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BRIEF COMMUNICATION: An exploratory investigation of the effects of selection for divergence in methane emissions on rumen digesta and carcass traits in eight-month-old sheep

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Introduction

Global agriculture accounts for approximately 14% of anthropogenic emissions. In New Zealand, methane emissions from ruminants comprise 31.5% of the total emissions (Ministry for Environment 2009), therefore, any future mitigation of emissions could have substantial economic implications for the agricultural sector. Reducing emissions from ruminant livestock without affecting animal production against a rising demand for animal products is challenging (Clark 2009). Measurements carried out over the last 15 years have shown a common feature of individual animal variation in methane emissions (Pinares-Patiño et al. 2011b). Recently it has been shown that enteric methane emissions from sheep are both heritable and repeatable (gCH_4/kgDMI 0.29 ± 0.05; repeatability 0.26 ± 0.02), whether expressed as gross emissions (g/d) or methane yield (emissions per unit of feed dry matter intake, g/kgDMI; Pinares-Patiño et al. 2013). This makes breeding an attractive mitigation strategy for the lowering of enteric emissions from ruminant livestock given animal production performance is not affected (Pinares-Patiño et al. 2011a).

Breeding animals with lower methane yield will guarantee a reduction in total CH_4 emissions if feed intake and animal productivity are maintained. However, the successful adoption of any breeding program, will be dependent on the economic cost and benefit largely driven by correlations between greenhouse gas emission and production. If a relationship were demonstrated between low methane yield and production, there could be financial benefits for producers selecting sheep for low methane yields (Clark 2009). It has been shown that low emitting animals have smaller rumens with lower rumen volatile fatty acid concentrations and higher passage rates of feed through the alimentary tract (Goopy et al. 2013; Pinares Patiño 2003; Hoffman 1989). We hypothesise that these anatomical and physiological changes may affect a variety of carcass traits. The objective of this study is to determine whether selection for divergent methane emissions has affected digestive organ anatomy and carcass traits.

Materials and methods

This study was conducted at the AgResearch Woodlands Research station, Invercargill (Southland). The experimental protocols followed were approved by the Invermay Animal Ethics Committee.

Trial design

The selection line flock was formed during 2008 and 2010-2012 by screening the methane yield of animals (born 2007, 2009-2011) from the central progeny test programme flocks (n=3), and an industry ram breeding flock. Animal model BLUP breeding values were estimated and matings conducted to generate divergent high and low CH_4 emission lines (Pinares-Patiño et al. 2013). These high and low methane selection lines are now closed and maintained by annual selection and mating of 100 ewes and 5 rams resulting in ~124 progeny per line per year. Breeding values are estimated from accurate measurements of methane emission using respiration chambers and feed dry matter intake, with 96 ram and 96 ewe lamb offspring of the current selection lines phenotyped annually. Generation 1 progeny were born in 2010, 2011 and 2012. Here we describe the analysis of 60 2012 born male progeny, 37 selected from the high CH_4 selection line (progeny of 4 sires) and 23 selected from the low CH_4 yielding line (progeny of 4 sires) that were surplus to breeding requirements. Differences between lines in gCH_4/day per kg DMI emitted was 6.5% ($P<0.0001$).

Measurements

Live weight was recorded for each animal prior to slaughter at 8 months of age at the Alliance Group Lorneville plant on the 19 June 2013. The animals were grazed on pasture and were slaughtered approximately 24 hours after removal from pasture. Carcass yield and quality traits measured included cold carcass weight, butt circumference, GR (GR, tissue depth over the 12^{th} rib), carcass length and leg length. Dressing percentage was calculated as the ratio of carcass weight divided by pre-slaughter weight. Estimated carcass weight, GR and the percentage of lean meat in the carcass, leg, loin and shoulder were estimated by the Alliance Group VIAscan® system (McLean et al. 2006). The alimentary tract consisting of the rumen, reticulum and omasum were collected. Rumen + reticulum full and empty weights, omasum full and empty weights were recorded. Rumen + reticulum and omasum contents were calculated as the difference between the full and empty weights.

Statistical Analyses

Pre-slaughter liveweight, carcass and digestive tract traits were analysed using a linear mixed model (1) implemented with ASReml 3 software (Gilmour et al. 2009). Wald test statistics were used to compare carcass related phenotypes of the high methane yield animals (n=37, progeny from 4 sires) with the low methane yield animals (n=23, progeny of 4 sires). Sire was fitted as a random genetic effect and for meat and alimentary tract traits a covariate was fitted to adjust for carcass weight.

