37. Association of genetic resistance to internal nematodes and production traits on feed efficiency and methane emissions in Corriedale lambs

E.A. Navajas[1], G. Ciappesoni[1*], D. Gimeno[2], J.I. Velazco[1] and I. De Barbieri[1]

[1]Instituto Nacional de Investigación Agropecuaria, INIA Las Brujas, 90100, Rincón del Colorado, Canelones, Uruguay; [2]Secretariado Uruguayo de la Lana, Servando Gomez 2408, 11200, Montevideo, Uruguay; gciappesoni@inia.org.uy

Abstract

Potential trade-off among weaning (WWT) and yearling weights (YWT), greasy fleece weight (GWT) genetic resistance to gastrointestinal nematodes assessed by faecal worm egg account (FEC), residual feed intake (RFI) and methane (CH_4) and carbon dioxide (CO_2) emissions were investigated in 217 Corriedale female lambs. Improving RFI was strongly associated with lower dry matter intake (DMI) and independent of metabolic body weight (MWT) and average daily gain (ADG). Person correlation coefficients were also no significant (P>0.05) with WWT, YWT, GFW and FEC expected progeny differences (EPD). FEC EPD was not correlated with any of the traits investigated here. Both CH_4 and CO_2 were not associated with RFI, although the moderate correlations with DMI. Higher EPD for WWT, YWT and GFW were correlated with higher DMI, CO_2 and CH_4. Optimising higher productivity and environmental sustainability requires further research for a more comprehensive understanding of these associations.

Introduction

Sustainable sheep production requires considering not only traditional production traits but also those associated with resilience and greenhouse gas (GHG) mitigation. Genetic evaluation of Corriedale, as dual-purpose breed, includes body weight and wool production, which are relevant for economic income of commercial production. Improving genetic resistance to gastrointestinal nematodes (GIN), using faecal worm egg count (FEC) as selection criteria, is also included in the breeding programme (Ciappesoni *et al.*, 2014). Given the important losses in pastoral grazing extensive systems due to infestation by GIN, and the difficulties to control it only by grazing management and chemical treatments, genetic selection by FEC may also contribute to economic and environmental sustainability.

Improving feed efficiency and reducing enteric methane (CH_4) and carbon dioxide (CO_2) emissions by genetic selection represents an opportunity for reducing production costs (Tortereau *et al.*, 2020) and contributing to GHG mitigation strategies. Although a minimum detrimental effect on productivity is expected by improving residual feed intake (RFI) (Tortereau *et al.*, 2020) and FEC (Ferreira *et al.*, 2021), potential trade-off between production, efficiency, resilience or immune system, and GHG emissions need to be evaluated. Feed efficiency traits and GHG emissions are being recorded in lambs of the Corriedale Information Nucleus in Uruguay, providing the basis for investigating the associations among current and potentially new breeding objectives towards environmentally sustainable sheep production. The aim of this study was to investigate the association between growth, wool and FEC, based on the expected progeny differences (EPD) for these traits, and feed intake, feed efficiency and GHG emissions.

Materials & methods

Two hundred and seventeen Corriedale female lambs, from three cohorts (2018-2020) sired by 12 rams genetically linked breeding population were studied. The EPDs published in 2021 for weaning weight (WWT-E), body weight as hogget (YWH-E), greasy fleece weight (GFW-E) and FEC (FEC-E), which included animal own records, were provided by the National Sheep Genetic Evaluation System (www.geneticaovina.com.uy)

R.F. Veerkamp and Y. de Haas (eds)

DOI: 10.3920/978-90-8686-940-4_37, © E.A. Navajas *et al.* 2022

Feed efficiency and methane phenotypes. 42-day feed efficiency tests were carried out, after 14 days of acclimatisation to feed and facilities. Lambs were allotted to one of five pens according to initial body weight, type of birth and sire, and fed *ad libitum* with Lucerne haylage (22.0% of crude protein, 26.6% of acid detergent fibre, 32.2% of neutral detergent fibre, and 59.0% of dry matter). Average dry matter intake (DMI) and growth rate (ADG) were calculated based on daily feed intake and body weights recorded by automated feed bins and weighing platforms (Intergado®, Belo Horizonte, Brazil), respectively (Ferreira *et al.*, 2020). Portable accumulation chambers (PAC) were used to measure CH_4 and carbon dioxide (CO_2) emissions using protocol described by Paganoni *et al.* (2017). Two estimates per animal were performed in the last weeks of the feed intake test, with one week between them.

