
VOLUME 62 2002

Effect of management change on methane output within a sheep flock

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ABSTRACT

The introduction of an emissions trading scheme means farmers are likely to incur some form of carbon tax on methane emissions. Consequently, it is important to explore management options that could reduce methane output per unit of product sold. A computer model was developed to test a range of management strategies on methane production, relative to farm output. These included changing ewe live weight, conception rate, scanning percentage, ewe and lamb survival, ewe culling rates, lamb growth rate, hogget lambing and ewe culling age. The dataset used to develop the model contains 6,000 ewe and 8,100 lamb records collected over 8 years. The reference flock used in the model comprised 1,000 ewes plus replacements, 1,378 lambs scanned, 989 lambs sold and 288 replacements kept. The carbon cost was 15.99 kg of methane per lamb sold. Three of the most significant influences on methane production per lamb sold were increasing ewe cull age from 5 to 6 years (4.6% reduction), increasing ewe scanning percentage from160% to 180% (7.8% reduction) and hogget lambing (11.7% reduction). Effects were not completely additive. The model allows methane output to be estimated for any defined production system and quantifies the most effective management changes to minimise methane production on an individual farm or across the wider industry.

Keywords: methane production; sheep; management; model.

INTRODUCTION

The move to some form of emissions trading scheme means that farmers are likely to incur some form of carbon tax on methane emissions from ruminant livestock. Methane production by sheep is directly related to feed intake (H. Clark, Personal communication) and, for any defined level of production, the energy requirement of individual sheep can be calculated and methane production predicted. Management changes that improve farm and animal efficiency and result in a greater meat and wool output per unit of methane production are likely to benefit sheep farmers.

The objective was to develop a model that would enable us to test a range of management strategies on methane production relative to farm output. These included increasing lambing percentage, improving ewe and lamb survival, improving lamb growth rate, changing breed, hogget lambing and increasing ewe age by reduced culling.

MODEL DESCRIPTION

The model was written in MS Excel. It is based on a flexible sheep production system and allows for variation in numerous farm production traits. The traits which can be altered in the model include sire, ewe and lamb parameters as well as flock structure (Table 1).

The data used in the base model were obtained from the Poukawa Elite Lamb flock and includes 6,000 ewe and 8,100 lamb records collected over 8 years. Where data were unavailable such as for hogget milk production, a ‘best guess’ approach was used. The model was based on a hypothetical reference flock of 1,000 ewes, including two-tooth ewes, plus replacement hoggets. The number of replacements required was influenced by ewe survival, ewe culling rate and ewe culling age. Lambs were slaughtered at a set live weight with a model output of number of lambs sold being the number of lambs weaned minus replacements. The base flock scanned 1,378 lambs, producing 989 lambs for sale with 288 replacements retained. The cost was 15.99 kg of methane per lamb sold. Changes in methane output per lamb sold are expressed as percentage change from the reference flock.

The annual variation in ewe live weight is shown in Table 2. These include hogget, two-tooth and mixed age ewe live weights and the effect of pregnancy on ewe live weight. Variation in lamb growth rate within sex, dam age and birth rank groups was modelled by creating individual lamb growth profiles for 50 lambs per group, for 16 classes of lamb. In addition, the model included the ability to increase, or decrease, lamb growth rate depending on the genetic growth potential of the sire. Data from composite ewe hoggets at Poukawa were used to calculate lamb growth rate, birth weight and lamb survival for the hoggets in the model. The hogget base data used 70% conception and 130% scanning, resulting in a weaning percentage (lambs weaned/hogget mated) of 81%.

Mortality rate was related to ewe age with an increase of 0.5% per year used in the model. Ewes in the base model were culled either as ‘dry ewes’ at pregnancy scanning (approximately 8% in the mixed age ewes) or for serious faults such as feet,

TABLE 1: Variables which can be changed within the developed model.

