**Application:** By exploring the utility of various methane metrics, this research will identify the most pertinent definitions of methane emissions in sheep. These insights can then inform breeding programs focused on selecting low emission animals.

**Introduction:** Methane is a potent greenhouse gas with a warming potential eighty times greater than carbon dioxide over a shorter timeframe, with ruminant livestock accounting for approximately 30% of global emissions 73% of these emissions due to enteric fermentation (Black et al., 2021) (EPA, 2013), thereby making methane a critical target for climate change mitigation. Previous studies have shown that genetic, dietary and management factors influence the efficiency of methane production, allowing some animals to produce less methane without compromising productivity (Islam & Lee, 2019; Johnson et al., 2022; Mahala et al., 2022). Advances in methane quantification techniques for small ruminants, such as Portable Accumulation Chambers (PAC), have made it feasible to measure methane emissions in ruminants on a large scale and offer scalable and practical alternatives to labour intensive, limited throughput respiration chambers (O'Connor et al., 2021). Defining methane in a meaningful way is a challenge, as no consensus exists in the literature. Various methane definitions exist with some focusing on absolute emissions and others adjusting for efficiency. This is one of the first studies to comprehensively examine a range of methane emissions in sheep.

**Materials and Methods:** A total 13,695 records of methane emissions data was available from 7,204 animals including on growing animals (4 to 19 months) and on ewes (lactating and dry); collected from 2019 – 2024. Further phenotypic data included live weight (recorded on the day of PAC measurement), body condition score, and dry matter intake (DMI) (both recorded within 30 days of PAC measurement). Dry matter intake was measured using the n-alkane technique when animals were grazing outdoors and via the feed and weigh method when housed indoors. For growing animals information was available on carcass weight, carcass fat %, carcass muscle %, and average daily live weight gain. Various methane emission metrics were explored, including ratio based traits such as methane per kg of bodyweight (reflects methane emissions relative to the animal’s total body weight), methane per kg of metabolic bodyweight (MBW) (adjusts emissions for metabolic activity, scaling by bodyweight raised to the power of 0.75), and methane per unit dry matter intake (DMI) (Relates emissions to the animals feed consumption efficiency). Pearson correlations were used to examine the relationships between these various traits/metrics.

**Results and Discussion:**

For ewes, the mean daily methane emissions were 21.0 (SD = 9.4) g/day. Their mean DMI was 1.8 (SD = 0.7) kg/day. For growing animals, the mean daily methane emissions were lower, at 13.7 (SD = 6.6) g/day, while their mean DMI was 1.2 (SD = 0.5) kg/d.

For growing animals daily methane emissions showed a moderate positive correlation with body weight and DMI, r = 0.37, CI: 0.26-0.48 (p < 0.001) and r = 0.43, CI: 0.32-0.53 (p < 0.001), respectively. Methane per kg of body weight was strongly correlated with daily methane emissions (r = 0.81, CI: 0.79-0.82, p < 0.001). Similarly, methane per kg MBW also showed a strong correlation with daily methane emissions (r = 0.89, CI: 0.88-0.90, p < 0.001). Methane per unit DMI showed a moderate positive correlation with daily methane emissions (r = 0.58, CI: 0.49-0.66, p < 0.001)

In ewes body weight and DMI showed a weak to moderate positive correlation with daily methane emissions, r = 0.16, CI: 0.14-0.19 (p < 0.001) and r = 0.13, CI: 0.02-0.22 (p < 0.001) respectively. Methane per kg of body weight showed a strong positive correlation with daily methane emissions (r = 0.95, CI: 0.95-0.96, p < 0.001), as did methane per kg MBW (r=0.97, CI: 0.97-0.98, p < 0.001). Methane per unit DMI had a moderate positive correlation with daily methane emissions (r = 0.40, CI: 0.31-0.49, p < 0.001).

These results indicate that body composition metrics such as body weight and metabolic bodyweight are key predictors of methane emissions across life stages, with metrics of DMI showing a strong but lesser association.

**Conclusion and Implications:** This study represents the first to comprehensively explore a range of alternative methane definitions for sheep, revealing that each metric captures distinct dimensions of methane efficiency. This suggests that no single metric fully encompasses the complexity of methane emissions. By identifying this, this study supports a more targeted approach, tailoring methane metrics to the unique aspects of an animal’s growth or production phase.

***References***

Black, J. L., Davison, T. M., & Box, I. (2021). Methane Emissions from Ruminants in Australia: Mitigation Potential and Applicability of Mitigation Strategies. *Animals (Basel)*, *11*(4). <https://doi.org/10.3390/ani11040951>

EPA. (2013). *Global Mitigation of Non-CO2 Greenhouse Gases: 2012-2030*.

Islam, M., & Lee, S. S. (2019). Advanced estimation and mitigation strategies: a cumulative approach to enteric methane abatement from ruminants. *J Anim Sci Technol*, *61*(3), 122-137. <https://doi.org/10.5187/jast.2019.61.3.122>

Johnson, P. L., Hickey, S., Knowler, K., Wing, J., Bryson, B., Hall, M., Jonker, A., Janssen, P. H., Dodds, K. G., McEwan, J. C., & Rowe, S. J. (2022). Genetic parameters for residual feed intake, methane emissions, and body composition in New Zealand maternal sheep. *Front Genet*, *13*, 911639. <https://doi.org/10.3389/fgene.2022.911639>

Mahala, S., Kala, A., & Kumar, A. (2022). Host genetics associated with gut microbiota and methane emission in cattle. *Mol Biol Rep*, *49*(8), 8153-8161. <https://doi.org/10.1007/s11033-022-07718-1>

O'Connor, E., McGovern, F. M., Byrne, D. T., Boland, T. M., Dunne, E., & McHugh, N. (2021). Repeatability of gaseous measurements across consecutive days in sheep using portable accumulation chambers. *J Anim Sci*, *99*(11). <https://doi.org/10.1093/jas/skab288>