

## Review

An examination of the New Zealand methane emissions dataset to obtain updated predictions of enteric methane emissions from sheep suitable for incorporation into the national greenhouse gas inventory

### General comments

*Note: I also reviewed the technical report, so many detailed comments provided for the report also have relevance for this paper and should be taken into consideration.*

This is an important paper and as such deserves rigorous scrutiny. As with the technical report, I find the paper lacks rigour and attention to detail. The discussion dwells upon comparisons between equations and data from 1990 and 2012. I think a lot of this could be cut out without compromising the paper. There should be more discussion regarding the underlying biological reasons as to why sheep under one year of age deserve a separate equation to older sheep. Consequently I recommend major revision with re-review.

Some of the key areas for improvement are detailed below.

- 1) Statistical design and method. Clearly, the choice of a statistical approach to the data is germane to the results and the whole approach towards a redesigned inventory method for NZ sheep. There needs to be some discussion around the merit of one approach over another. A stepwise approach that trades off complexity against accuracy would have been useful. At what point is the pursuit for accuracy and precision defeated by a too complex solution to meet the needs of the objective – to develop a better sheep equation for estimating emissions? Were other methods considered and discarded and if so on what grounds? The idea of a stark demarcation related to sheep < or > 1 year of age is a solution that improved the fitness of your model. Nevertheless it is difficult to understand this biologically. The current authors have taken the approach of Meutzler and Clark without question. Without access to that paper it is impossible for me to understand how such an approach was initially arrived at. In addition, more detail on the statistical method is required.
- 2) Format of the paper. Some of the introduction borders on methods and results and some of the discussion could be in the results. Some realignment of the various sections may improve the clarity of the paper. The section on updated equations and their effects on national inventory is poorly constructed and needs some rethinking. I am not sure how useful Tables 3, 4 and 5 are in their current form.
- 3) The discussion. I would like to see some comparison with approaches taken in other countries. In particular the rather weak association with diet quality tends to contradict many studies where diet quality has been specifically manipulated, but supports our conclusions with cattle in Australia (just published and available on line in Animal Production Science). No dataset can truly represent a population. This paper covers a large number of observations across a reasonable cross section of the sheep population, but reference should be given to any inadequacies of the dataset.
- 4) A single versus two equations. The authors are wise to reflect that while a single relationship is OK, splitting the data along age grounds apparently improved the fit. My question remains, does this really impact on how well the emissions of the national flock are characterised. This is an area for some insightful discussion.

Specific comments.

Title: Way too long

Line 16: Second > should be a <

Line 17: English – replace 'being' with 'were'

Line 18-22: English – Replace with 'New Zealand sheep data... chambers (n=817) were used to update ... greenhouse gas inventory.'

Line 23 and elsewhere: need units associate with equations.

Line 24: define 1 (year old).

Line 28: The use of updated algorithms compared to the original method in the national inventory.

Line 27 to 29: Is this really the important conclusion you want to make. Would it not be more important to demonstrate the impact of the new versus old algorithms on the 2012 inventory values? Also, I can't see how you get an increase in 1990 and a decrease in 2012 unless the balance between old and young sheep has changed, or there has been a differential change in size of old and young sheep. You need to ponder on this issue – makes a good argument in the discussion.

Line 34: Add New Zealand and inventory to key words

Line 37 to 38: English! – A terrible sentence to start off with. Suggest 'Methane (CH<sub>4</sub>) is an end product of the fermentation of ingested feed and methanogenesis is the principal mechanism to remove hydrogen from the gut of ruminants.

Line 38-39: This sentence is redundant.

Line 40: remove the first 'the' and change 'sectors' to 'sector is'

Line 43: Period after emissions and insert 'are' between as and all (i.e. as are all annex 1 parties... You may need to explain what is meant by Annex 1

Line 50: Change to '(e.g. CH<sub>4</sub> yield for adult sheep (Ym...'

Line 57: State the indirect methods used.

Line 60: replace 'old and young sheep' with 'emissions from sheep < and > one year old'

Line 70-71: This sentence needs to be rephrased using a more appropriate scientific syntax.

Line 80: remove the word 'tailored'

Line 83 remove the comma after with and insert a period after dataset. Begin the new sentence with 'The aim was to obtain definitive ...'

Line 108-109: Need to expand the detail around the statistical methods

Line 110: Should 'exploratory' be 'explanatory'?

Line 112-117: Need more detail here and include some references to the method chosen.

Line 129: standardise the use of capitals to designate Original, Additional and Combined.

Figure 1. Based on my interpretation of the distributions of age, only about 18% and 10% of sheep were under 1 year of age in the Original and Additional datasets. Is this correct? 40% of sheep appeared to be in the 1 year age bracket.

Figure 1 and table 1: Need to indicate that ME was determined by NIR.

Figure 2: Need to identify which equation belongs to which dataset when figure is in monochrome. It is also quite difficult to differentiate between dots and triangles.

Figure 3 and 4: Faint and small

Line 178: 'explanatory' or 'continuous'

Line 183-184: Although this is statistically significant, it would be useful to consider in the discussion just how much of a difference this makes to the inventory.

Figure 4: denote which is 4A and 4B.

Line 206: It would be worth mentioning that all this work was done in the same chambers under standardized conditions – a real advantage.

Line 250: Could also be a rate of passage effect. Also replace the word 'higher' with 'more' and precede with a comma.

Line 252: Replace 'being' with 'is'

Line 256: insert 'that' after 'impact'

Line 263: Tables 6 and 7 are not in the paper.

Tables 3, 4 and 5 need more attention. There is the option to drop some or combine. Also it would be more useful to look at the change in relation to the choice of method rather than change in relation to the year. Also check your units, suspect some are as CO<sub>2</sub> equivalents not methane.

Line 316: replace 'increase of' with 'higher'

Line 328-331: The main conclusion is that the additional data confirms the strong relationship between DMI and methane production. A secondary conclusion is that younger sheep appear to have lower emissions and are sensitive to diet quality (using ME as a proxy of quality).

