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FEED-INTAKE AND METHANE EFFICIENCY FOR WEIGHT AND GROWTH PRE-SLAUGHTER OF MLA RESOURCE FLOCK LAMBS.

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SUMMARY

Improving feed-use efficiency and reducing methane emissions in sheep are critical strategies for enhancing market access, profitability, and the long-term sustainability of the sheep industry. In this study, 758 lambs from Merino, Maternal and Shedding ewes mated artificially to Merino, Maternal, Terminal and Shedding sires were assessed for weight, growth, and methane production prior to slaughter across six kill groups (2 years x 3 ages). Weight and growth accounted for 72-89% of the observed variation in daily feed intake. No additional variation was explained by body composition or methane production, as measured in this study. Residual feed intake exhibited high variability across all breed types (sire means ranged from -0.17 to +0.18 kg/hd/day, SD=0.12), suggesting that genetic selection for feed efficiency and methane reduction is achievable for Terminal, Shedding, and Merino sheep. This research highlights the potential for genetic improvements in reducing methane emissions and enhancing feed efficiency in sheep, offering pathways to a more sustainable and profitable sheep industry.

INTRODUCTION

Efficient use of feed is a critical determinant of productivity and sustainability in livestock systems, particularly in the red meat industry. Understanding factors that influence feed intake and efficiency is essential to develop strategies that enhance growth performance, reduce costs, and mitigate environmental footprints.

Breeding sheep that use less feed to produce the same or more productivity is an attractive solution, however progress is likely to be slow due to the low-moderate heritability (0.1-0.45) of residual feed intake for sheep and trait instability due to feed and environmental variation (Snowder and Van Vleck 2003; Cammack *et al.* 2005; Paganoni *et al*. 2017; Tortereau *et al.* 2020; Ellison *et al.* 2022). Centralised research facilities and protocols that can estimate feed intake traits should play a valuable role in establishing protocols and increasing trait screening and accessibility to all sheep producers through existing services such as Sheep Genetics Australia and established resource flocks such as the Information Nucleus (Fogarty *et al*. 2007). Additionally, established resource flocks allow breeders to take advantage of genomic selection to accelerate genetic improvement exploiting opportunities to increase red meat production while simultaneously reducing methane emissions.

This study investigated variation in feed intake and associated traits including methane production under *ad libitum* feeding pre-slaughter.

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MATERIALS AND METHODS

Lambs from the MLA resource flock at Katanning born in July 2022 (n=929) and 2023 (n=899) were measured for methane and body composition at early post weaning age (5-6 months old), and measured for feed intake (total=736), then methane (n=1,300) and body composition (n=1575) a second time prior to slaughter (7-10 months old). Kill groups 2,3 and 4 of both cohorts entered indoor feedlot facilities between Jan-May prior to slaughter (7-10 months old; Table 1). In each kill group, approximately half had average daily feed intake captured for approximately 28-32 days.

Table 1. Kill group numbers and dates for the 2022-born and 2023-born cohorts of lambs from the MLA resource Flock at Katanning

Kill Grp	2022-born		2023-born	
	No.	Breed	No.	Breed
1	224	Dorper	198	Merino/Maternal/Terminal/Dorper
2	231	Merino/Maternal/Terminal/Dorper	240	Merino/Maternal/Terminal
3	231	Merino/Maternal/Terminal/Dorper	204	Dorper
4	243	Merino/Maternal/Terminal/Dorper	241	Merino/Maternal/Terminal
Total	929	(slaughtered)	883	(slaughtered)

*Slaughter numbers were lower in 2023 due to less ewes mated/lambs weaned

Methane. Post-weaning methane production (CH_4) using Portable Accumulation Chambers (PACs) was captured at early post-weaning (5 months old) in December 2022 (n= 929) and 2023 (n=899). A second CH_4 measurement was completed prior to slaughter for kill groups 2-4 (8-10 months old) for both cohorts. In both years, pasture had senesced, therefore all lambs were being supplemented with grower pellets and oaten hay in 2022, and oaten hay and a 70% oat:30% lupin mix in 2023. Prior to measurement lambs were drafted into groups of 16 and. time off-feed ranged between 1-5 hours. CH_4 was recorded 3 times over 45 minutes using an Eagle 2 gas analyser (*E2*, RKI Instruments, Union City, USA). All non-linear CH_4 accumulation was removed (2%).