Trait	Variable
Flock	
Mating	Hogget lambing optional
Replacement policy	Retain or buy in replacements
Hogget	
Live weight	Date and live weight
Survival	Percentage mortality
Culling	Percentage culled
Scanning	Percentage dry, single, twin
Lambing	Date
Lactation	Yield and composition
Two-tooth	
Live weight	Date and live weight
Survival	Percentage mortality
Culling	Percentage culled
Scanning	Percentage dry, single, twin, triplet
Lambing	Date
Lactation	Yield and composition
Ewe	
Live weight	Date and live weight
Survival	Percentage mortality by age
Culling	Percentage culled by age, Age all removed
Scanning	Percentage dry, single, twin, triplet
Lambing	Date
Lactation	Yield and composition
Lamb	
Birth	Date and live weight by single, twin and triplet
Weaning	Date and live weight by single, twin and triplet
Growth	Liveweight gain by birth rank and age of dam
Slaughter	Drafting weight, dressing percentage, carcass value
Store lambs	Optional, date and value
Survival	Perinatal and pre-weaning mortality by birth rank
Sire	
Growth rate	Terminal sire effect on lamb growth rate

TABLE 2: Ewe live weight (kg) by age distribution data used in the model.

Event	Date	Ewe parity			
		Dry	Single	Twin	Triplet
Hoggets					
Ram out	11 Apr	41	41	41	
Lambing	1 Sept*	49	60	65	
Weaning	24 Nov	52	50	48	
Two-tooths					
Ram out	25 Mar	57	57	57	57
Lambing	15 Aug*	65	65	70	75
Weaning	7 Nov	65	63	61	60
MA ewes					
Ram out	25 Mar	70	70	70	70
Lambing	15 Aug*	76	76	80	82
Weaning	7 Nov	76	73	72	72
Milk production (L/d)					
Lambing			1.46	1.91	2.13
6 weeks			1.31	1.68	1.86
12 weeks			0.89	0.85	0.82

* Dates derived from selected lambing dates

teeth and udder, two weeks post-weaning and two weeks pre-mating. All remaining ewes in the base model were culled at 5 years of age.

In the base model, scanning percentages of 150% and 160% were used for in lamb two-tooth and mixed age ewes respectively, with 8% being 'dry ewes'. The proportion of singles, twins and triplets were calculated from the data of Muir *et al.* (2005). The time of lamb death (Table 3) was grouped into two categories; birth to 2 days of age, to account for the resources utilized during pregnancy, and 2 days to weaning, to account for the resources needed during lactation as well as pregnancy. In the base model, different mortality rates were used for different birth ranks due to the findings of Thomson *et al.* (2004). In the base model, this resulted in a weaning percentage of 127.7% (lambs weaned/ewe mated).

Data on milk yield and composition were available at three weekly intervals in mixed age ewes rearing single, twin or triplet lambs. Milk yield at lambing was assumed to be 90% of milk yield at 3 weeks lactation (Table 2) and milk consumed by lambs was assumed to be 80% of total milk yield. Milk yields for hoggets and two-tooth ewes were assumed to be 80% and 90% of the milk yields for mixed age ewes. Milk energy content was calculated from milk composition using the data collected on milk composition and the equations published by Agriculture and Food Research Council (1993) and CSIRO (1990) but, as there was little variation in the ME of the milk over lactation, a constant milk energy content of 5.63 MJ/L was used.

In the model, lambs were drafted weekly at target weights of 37kg fro ewe lambs and 40 kg for ram lambs. This resulted in an average hot carcass weight of 17.4 kg. The variation in growth rate and birth rank means that in the base model there were 23 drafts resulting in 989 lambs for sale between 11 November and 25 July.

The energy content of pasture (MJME/kg DM) has been adjusted seasonally. The values used in the base model were 9.9, 9.6, 10.8 and 11.4 MJME for summer, autumn, winter and spring respectively (Litherland *et al.*, 2002). ME requirements were calculated daily for individual animals based on equations used by Agriculture and Food Research Council

TABLE 3: Lamb live weight (kg) and survival (%) by ewe age data used in the model.