Data calculation and analysis. Residual feed intake (RFI, Koch *et al.*, 1963) was estimated as:

$$y = u + MBW + ADG + Test \times Pen + e(RFI)$$

where y = DMI (kg/day), MBW is the metabolic average body weight (kg, covariate), ADG is the average daily gain, previously calculated by linear regression (g/day, covariate), Test is the effect of the test (3 levels), Pen is the effect of the pen (5 levels) and RFI is the residual error.

Phenotypes of DMI, MBW and ADG, as well as CH_4 and CO_2, were adjusted by environmental effect using a lineal model that included Test × Pen as class effects, and age (days) as covariate. The corresponding residuals DMI-A, MBW-A, ADG-A, CH_4-A and CO_2-A were included in the analysis. Given the criteria used to allot animals to pens, adjusting by this factor also implies indirectly adjusting by initial body weight. The associations among traits were assessed by Pearson correlation coefficients based on the data described in Table 1. All analysis were carried out using CORR and GLM procedures in SAS program version 9.4 for Windows (SAS Inst., Cary, NC, USA).

Table 1. Mean, standard deviation (SD), minimum (Min) and maximum (Max) values of EPD for production traits, and feed efficiency and GHG emissions phenotypes of Corriedale female lambs (n=217).

Traits	Mean	SD	Min	Max
Weaning weight EPD (WWT-E, %)	7.80	3.70	-2.53	17.39
Yearling body weight EPD (YWT-E, %)	6.87	3.34	-2.51	15.84
Faecal worm egg count EPD (FEC-E, log FEC)	-0.11	0.10	-0.39	0.21
Greasy fleece weight EPD (GFW-E, %)	1.96	2.94	-5.63	11.82
Residual feed intake (RFI, kg DMI/day)	0.00	0.11	-0.26	0.49
Dry matter intake (DMI, kg/day)	1.21	0.22	0.49	1.80
Metabolic body weight (MWT, kg)	14.20	1.45	9.88	18.30
Average daily gain (ADG, kg/day)	0.17	0.04	0.05	0.27
Methane emissions (CH_4, g/day)	16.41	4.75	6.10	28.48
Carbon dioxide emissions (CO_2, g/day)	826.97	179.06	441.42	1,448.00
Adjusted DMI (DMI-A, kg/day)	0.00	0.15	-0.37	0.53
Adjusted MWT (MWT-A, kg)	0.00	0.77	-2.07	3.52
Adjusted ADG (ADG-A, kg/day)	0.00	0.04	-0.11	0.12
Adjusted CH4 (CH_4-A, g/day)	0.00	2.65	-7.93	7.91
Adjusted CO_2 (CO_2-A, g/day)	0.00	110.96	-319.50	340.64

Results

As expected, RFI was correlated with DMI (r=0.50) and independent of weight and growth. Similar associations were found between RFI and the adjusted traits, although the correlation coefficient with DMI-A was higher than with DMI (r=0.74). The associations among feed efficiency traits and GH emissions are in Table 2. High positive correlations were calculated for DMI and both GHG (~0.60), and the association was weaker for the adjusted phenotypes.

The correlations of growth and weights were also high with unadjusted and adjusted DMI, CH_4 and CO_2 (range 0.30 to 0.74). No significant association (*P*>0.05) were found between RFI and GHG emissions.

Body weights EPD had positive correlations with most of the traits included in this study. They were medium to high with DMI (0.57), MWT (0.66) and both GHG emissions traits (0.51-0.54). When these traits were adjusted, the correlation magnitude decreased to low-moderate (0.19-0.44) but remained significant (Table 3). The associations of GFW-E were positive and low with MWT and DMI, and negative with ADG. No association were found with between GFW-E and GHG emissions (*P*>0.05). On the other hand, any of the feed efficiency traits or GHG emissions were significantly correlated with FEC-E. RFI was not significantly associated with any of the EPD considered here.

Table 2. Correlation coefficients between feed efficiency and GHG emissions traits.[1]

Unadjusted[2]	**DMI**	**MWT**	**ADG**	**RFI**
DMI		**0.74**	**0.47**	**0.50**
CH_4	**0.58**	**0.52**	**0.38**	-0.04
CO_2	**0.59**	**0.70**	**0.51**	-0.03
Adjusted	**DMI-A**	**MWT-A**	**ADG-A**	**RFI**
DMI-A		**0.61**	**0.43**	**0.74**
CH_4-A	**0.26**	**0.35**	**0.30**	-0.04
CO_2-A	**0.42**	**0.54**	**0.45**	-0.03

[1] Coefficients significantly different from zero (*P*<0.05) are in bold.

