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BRIEF COMMUNICATION: Can a portable Laser Methane Detector be used to measure compare methane production in grazing animals?

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Abstract

Methane production from grazing animals makes a significant contribution to New Zealand's greenhouse gas emissions and as such there is a need to compare methane emissions from different feeds and management systems. Laser Methane Detector (LMD) meters are portable, fast and relatively inexpensive and have been utilised overseas to measure methane emissions. The aim of this study was to determine whether LMD meters could be used to measure methane in grazing animals by testing it in a situation where methane production was likely to vary, in this case morning (AM) and afternoon (PM). The method used involved eight hand-reared hoggets and a small sheltered pen to minimise external air flows and enable a set distance from the LMD operator and the hoggets. The amount of methane produced in the PM was greater than the methane produced in the AM and the pattern was different with multiple smaller peaks in morning and a small number of larger peaks in the afternoon.

Keywords: Methane, grazing, LMD meter, laser, sheep.

Introduction

Ruminants produced methane through the fermentation of feed within the gastrointestinal tract, typically the rumen (McCaughey et al. 1997). In New Zealand, most farmed ruminants are grazed on pasture and contribute around 48% of the country's greenhouse gas output (CH_4) (MfE 2022) making it desirable to evaluate methane production from grazing animals under different forage and management systems. Many methane measurement techniques currently employed require expensive equipment and/or are limited in the number of measurements and difficult to use in a forage grazing system. Overseas, Laser Methane Detectors (LMD) have been used to measure methane release patterns in dairy cows, sheep and goats (e.g. Chagunda et al. 2009, Pereira et al 2023, Roessler Schlecht 2021; Sorg 2022) and the present study evaluated a portable LMD in a field situation.

Materials and methods

Based on published data (Bruder et al. 2017; Chagunda et al. 2009; Chagunda 2013; Sorg 2022) the following criteria were set: firstly, the unrestrained animal had to be standing 1m from the person using the LMD with minimal head movement for around 3 minutes. Secondly, measurements needed to be carried out in an area with protection from air movements and close to or in the paddock the animals were grazing to minimise disturbance to their grazing patterns.

Eight hand reared ram hoggets were grazed together and were accustomed to the presence of the person and the LMD. Methane measurements were taken with a portable LMD (LaserMethaneMini^{TM} Tokyo Gas Engineering, Tokyo). This model has a laser guide beam to facilitate methane measurements at the animal's nostril. The LMD records methane concentration at the focal point at 0.5 sec intervals.

A series of measurements were carried out to determine what worked and what didn't work to get a continuous measure of methane output. Observations on animal behaviour and weather were recorded as measurements were taken and protocols adapted. Methane release was then measured between 10 and 11 am and between 2 and 3 pm on two different days in the eight animals. For each animal, methane concentration was recorded at a distance of 1m over a 3 minute session. All measurements were carried out by one operator to avoid any differences due to operator.

Within each methane data set, points were categorised into four bands (0-10 ppm background d, 11-30 ppm, 31-100 ppm and 101 ppm plus). The number and sum of the values within each band were calculated for each animal at each measurement. The analysis was carried out as the percentage of methane measurements in each band. Data was analysed using GLM (Minitab for Windows version 14).

Results and discussion

The current gold standard for methane measurement uses static chambers (Jonker and Waghorn 2020). This method measures the total amount of methane produced (breath and flatulence) over the measurement period- typically around 24 hours. This is expensive and it is difficult to replicate the effects of natural grazing and diet selection. More recently, a laser methane detector (LMD) has been developed – this involves a person holding the meter directed at the animal's muzzle. It is more labour intensive but can measure a number of animals regularly (Jonker et al. 2020). The LMD measures changes in concentration of methane in the animals breath over the measurement period, in this case 3 minutes. The values obtained from techniques using spot samples (greenfeed, LMD etc) vs continuous measures like static chambers vary due to when the spot sampling occurs and what is being measured (Chagunda 2013; Jonker and Waghorn 2020; Sorg 2022) and these factors need to be taken into account when interpreting the results. Work by Changunda (2013) and Changunda and Yan (2011) showed the strength of the relationship between the values from the static chambers and the LMD varied depending when the spot samples were taken and that this was likely to be due to cyclic variations in methane release.

