**Application**

This study suggests that diversifying the grazed sward, through legume or herb inclusion, can enhance the growth performance of lambs while directly or indirectly reducing methane output. These results could inform sustainable farming practices, guiding pasture management strategies that improve animal productivity and environmental sustainability. Furthermore, the study provides a basis for developing recommendations at farm level to optimize pasture-based lamb-finishing systems.

**Introduction**

Increasing lamb growth rates directly from pasture and reducing enteric methane (CH4) emissions are key drivers to enhancing production efficiency and achieving more sustainable lamb-finishing systems. Pasture-based production systems in temperate climates are predominated by perennial ryegrass (*Lolium perenne L.*), a productive pasture species characterized by its high forage yields and nutritive value. Grazed grass incurs lower production costs, offering a unique economic advantage over alternative feed sources. However, while perennial ryegrass monocultures can maintain productivity year-round, their chemical composition, digestibility and growth exhibit seasonal variations, often becoming notably suboptimal during summer and autumn, hindering intake and performance of grazing animals. Botanically diverse pastures containing legumes and herbs can boost sward quality in the latter half of the grazing season and have demonstrated significant potential for enhancing animal performance (Cranston et al., 2015). Furthermore, manipulation of the diet to reduce CH4 emissions is an important strategy available to livestock farming, however strategies that require daily supplementation of the basal diet are not currently feasible in most pasture-based systems. Implementing strategies to increase the daily live-weight (LW) gain of growing animals at pasture, such as improved grassland management and sward diversification can potentially reduce age at slaughter, thereby decreasing the animal’s lifetime emissions. Hence, the objective of this study was to assess the influence of binary sward mixtures of perennial ryegrass plus a companion forage, on growth performance, enteric CH4 output and the rumen microbiome in lambs post-weaning.

**Materials and Methods**

A randomized block design was employed to investigate five sward treatments, namely, perennial ryegrass (PRG), PRG plus white clover (*Trifolium repens L.;* PRG+WC), PRG plus red clover (*Trifolium pratense L.;* PRG+RC), PRG plus chicory (*Chicorium intybus L.;* PRG+Chic) and PRG plus plantain (*Plantago lanceolate L.;* PRG+Plan). A rotational leader follower grazing system was implemented post-weaning. A subset of 120 lambs, *circa* 15 weeks of age (n=24 per treatment) were selected at weaning in 2021 and 2022 for CH4 measurements using portable accumulation chambers. Groups were balanced for weaning LW, sex and reared litter size (LS). Six CH4 measurements were obtained from each lamb between weaning and slaughter. Rumen fluid was harvested using a transoesophageal sampling device. Lambs were drafted for slaughter once they reached a minimum LW of 45kg. Average sward companion forage content was 28% on a dry matter basis.

Data were analysed using a linear mixed model, PROC MIXED in SAS. Fixed effects of treatment, birth LS, reared LS, sex and dam parity were included, while dam was included as a random effect for all lamb performance traits. Fixed effects of treatment, dam parity, lamb LW, time off feed, temperature, pressure, humidity and chamber were included for CH4 g/day, CH4 g/kg LW and CH4 g/kg average daily gain (ADG). Contemporary group accounted for date and lot number and was included as a random effect for CH4 traits. Fixed effects of treatment, lamb age and LW were included for microbiome analysis.

**Results**

Lambs grazing PRG+WC, PRG+RC or PRG+Chic had a higher post-weaning ADG (*P<*0.001) of 29-60 g/day and an increased lifetime ADG (*P<*0.001) of 24-46 g/day, compared to lambs grazing PRG. The addition of any companion forage reduced age at slaughter, with reductions of 39, 50, 30 and 16 days achieved for lambs grazing PRG+WC, PRG+RC, PRG+Chic and PRG+Plan respectively (*P<*0.001). Lambs grazing PRG+WC, PRG+RC or PRG+Plan ranked lower for CH4g/day, CH4 g/kg LW and CH4 g/kg ADG compared to lambs grazing PRG (*P<*0.001). There was a lower relative abundance of *Methanobrevibacter* (*P<*0.001) in the rumen of lambs grazing PRG+RC than those grazing PRG, PRG+Chic and PRG+Plan.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Sward Type1 |  |  |
|   | PRG | PRG+WC | PRG+RC | PRG+Chic | PRG+Plan | SEM | P-value |
| *Lamb performance* |  |  |  |  |  |  |  |
| Post-weaning ADG2 | 120d | 163ab | 180a | 149bc | 131cd | 0.7 | <0.001 |
| Lifetime ADG | 162c | 195ab | 208a | 186b | 173c | 0.4 | <0.001 |
| Age at slaughter | 252d | 213ab | 202a | 222b | 236c | 4.0 | <0.001 |
| *CH43output* |  |  |  |  |  |  |  |
| CH4, g/day | 14.3a | 13.4bc | 12.4d | 13.9ab | 13.2c | 0.30 | <0.001 |
| CH4, g/kg LW4 | 0.40a | 0.37bc | 0.34d | 0.38ab | 0.36c | 4.1 | <0.001 |
| CH4, g/kg ADG | 109.6a | 88.8b | 77.6c | 92.3a | 98.9b | 0.01 | <0.001 |
| *Rumen archaea* |  |  |  |  |  |  |  |
| Methanobrevibacter | 89.0b | 84.4ab | 81.4a | 87.1b | 86.6b | 1.24 | <0.001 |

Table 1. Effect of sward type on performance, CH4 output and the relative abundance of *Methanobrevibacter* in the rumen of lambs post-weaning.

a-dValues within rows with different superscripts differ at *P<*0.05;1PRG=perennial ryegrass, PRG+WC=perennial ryegrass and white clover, PRG+RC=perennial ryegrass and red clover, PRG+Chic=perennial ryegrass and chicory, PRG+Plan=perennial ryegrass and plantain.2ADG=average daily gain.3CH4=methane.4LW=live weight.

**Conclusions**

Enhancing production efficiency in tandem with a reduction in enteric CH4 emissions will enhance the profitability and environmental sustainability of pasture-based lamb production. This study demonstrates that incorporating herbs and legumes into perennial ryegrass swards significantly enhances lamb performance post-weaning, reducing age at slaughter compared to those finished on perennial ryegrass monocultures. Additionally, these findings indicate that more diverse swards offer the potential to achieve direct and indirect reductions in CH4 output while manipulating the population of methanogens within the rumen, potentially offering a more favourable microbial signature to reduce CH4 output. This research supports the use of binary sward mixtures in intensive pasture-based sheep production systems as a practical and effective strategy to improve production efficiency and mitigate CH4 emissions in lamb-finishing systems.

**References**

Cranston, L., Kenyon, P., Morris, S., and Kemp, P. (2015). Journal of New Zealand Grasslands, 77, 89–94.