Body composition. Muscle and fat were measured twice via ultrasound at the C-site (Robinson *et al.* 1992) using a Sheep Genetics accredited scanner.

Feed intake. All lambs prior to entry into the feed intake shed were adapted to an *ad libitum* pellet diet over 14 days (11MJ,13%CP). The sheep were then stratified by weight (max range of 5kg per pen to minimise bullying) and randomised by sire into up to 20 pens with 10-14 sheep per pen. Animals in all pens were weighed twice weekly. Daily feed intake measurements were recorded automatically for about half of each kill group in the facility (10 reading and 10 non-reading pens; total=758 lambs). Intake data was captured as individual meals. A cleaning algorithm removed meals with blank or not-present EID, where feed intake was 0 or negative and outlier meals (3 x SD from mean meal intake rate – to remove events involving cleaning/vacuuming of the feed trays). After cleaning, the data was summarised into individual daily intake for each sheep. All sheep with >40% coefficient of variation in daily intake were removed as confidence of a stable trait was too low (n=41 or 5% of records).

Residual Feed Intake (RFI). RFI was analysed using a two-step approach. First multiple linear regression was used where average daily intake (ADI) was adjusted by fitting (1) mean metabolic mid weight; MMWT and (2) Average Daily Gain (ADG) as covariates:

(1) MMWT = the predicted mid weight during the feed intake test calculated via linear regression of the twice weekly weights throughout the intake test

(2) ADG = the slope of the linear regression used to calculate MMWT

Each kill group was modelled separately with pen fitted as group. Date of birth, birth type and sex were added and dropped from all models as their effects were insignificant (excepting one model/kill group) after fitting MMWT and ADG. The unexplained variation after fitting the above model was the residual feed intake. In the second step, Residual Maximum Likelihood was used to test feed intake for significant sire effects for each cohort separately. Kill group, MMWT and ADG and sire were fitted as fixed effects (plus all significant two-way interactions) with dam and pen fitted as random effects. All non-significant terms were dropped from the final model(s).

RESULTS AND DISCUSSION

Differences in sire means for RFI were significant for the 2022 cohort (P<0.001; Figure 1). For this cohort 99 sires were represented amongst the intake measures with an average of 3.4 progeny per sire (range 2-7 progeny per sire). For the 2023 cohort there were 101 sires screened for intake with an average of 3.0 progeny per sire (range 2-8 progeny per sire), sire differences were undetectable for this cohort. (Only half of the progeny from each sire is represented at Katanning and only half of each kill group was measured for intake, this limitation meant no common sires were measured across years). More importantly, sires from all breed types were represented at the extreme ends of RFI across both cohorts. Sires means for RFI (using only sires with at least 3 progeny per sire) varied from -170 ± 0.10 g/hd/day (n=10) to +180 ± 0.08 g/hd/day across all kill groups and cohorts Using the average standard deviation in RFI within breed and kill group (0.12) and an estimated heritability in sheep of 0.1 (Cammack *et al.* 2005; Paganoni *et al.* 2017), this indicates potential genetic gains of 0.3% per year may be possible through feed-intake testing under ad libitum feeding conditions pre-slaughter (assuming selection pressure is 1 and a 4-year generation interval).