Various authors have demonstrated that methane production varies with activity (Bruder et al. 2017, Chagunda et al. 2011; 2012; Roessler and Schlecht 2021) and having the animals remain still was a high priority. A 3 minute measurement period was used to maximise the potential for capturing peaks (Bruder et al. 2017). Initially a gate was used to set a distance of 1m between the lambs and the recorder. This enabled a consistent distance between days and animals so reduced the variability due to the plume thickness. The gate was replaced with a 4m x 4m pen as it was difficult to measure an individual when other lambs came to investigate. Lambs were still free to move about the pen. A continuous 3 minute measurement period was the target but with unrestrained loose animals at times two consecutive measurement periods were necessary. Data were analysed as a percentage of the data points in each band.

Chagunda (2013) reported that measurements were affected by wind (amount and direction), rain and sunlight. Here, solid sides were added to the pen set up in a sheltered spot and measurements were undertaken on calm dry days. This methodology produced similar figures to indoor measurements (Thomson, unpublished data).

Diurnal variations occur in the chemical composition of pasture (Box et al. 2017; Vibart et al. 2019) and feed intake, rumen fill and grazing patterns (Thomson et al. 1985) also show diurnal variations. McCaughey et al. (1997) found grazing management and time of measurement affected CH_4 production when measured using SF technologies. We set out to test for differences in AM and PM methane output using the LMD meter.

The figures produced at different time of the days differed (Figure 1). In the AM there were significantly more small peaks (Band 2) while in the PM there were significantly more larger peaks (Band 3). Overall, there was significantly more methane produced in the AM (Table 1).

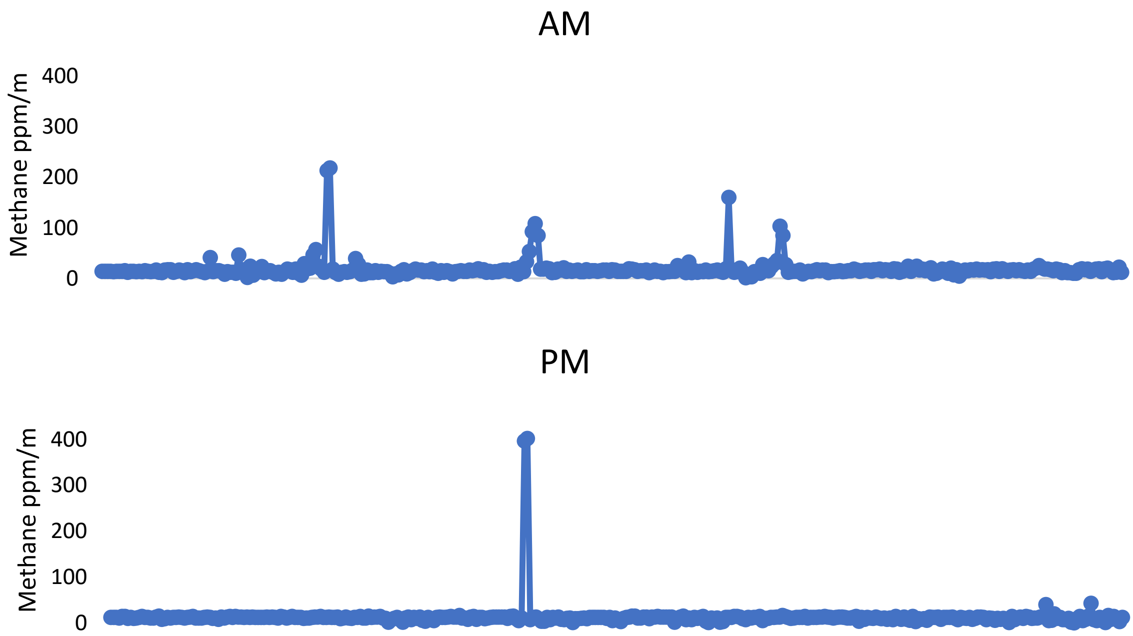

Figure 1. Typical readings from an individual sheep in the morning and the afternoon

Table 1. Proportion of the number and sum of the peaks in the different bands in the morning and afternoon.

Band	AM	PM	SE	P
No peaks 1	0.118	0.279	0.034	0.002
No peaks 2	0.877	0.70	0.037	0.001
No peaks 3	0.0046	0.017	0.0044	0.041
No peaks 4	0.0007	0.0038	0.002	0.29
Sum 1	0.074	0.160	0.022	0.008
Sum 2	0.905	0.734	0.035	0.001
Sum 3	0.015	0.064	0.0137	0.014
Sum 4	0.007	0.042	0.018	0.16
Sum 2-4	0.926	0.840	0.022	0.008

As LMD values are highly variable with operator and environmental conditions standardisation of technique is essential. This pilot study suggests that with good protocols it is possible to get comparisons between animals in what is close to a grazing environment with minimum disturbance to their grazing.

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