$y_{ijk} = \mu + line_i + \beta cwt + sire_j + error_{ijk}$ (1)

Where y_{ijk}, is phenotypic trait measure of the kth animal from the *i*th selection line, and having the jth sire, μ is the mean, β is a regression co-efficient describing relationship with carcass weight when fitted as a covariate, sire and error are normally distributed genetic and within individual residual error terms respectively.

Results and discussion

Table 1 identified that the CH_4 selection lines differed in lean carcass yield, rumen and reticulum weight and on dressing out percentage. Low methane emitting animals had higher estimated lean yield (leg, shoulder and total; 2.7%; P<0.05) and lighter rumen, reticulum and contents weights (P<0.05). Dressing percentage was 1.3% higher in the low methane progeny (P=0.05).

Under the VIAscan® computer vision image analysis carcass grading system, farmers receive payment based on the percentage lean meat yield from the hindleg, loin and shoulder primal cuts (Jopson et al. 2009). One of the scientific drivers for CH_4 mitigation is a reduction of energy losses through methane production. This has the potential to manifest as greater production efficiency, and increased yield of animal product (Pinares-Patiño & Clark 2010). Given the significantly greater meat yield in low methane selected progeny and higher dressing percentage shown in this study, we conclude that selection for low methane emitting animals has not resulted in reduced carcass value and potentially may result in favourable carcass changes, although we stress that independent confirmation of these results is still required.

One of the greatest sources of variation in DO%

Table 1 Means of live weight and carcass traits for progeny from low CH_4 (n=23) and high CH_4 (n=37) selection lines with Wald test statistics for differences between lines.

	Phenotypic trait means				
Trait	Low	High	High Vs. Low[a]	SED	P value
Pre-slaughter weight (kg)	46.9	46.5	-0.39	1.42	0.79
Cold Carcass weight (kg)	19.1	18.3	-0.78	0.66	0.24
Dressing out percentage (%)	40.5	39.2	-0.93	0.40	0.05
Carcass Butt Circumference (cm)	65.7	64.7	-0.75	0.62	0.91
Carcass Fat Depth 12th Rib (mm)	1.9	2.4	0.61	0.37	0.15
Carcass Length (cm)	87.3	86.4	-0.06	0.95	0.95
Carcass Leg Length (cm)	28.4	28.1	-0.15	0.42	0.73
Viascan carcass weight (kg)	19.5	18.7	0.01	0.01	0.36
Viascan GR (mm)	2.8	3.4	0.81	0.86	0.39
Viascan leg lean (%)	23.6	22.5	-1.19	0.35	<0.01
Viascan loin lean (%)	15.4	14.9	-0.42	0.26	0.18
Viascan shoulder lean (%)	17.8	16.7	-1.04	0.30	0.02
Viascan lean yield (%)	56.8	54.1	-2.64	0.70	<0.01
Rumen and reticulum full weight (g)	4785.3	5346.6	722.4	370.2	0.01
Rumen and reticulum empty weight (g)	960.4	974.0	35.6	24.9	0.20
Omasum Full (g)	132.0	139.3	9.7	10.4	0.39
Omasum empty (g)	84.9	83.9	1.2	5.1	0.06

[a] Estimated difference between lines after fitting sire and carcass weight.

is the weight of contents of the gastrointestinal tract at the time of pre-slaughter weighing. Gut-fill can vary between 10% and 22% of pre-fast live weight (Litherland et al. 2010). Low methane progeny had lighter full weights of rumen and reticulum than high methane emitting progeny. This difference is potentially a consequence of smaller rumen size, faster feed passage rates and therefore lower methane yield and is consistent with previously published results (Goopy et al. 2013; Hoffman 1989; Pinares Patiño 2003; Pinares-Patiño 2011a).

Conclusion

This preliminary work suggests that selection for low methane yield may result in improved carcass traits, that are likely a consequence of differential anatomical and physiological changes in the digestive tract. Replication across years will be essential to both increase numbers and therefore precision and to account for environmental variation between years. Meat quality traits and rumen histological and anatomical features are currently being assessed in further trials.

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