0.63

*YCFW – yearling clean fleece weight %, YFD – yearling fibre diameter, FI- feed intake, YWT – yearling body weight, ACFW – adult clean fleece weight %, AFDCV – adult fibre diameter coefficient of variation, NLW - number of lambs weaned

Table 2. 14% MP index- assumed correlations (phenotypic above, genetic below diagonal)

	YCFW	YFD	FI	YWT	ACFW	AFD	AFDCV	AWT	NLW	CH_4
YCFW		0.31	0.13	0.30	0.42	0.20	-0.01	0.26	0.07	0.10
YFD	0.30		0.07	0.20	0.17	0.62	-0.05	0.15	0.03	0.00
FI	0.14	0.39		0.30	0.11	0.09	-0.04	0.30	0.40	0.77
YWT	0.25	0.20	0.73		0.23	0.14	-0.06	0.61	0.10	0.62
ACFW	0.70	0.25	0.03	0.15		0.29	0.06	0.22	0.04	0.10
AFD	0.30	0.84	0.44	0.15	0.34		-0.11	0.17	0.03	0.04
AFDCV	0.15	-0.06	-0.23	-0.05	0.24	-0.14		-0.14	0.02	0.00
AWT	0.10	0.21	0.73	0.80	0.15	0.20	-0.14		0.10	0.62
NLW	-0.10	0.00	0.40	0.15	-0.10	0.00	0.00	0.15		0.26
CH_4	0.05	0.00	0.70	0.65	0.05	0.02	0.00	0.65	0.25	

RESULTS AND DISCUSSION

When positive correlations between CH_4 production and production traits were assumed, CH_4 production increased as a result of selection until carbon price was over \$150/t CO_2-e, even when both feed intake and CH_4 production were included as selection criteria.

To achieve a 1% p.a. CH_4 reduction the carbon price needed to be \$418/t CO_2-e if both feed intake and CH_4 production were used as selection criteria, \$421/t CO_2-e if only CH_4 was a criterion, \$570/t CO_2-e if only feed intake was a criterion and \$698/t CO_2-e if neither were used as additional criterion. A carbon price of \$140/t CO_2-e was needed for zero predicted change in CH_4.

Table 3. Predicted gains in traits or ratios (/10 years) assuming a carbon price of \$30/tCO_2-e, positive production- CH_4 correlations, with different combinations of selection criteria in addition to CFW, FD, FDCV, WT and NLW.

Selection criteria	ACFW	AFD	AWT	CH_4	Feed intake	CH_4 /kg AWT	CH_4 /kgACFW
None	0.41	-2.77	-0.72	0.31	-21.85	-5.5%	5.0%
CH_4	0.40	-2.77	-0.73	0.29	-22.09	-5.3%	5.1%
Feed intake (FI)	0.51	-2.81	-0.89	0.27	-23.91	-5.3%	7.5%
CH_4 and FI	0.68	-2.84	-1.04	0.33	-24.91	-6.4%	10.0%
*CH_4+FI (sire)	1.74	-2.84	-0.66	0.38	-22.05	-6.4%	25.6%

*Half sib progeny measured in addition to individual performance

CH_4 production (per year and per kg CFW) increased when feed intake and/or CH_4 production were included as criteria as they were assumed positively correlated to production traits and indirectly increased these traits. An annual fleece was worth ~\$36.00 compared to the carbon cost of annual CH_4 production (~7.3kg/head) of -\$4.60, using the assumed CH_4 EV in Table 1. When the production –CH_4 correlations in Table 2 were given the opposite, negative sign the predicted reductions in CH_4 production were, as expected, much greater (Table 4).

Table 4. Predicted gains in traits or ratios (/10 years) assuming a carbon price of \$30/ t CO_2-e, negative production- CH_4 correlations, with different combinations of selection criteria in addition to CFW, FD, FDCV, WT and NLW.

Selection criteria	aCFW	aFD	aWT	CH_4	Feed intake	CH_4 /kg wt	CH_4 /kgCFW
None	-0.20	-2.95	-1.85	-0.62	-28.02	5.6%	3.9%
CH_4	-0.12	-3.02	-1.86	-1.26	-36.60	14.6%	14.8%
Feed intake	0.63	-2.82	-0.19	-0.92	-18.93	12.3%	24.0%
Both	0.77	-2.74	-0.60	-0.14	-10.87	0.9%	17.1%
Both (sire)	1.82	-2.82	0.25	-0.81	-13.86	11.5%	38.0%

The sensitivity analyses of production trait – CH_4 correlations and CH_4 EV demonstrated that the predicted CH_4 responses were very dependent on these values (Figure 1). However, it is expected that these correlations are positive, as the feed intake- CH_4 correlation is highly positive, and production traits are positively correlated to feed intake, so the predicted responses of increases in CH_4 production (Figure 1a) are more likely than small increases or reductions in CH_4 (Figure 1b).

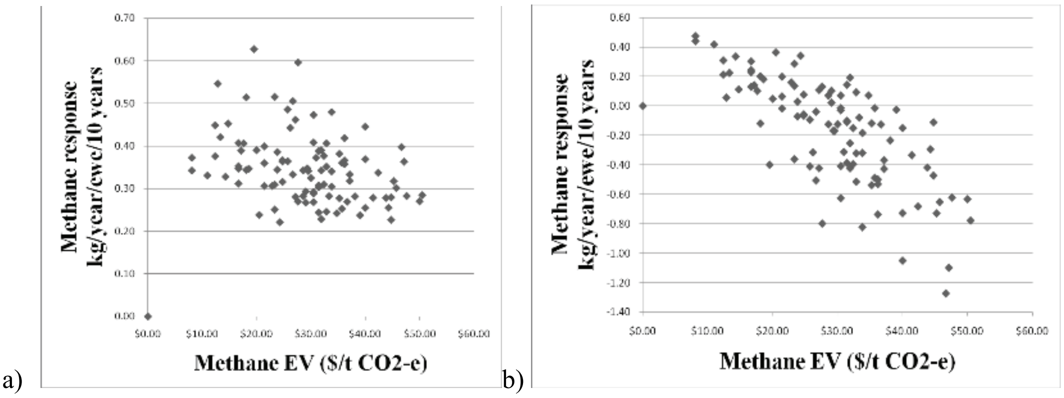

Figure 2. Sensitivity of CH_4 response to selection (/10 years) versus carbon price with CH_4 and feed intake as additional selection criteria where correlations were samples around a) positive, or b) negative values for the mean production-CH_4 correlation.

CONCLUSIONS

The results of these analyses suggest that CH_4 production per sheep has probably been increasing in Merino flocks using the 14% MP index, where CH_4 and feed intake have not been available for use as practical selection criteria. If they could be used, CH_4 production would probably still increase if carbon prices are around \$20-30/tCO_2-e because the price is not high enough to place enough selection pressure to reduce CH_4 production. Estimates of production trait- CH_4 correlations are needed to design optimum sheep breeding programs if agriculture is to be included in carbon trading schemes in the future.

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