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USE OF RESIDUAL FEED INTAKE AS AN INDIRECT SELECTION TRAIT FOR REDUCTION OF METHANE EMISSIONS IN GRAZING BEEF CATTLE

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SUMMARY

In Australia, cattle are the largest single source of greenhouse gas emissions from the agricultural sector. A short-fed domestic selection index has been used to predict the genetic gain in beef cattle traits using methane production and/or feed intake as selection criteria with various assumed carbon prices. Indirect selection for reduced methane emissions via feed intake was predicted to be more cost effective than direct measurement via methane emissions.

INTRODUCTION

About 62% of agricultural greenhouse gas emissions result from methane (CH_4) produced by grazing beef cattle and 2.5% from feedlot cattle. Direct selection against MPR is difficult. As MPR and dry matter intake (DMI) are highly correlated (DCC 2008), one genetic approach to reducing methane production rate (MPR) is to breed livestock that consume less feed (Cottle et al. 2011; Hegarty et al. 2010). Residual feed intake (RFI) is a possible indirect selection trait (Archer et al. 2004; Basarab et al. 2007; Herd and Arthur 2009). The high cost of RFI measurement and its interaction with feed type and level may limit its use (Lanna 2009). A system that allows estimation of feed intake or RFI of individual animals on pasture has recently been invented (PCT/AU2010/001054). Indirect benefits from using this system could include indirectly reducing MPR. This study was conducted to model impacts on MPR of including RFI as a feed intake selection trait, with varying assumed carbon prices (C prices).

MATERIALS AND METHODS

The MTIndex program (Cottle et al. 2009) was modified to include RFI and MPR as breeding objective and selection traits. A subset of parameter values for the domestic Australian market, where Angus steers are finished at pasture and slaughtered at 400kg liveweight, was used (Archer et al. 2004). Breeding objective traits (economic value (EV) in brackets) were: direct sale liveweight (SW: \$0.81/kg), dressing percentage (\$6.39/%), saleable meat (SMP: \$5.03/%), fat depth (FD: \$0.74/mm), cow weaning rate (CWR: \$0.93/%), cow weight (CW: -\$0.15/kg), direct calving ease (CE: \$0.65/%), cow RFI (CRFI: -\$27.50/kg/d), yearling RFI (YRFI: -\$20.64/kg/d), cow MPR (CM: \$0 to -\$1.26/kg/y) and yearling MPR (YM: \$0 to -\$1.26/kg/y).

Selection criteria were: birth weight, 200d LW, 400d LW, P8 fat depth, EMA, IMF, scrotal circumference, bull RFI and bull MPR. Published estimates of MPR correlations were used or when correlations were unknown, they were based on known MPR correlations with other traits. The EV of CH_4 (per kg) was calculated as assumed carbon price (\$/t CO_2-e) multiplied by 21/1000. Bull selection only was modelled with a typical herd age structure (Archer et al. 2004). Trait records were assumed to exist for bulls, their sire and dam and 12 of their paternal half sibs.

RESULTS

Calculated annual genetic gains are shown in Table 1. With zero C price, MPR per head increased when using the domestic short- fed index. As C price increased the annual gain in index value decreased until MPR started to reduce in the calculated index. When MPR genetic change is negative the index value increases. However the overall index gain with the effect of the lower carbon penalty removed (IndexM in Table 1) continued to fall with higher C prices because selection pressure is reduced on traits other than MPR in the breeding objective.

Table 1. Calculated annual genetic gains per animal through sire selection with and without RFI and MPR included as bull selection criteria.