[2] Abbreviations are described in Table 1.

Table 3. Correlation coefficients of feed efficiency and GHG emissions with EPD of production traits and FEC.[1,2]

	WWT-E	**YWT-E**	**FEC-E**	**GFW-E**
RFI	-0.05	-0.04	0.08	0.10
DMI	**0.57**	**0.57**	0.03	**0.21**
MWT	**0.66**	**0.66**	-0.02	**0.21**
ADG	**0.22**	**0.21**	-0.05	**-0.14**
CH_4	**0.54**	**0.53**	0.11	0.05
CO_2	**0.51**	**0.51**	0.06	-0.06
DMI-A	**0.19**	**0.20**	0.07	**0.23**
MWT-A	**0.43**	**0.44**	0.07	**0.35**
ADG-A	0.05	0.05	-0.08	-0.07
CH_4-A	**0.15**	**0.16**	0.05	0.07
CO_2-A	**0.24**	**0.24**	0.04	0.07

[1] Abbreviations are described in Table 1.

[2] Coefficients significantly different from zero (*P*<0.05) are in bold.

Discussion

Improving RFI by selection is an alternative to reduce production cost by lowering DMI without compromising animal performance (Tortereau *et al.*, 2020). The lack of statistically significant associations between RFI and genetic merits for growth and wool production is encouraging about the potential benefits of integrating this trait in the Corriedale breeding programme. However, we did not find a reduction in CH_4 emissions in more efficient lambs, as in other studies (i.e. Paganoni *et al.*, 2017). If genetic correlations follow these coefficients among adjusted phenotypes, RFI could not be considered as indirect selection criteria for GHG mitigation.

The positive associations between CH_4 and CO_2 and EPDs for growth and wool production indicate that reducing GHG emissions would imply a decrease of animal performance, and, therefore, of economic incomes derived from meat and wool. When GHG emissions were adjusted, correlation coefficients decreased from moderate-high to low magnitudes similar to those reported by Robinson *et al.* (2014).

One relevant driver of the associations among production, feed efficiency and GHG emission is DMI. Our results confirm DMI is highly correlated with RFI, as was reported at phenotypic and genetic level in the literature (Paganoni *et al.*, 2017; Tortereau *et al.*, 2020). High DMI is also associated with better animal performance, particularly when animals are fed at libitum like in the feed efficiency tests, as well as with CH_4 and CO_2. However, disentangling the biological interrelation among these traits is constrained given DMI remains as very difficult- to-measure trait, with limited available alternative for grazing conditions.

The non-significant correlations of FEC-EPD with feed efficiency traits indicate that improving FEC does not affect feed efficiency, productivity or GHG emissions. These results are in agreement with Ferreira *et al.* (2021), who did not find differences in these traits between lambs from Corriedale divergent FEC selection lines under natural and artificial GIN challenge.

In summary, these preliminary results indicate that improving feed efficiency by RFI would imply maintaining productivity with lower feed costs, with no unfavourable effect on genetic resistance to GIN and independently of GHG emissions. However, the positive correlations of DMI with GHG emissions and productivity implies a trade-off to be considered at the time of including GHG mitigation as new breeding objective, which will be checked by the estimation of the genetic correlations. As phenotyping continues, larger database will enable the estimation of these genetic parameters.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 772787 (SMARTER), INIA-CL38- RUMIAR, the SusAn, ICT-AGRI 2 and FACCE ERA-GAS funding bodies (GrassToGas).

References

Ciappesoni G., Gimeno D., and Coronel F. (2014) Arch. Latinoam. Prod. Anim. 22:73-80.

Ferreira G.F., Ciappesoni G., Castells D., Amarilho-Silveira F., Navajas E.A., *et al.* (2021) Anim. Prod. Sci. 61(8): 754-760. https://doi.org/10.1071/AN20121

Koch R., Swiger L., Chambers D., and Gregory K. (1963) J. Anim. Sci. 22(2):486–494. Paganoni B., Rose G., Macleay C., Jones C., Brown D.J., *et al.* (2017). J. Anim. Sci. 95(9): 3839–3850. https://doi.org/10.2527/jas.2017.1499

Robinson DL, Goopy JP, Hegarty RS, Oddy VH, Thompson AN, *et al.* (2014) J. Anim. Sci. 92(10):4349-63. https://doi.org/10.2527/jas.2014-8042