Trait	Birth status					
	Single		Twin		Triplet	
	Ram	Ewe	Ram	Ewe	Ram	Ewe
Hoggets						
1 Sept (Birth)	4.7	4.3	3.7	3.5		
24 Nov (Weaning)	26.5	24.5	23.5	21.7		
Born dead (%)	1.9		5.6			
Birth to weaning (%)	5.6		10.7			
Two-tooth ewe						
15 Aug (Birth)	5.74	5.32	4.52	4.34	4	3.8
7 Nov (Weaning)	29.9	27.6	26.5	24.4	23.0	21.0
Born dead (%)	4.8		4.2		9.5	
Birth to weaning (%)	4.9		7.6		15	
MA ewe						
15 Aug (Birth)	5.74	5.32	4.52	4.34	4	3.8
7 Nov (Weaning)	31.4	29.0	27.8	25.7	24.2	22.1
Born dead (%)	4.8		4.2		9.5	
Birth to weaning (%)	4.9		7.6		15.0	

TABLE 4: Effect of altering flock performance on methane output per lamb sold calculated within the model.

Input	Change	Methane output per lamb sold
Base flock	Base flock	15.99 (kg CH_4/lamb)
Ewe live weight (kg)	10% decrease	-3.9%
Lamb growth rate (g/d)	10% increase	-2.6%
Ewe deaths (%)	10% decrease	-0.04%
Ewe culling (%)	10% decrease	-0.03%
Cull year	1 year longer	-6.4%
Lamb mortality (%)	10% decrease	-1.3%
Dry ewes (%)	8% to 6%	-2.7%
Scanning percentage (%)	10% increase	-7.8%
Hogget lambing(%)	Wean 81%	-13.6%

(1993), CSIRO (1990) and Cruickshank (1986). In the model, methane production was related to dry matter intake with 16.8 g/kg dry matter intake (DMI) for sheep less than one year of age and 20.9 g/kg DMI for sheep over one year of age (H. Clark, Personal communication).

RESULTS

Decreasing ewe live weight, without altering productivity, increased ewe efficiency and reduced the methane production per lamb sold. The model indicating that a 10% decrease in ewe live weight over the year will decrease methane output by 3.9% (Table 4). Increasing lamb growth rate by 10% resulted in lambs reaching killable weights faster and leaving the property earlier. This reduced methane output by 2.6% (Table 4).

In the base flock, ewe mortality was already low, so reducing mortality by 10% resulted in a small reduction in mortality, from 1.5% to 1.35% or 1.5 ewes per 1000 ewes for 4 year-old ewes. This small change had only a minor effect on methane output, with a 10% reduction in mortality leading to a 0.04% reduction in methane output per lamb (Table 4). Culling rates in the base Poukawa flock are relatively low because only ewes with severe issues are culled. However, delaying culling on age for a year to 6 years of age rather than 5 years of age, had a larger effect and decreased methane emissions by 6.5%, as fewer replacements were needed and a higher proportion of the flock was productive (Table 4).

In this flock, lamb mortalities were relatively low (Table 3) and thus, reducing lamb mortality only had a small effect on methane production with a 10% decline in mortality reducing methane production by 1.8% (Table 4). In flocks with higher mortality levels this effect would be greater.

Reducing the level of ‘dry ewes’ in the base model from 8% to 6% for both two-tooth and mixed age ewes reduced the methane output by 2.7%. Changing the scanning percentage alters the number of multiples which in turn affects lamb growth rates and survival. Assuming a constant scanning difference of 10 units between two-tooth and mixed age ewes and lifting the scanning rate of mixed age ewes from 160% to 180% resulted in 14.7% more lambs weaned. However, an increase from 200% to 220% in the mixed aged ewes resulted in only 11.7% more lambs weaned because of the higher mortality in triplet lambs.

In the hypothetical base flock, ewes lamb for the first time as two-tooths. Lambing ewe hoggets using Poukawa data of 81% lambs weaned/hogget mated increased the number of lambs produced by the base flock by 18% and resulted in a 13.6% reduction in methane production per lamb sold (Table 4).

DISCUSSION

Factors that will improve flock efficiency and produce more lamb for the same level of dry matter intake will reduce the methane produced per lamb sold. Hogget lambing had the greatest impact on methane production of 13.5% less methane per lamb, because it meant more lambs would be produced without the maintenance cost of running

TABLE 5: Effect of changing scanning percentage, age culling and hogget lambing on number of ewes, hogget replacements, lambs sold and methane output (kg CH_4/lamb sold) when available dry matter is held constant.