C price	SW	SMP	FD	CW	CE	CRFI	YRFI	CM	YM	Index	IndexM
RFI and MPR not included											
0	2.30	0.10	-0.03	2.24	-0.24	-0.02	-0.02	0.39	0.12	2.68	2.68
30	2.01	0.13	-0.04	2.00	-0.24	-0.02	-0.02	0.20	0.07	2.43	2.60
60	1.52	0.15	-0.05	1.57	-0.23	-0.01	-0.01	-0.04	0.01	2.35	2.31
RFI included											
0	1.91	0.11	-0.03	2.22	-0.12	-0.03	-0.03	0.26	0.06	3.12	3.12
30	1.55	0.13	-0.03	1.95	-0.10	-0.03	-0.03	0.07	0.00	3.00	3.04
60	1.10	0.14	-0.04	1.58	-0.08	-0.03	-0.03	-0.13	-0.05	3.03	2.81
MPR included											
0	2.04	0.09	-0.03	2.24	-0.25	-0.02	-0.02	0.31	0.07	2.74	2.74
30	1.53	0.11	-0.03	1.94	-0.25	-0.03	-0.03	0.06	0.01	2.60	2.64
60	0.88	0.12	-0.03	1.48	-0.24	-0.03	-0.03	-0.21	-0.09	2.68	2.32
RFI and MPR included											
0	1.88	0.11	-0.03	2.22	-0.13	-0.03	-0.03	0.25	0.05	3.13	3.13
30	1.41	0.12	-0.03	1.95	-0.12	-0.03	-0.04	0.02	-0.02	3.03	3.03
60	0.86	0.13	-0.03	1.55	-0.11	-0.03	-0.04	-0.20	-0.09	3.12	2.76

Trait abbreviations and units defined in text; Index: standard deviation of Index ($); IndexM: standard deviation of Index minus value of methane change ($).

Inclusion of feed intake increased index gain more than including MPR and was predicted to reduce MPR nearly as much as direct MPR selection. The largest increase in index value occurs when both RFI and MPR were used. The C prices resulting in no change in MPR were \$55/tCO_2-e without RFI and MPR included as selection criteria, \$41/tCO_2-e when RFI was included, \$36/tCO_2-e for MPR or \$33/tCO_2-e when RFI and MPR were both included as selection criteria.

DISCUSSION

The results in Table 1 suggest that RFI (or DMI) is more cost effective than MPR as a selection criterion for C prices from zero to \$60/t CO_2-e. This also applied when a C price of \$120 was modeled. Initial C prices of \$20-\$30/t CO_2-e are expected in Australia. MPR per head or per herd would have to be monitored or estimated for the application of CH_4 penalties to beef producers.

The results do not take into account the cost of measuring RFI or MPR or changes in livestock numbers grazing a set land area as a result of changes in traits such as CWR or CW. CW has a negative EV and is probably positively correlated to MPR, so selection pressure to reduce CW should reduce MPR. More sophisticated modeling, such as ZPLAN (http://zplan.uni-hohenheim.de), accounting for costs and stock numbers would be justified and more credible if MPR genetic parameters were better defined. Indices currently used for British breed short-fed cattle would probably reduce MPR/herd if output per land area is kept constant as the index would lead to fewer cows due to a higher CW and a shorter period to slaughter due to faster growth rates, so less feed would be required for herd maintenance. This may not necessarily lead to lower CH_4 per kg DMI or CH_4 per kg saleable meat (SMP), which are better measures of system efficiency and total emissions from the beef sector.

For individual herds to achieve reductions in CH_4 outputs, one decision to be made is whether the breeding objective trait is MPR/head, or MPR/kg SMP or MPR/kg DMI (i.e. ratio traits). An argument for having MPR/head as a breeding objective rather than MPR/kg DMI or SMP is that if DMI and SMP are included in the breeding objective with MPR, then it is most efficient to include these traits as breeding objectives rather than selecting for a ratio breeding objective that includes two traits (i.e. MPR and DMI or SMP) with different variances (Gunsett 1986). Use of MPR/head as an estimated breeding value still allows the subsequent calculation of EBVs for MPR/kg DMI or MPR/kg SMP, if information is preferred in this form by breeders.

Selection on RFI and production leads to identical responses to those from selection on DMI and production, as RFI adds no new genetic information (Kennedy et al. 1993). The EBV_{RFI} of animals determined on ad lib grain (Herd et al. 2006) or hay rations (Meyer et al. 2008) may be poorly correlated with their feed efficiency on lower levels of intake when at pasture (Lanna 2009) or with their progenies' EBV_{RFI} (Rutherford 2010). A new pasture intake measurement system (Proway Livestock) using RFID and plant marker technology could assist genetic selection for improved feed use efficiency and also be used to indirectly select for MPR reduction.

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