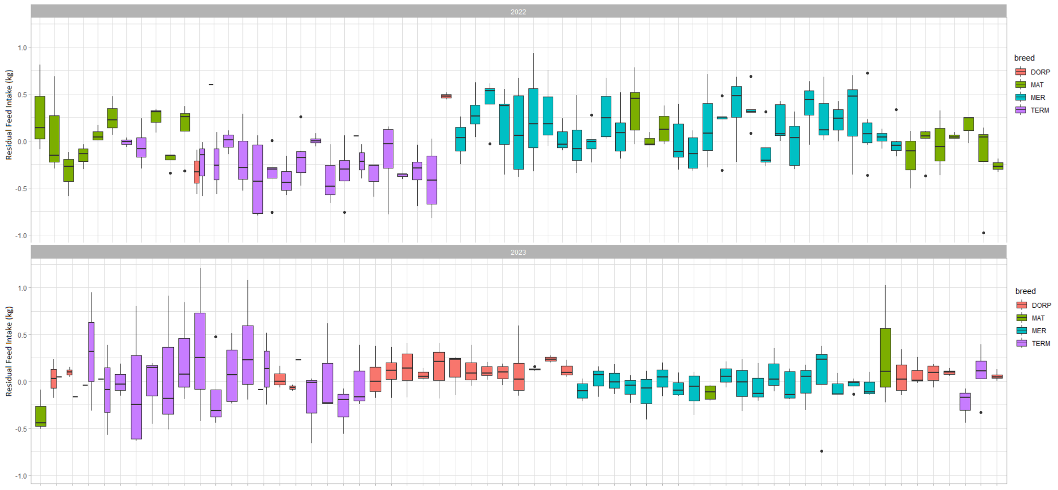

Figure 1. Sire predicted means for residual feed intake (kg) for the 2022-born (upper) and 2023-born (lower) lambs grouped by key breed types (Dorper = orange, Maternal = green, Merino = blue, Terminal = purple) from the MLA resource flock

MMWT varied from 47-58 kg and ADG pre-slaughter from 79-225g/hd/day and ADI varied between 1.4 and 1.9 kg/hd day between kill groups across both cohorts.

MMWT and ADG explained 72-89% of the variation observed in ADI (Table 2), consistent with, or higher, than previous reports for sheep (Paganoni *et al.* 2017). MMWT had the largest and most significant effect on ADI (strongest correlation) across most of the kill groups with consistent increase in intake of 60-70g for every 1kg increase in weight (P<0.05; Table 2). ADG had additional significant positive effects to MMWT for four of the six kill groups measured (P<0.05; Table 2). For every 1g/hd/day increase in ADG there were additional increases in ADI of 1.5-2g per day

(P<0.05; Table 2). There were no significant effects of birth type or sex on ADI (beyond differences accounted for by MMWT). Date of birth had a small significant additional effect on ADI for one of the six kill groups measured (19g of additional ADI/day older at slaughter, P<0.05; Table 2). Body composition as measured by ultrasound scanning of muscle and fat pre-slaughter had no significant effects on ADI, neither did changes in muscle and/or fat between the post-weaning and pre-slaughter measurements. There were also no significant relationships detected between ADI and methane production measured via PACs pre-slaughter or the average of both PACs (pre-slaughter and post-weaning).

Table 2. Estimates of significant terms from the linear regression model (first-step) for residual feed intake for the kill groups 2-4 of the 2022&2023-born lambs from the MLA resource flock at Katanning. The variation explained by the significant model terms appears in brackets (%VE)

Year, grp (%VE)	MMWT	ADG	Date of Birth
2022 2 (89%)	0.11 ± 0.004	n.s.	0.019 ± 0.005
2022 3 (72%)	0.07 ± 0.025	n.s.	n.s.
2022 4 (84%)	0.06 ± 0.022	1.52 ± 0.730	n.s.
2023 2 (89%)	n.s.	1.81 ± 0.840	n.s.
2023 3 (75%)	0.07 ± 0.026	2.03 ± 0.794	n.s.
2023 4 (77%)	0.06 ± 0.018	1.53 ± 0.804	n.s.

CONCLUSION

The findings of this study provide key preliminary insights into variation for feed intake and efficiency traits in Australian sheep. Initial findings indicate that genetic gains in residual feed intake, may be possible for permanent and cumulative efficiency gains in lamb finishing systems. Notably, over 75% of variation in daily feed intake is explained by weight and growth, with methane production and body composition, as measured in this project, contributing minimally. This underscores the central role of weight and growth in driving feed-use efficiency, under *ad libitum* finishing systems. Importantly, sires across all major breed types exhibit extremes in residual feed efficiency, suggesting broad genetic variability that can be leveraged for selection.

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