Scanning (%)	Cull age (Years)	Hogget lambing	Number of ewes	Number of hogget replacements	Number of lambs sold	Methane output (kg CH_4/lamb)	% change
160	5	No	1,000	288	989	15.99	
160	6	No	1,021	248	1,060	14.96	-6.4
180	5	No	933	269	1,061	14.82	-7.3
180	6	No	951	231	1,128	13.97	-12.6
160	5	Yes	930	268	1,136	13.81	-13.6
160	6	Yes	959	233	1,183	13.31	-16.8
180	5	Yes	872	251	1,194	13.08	-18.2
180	6	Yes	897	218	1,239	12.63	-21.0

more ewes. Other significant management factors which would reduce methane output per lamb were increasing scanning percentage, increasing ewe longevity through later age culling, reducing ewe live weight and increasing lamb growth rate. An increase in scanning percentage assumes no increase in ewe live weight and is achievable with Androvax or a breed change. Reducing ewe live weight without decreasing lamb live weight is difficult but achievable using Finn genetics. High lamb growth rates can be achieved with better feeding or by using rams with superior breeding values for weaning weight.

Unfortunately, reductions in methane output are not necessarily cumulative as a ewe flock is a complex dynamic system. For example, increasing scanning percentage also increases the number of multiples born, which in turn affects lamb growth rate and survival. Many of these interactions have been included directly in the model such as the effect of increasing scanning on lamb survival and growth rate. The combined effect of increasing longevity and scanning percentage together with lambing hoggets, resulted in a reduction of 21% in methane output per lamb sold.

The model calculates the extra feed required to increase production of a 1,000 ewe flock, which could be met by increasing dry matter production. The model also adjusts ewe numbers to simulate a farm with a constant dry matter production. In the latter situation, the number of ewes carried would decline as production increased but the total dry matter intake and methane produced for the farm would remain relatively constant. However, the amount of methane produced per lamb sold would decline (Table 5). This means that any emissions trading scheme which places a carbon charge per head will effectively penalize more efficient operators, while a carbon charge per ewe is likely to encourage the adoption of more efficient farming practices.

Improving farm efficiency will not impact on the amount of methane produced at either the farm or a national level. However, improvements in efficiency will change the amount of methane produced per unit of saleable product. Management practices which increase performance without markedly affecting ewe maintenance requirements will have the greatest impact.

ACKNOWLEDGEMENTS

Much of the data used in this model were obtained from trial work undertaken at the Poukawa Research Farm and funded by Meat and Wool New Zealand. Completion of the model was funded by the Ministry of Agriculture and Fisheries Sustainable Land Management and Climate Change Plan of Action Research Programme.

REFERENCES

Agriculture and Food Research Council, 1993, Energy and protein requirements of ruminants. An advisory manual prepared by the Agriculture and Food Research Council Technical Committee on responses to nutrients. CAB International, Wallingford, Oxfordshire, UK.

Cruickshank, G. 1986: Nutritional constraints to lamb growth at pasture. Ph.D. thesis, University of Canterbury, New Zealand.

CSIRO, 1990: Feeding standards for Australian livestock. Ruminants. Australian Agricultural Council. Ruminants subcommittee. CSIRO Publishing. Melbourne, Australia. 296 pp.

Litherland, A.J.; Woodward, S.J.R.; Stevens, D.R.; McDougal, D.B.; Boom, C.J.; Knight, T.L.; Lambert, M.G. 2002: Seasonal variations in pasture quality on New Zealand sheep and beef farms. *Proceedings of the New Zealand Society of Animal Production* **62**: 138-142.

Muir, P.D.; Thomson, B.C.; Knight, T.W. 2005: Factors affecting lamb survival. Proceedings of the Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association **35**: 73-82.

Thomson, B.C.; Muir, P.D.; Smith, N.B. 2004: Litter size, lamb survival, birth and twelve week weight in lambs born to cross-bred ewes. Proceedings of the New Zealand Grassland Association **66**: 233-237.