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OPTIMISING THE PROPORTION OF SELECTION CANDIDATES MEASURED FOR METHANE EMISSIONS IN A BEEF CATTLE BREEDING OBJECTIVE THAT INCLUDES FEED INTAKE

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SUMMARY

Reducing daily feed intake (DFI) via selection for lower daily methane production (DMP) has the potential to be more cost effective than direct selection for DFI. DMP has a high heritability and high genetic correlation to DFI. The optimal proportion of randomly selected young male and female cattle in which to measure DMP was determined by modelling the measurement costs and response to selection of Angus cattle using the Angus breeding index (ABI) augmented with DMP and DFI in a combined breeding objective (BO), but without DFI being measured. Assuming a 20 year planning horizon, it was not profitable to measure any candidates for DMP. The highest breakeven DMP test cost ($41.80/head) occurred when 38% of males and no females had DMP measures. The selection response for DFI only became negative when at least 52% of males had DMP estimates.

INTRODUCTION

Methane emissions from livestock are receiving increased attention (Cole et al., 2016). Reduction in daily methane production **(**DMP**)** can be achieved via direct or indirect selection, e.g. via daily feed intake **(**DFI**)**, as DFI is a highly correlated trait (Cottle, 2011; Jones et al., 2011). DMP and DFI are both very difficult and expensive to measure in pasture based systems. Robinson and Oddy (2016) suggested that when it is not practical or cost effective to measure DFI, DMP can be used as a proxy for feed eaten. Even at the highest plausible cost of methane emissions they found that the economic benefits from improved feed efficiency when measuring DMP were greater than those from reducing methane emissions.

Key questions to answer in a breeding program are: i) how much can beef producers afford to invest in DMP measurement?; ii) what is the breakeven price (BE) for individual test cost to obtain a positive net present value (NPV)?; iii) what proportions of candidate males or females in the herd should breeders measure?; and iv) what is the predicted impact on DFI of any optimal DMP measurement program? The main aim was therefore to determine the optimal proportions of male and female selection candidates to measure for DMP in a one stage selection program aimed at increasing overall index value. These proportions were determined by modelling the selection costs and responses of Angus cattle selected on the Angus Breeding Index (ABI) with DMP and DFI also included in the combined breeding objective (BO), but with DMP, not DFI, being measured in a random sample of the selection candidates.

MATERIALS AND METHODS

Selection index theory was used (Hazel, 1943). A random proportion (M) of selection candidates were measured for DMP that had an enhanced index with a higher accuracy and a larger standard deviation (SD). Let the total number of selection candidates be N. Selection is across these two cohorts, with M.N and (1-M).N candidates per cohort. Assuming random measurement of DMP, both cohorts will have the same genetic mean, and the SD of the index values within cohort j is $\sigma I_j = rIH_j.\sigma H$, where rIH_j is the accuracy of index j, and σH is the SD of the BO. Each of the three traits (Angus Breeding Index (ABI), DMP and DFI) is represented in the BO and selection on EBV was modelled as based on a single phenotype with heritability equal to the EBV reliability, with phenotypes available on the selection candidate for either trait 1 (ABI) or for trait 1 and trait 2 (DMP). Key parameters used in the indexes are summarized in Table 1. The REVs of trait 2 and 3 are negative (DMP and DFI have a cost), reflecting a typical example of unfavourable correlations. Typically, traits 2 and 3 will be selected in the non-desired direction when only using the ABI, i.e. animals will produce more methane and eat more.

Response to selection was predicted using the distributional properties of the mixture of distributions of animals; those with the ABI only, and those with the enhanced index that also includes DMP (Cottle and van der Werf, 2017). The proportion M of males or females randomly measured for DMP was varied by 1% increments to determine the genetic and economic responses for each value of M. A self-replacing herd of 300 breeding cows was assumed with a 90% calving percentage, annual 5% culling/death rate, with 5% of the male candidates and 42% of female candidates selected for replacement to maintain herd numbers.

Table 1. The key parameter values assumed in the 3-trait model. Trait 2 (T2) and trait 3 (T3) relative economic values (REV) are calculated on a yearly basis to be on the same scale as the trait 1 (T1) genetic standard deviation (GenSD)

Parameters	Trait 1 (Angus Breeding Index: $)	Trait 2 (DMP: kgCO$_2$e)	Trait32 (DFI: kg DM)
Accuracy of EBV (h)	0.50	0.55	0.60
REV ($/GenSD)	1.0	-3.65	-18.25
GenSD	44.28	0.80	1.92
Correlations	Genetic	Phenotypic	Residual
T1: T2	0.3	0.16	0.1
T1: T3	0.5	0.22	0.1
T2: T3	0.8	0.46	0.3

Notes:

T1: GenSD advised by Dr. Peter Parnell, Angus Australia CEO.

T2: GenSD = phenotypic SD of 42% of 138 g methane/d (Cottle, 2016b) * 25 (greenhouse warming potential of methane) = 1.45 kgCO$_2$e * accuracy = 0.80. EV = net price of $10/tonne CO$_2$e (Cottle et al., 2016) = $0.01/ kgCO$_2$e * 365 days = -$3.65/kg CO$_2$e/year.

T3: GenSD = phenotypic SD of 42% of 7.5kg DM/d (from Minson and McDonald, 1987 and Cottle, 2016b) * accuracy = 1.92. EV = 5c/kg DM * 365 days = -$18.25/kg DM/year, a small increase on feed cost assumed by Cottle et al. (2011) and Robinson and Oddy (2016).

A discounted cost benefit analysis of strategies with and without DMP measurement was based on the increased benefit from the additional genetic gain versus the additional cost of measuring DMP over a time horizon of 20 years with DMP estimates only occurring in the first 10 years and the first genetic benefit from DMP estimates realised in year 2 (Cottle and van der Werf, 2017). Economic assessment was based on estimated combined BO gain, traits' genetic gain, NPV of the cumulative BO ($) gain over 20 years and breakeven (BE) DMP test cost.

RESULTS AND DISCUSSION

An example comparison of the male and female population distributions with either ABI index alone or extended ABI/DMP index with an arbitrary 70% measured for DMP is given in Figure 1. The annual genetic responses of males or females in the combined BO (all 3 traits), ABI, DMP and DFI with different proportions of males or females measured for DMP are shown in Figure 2.

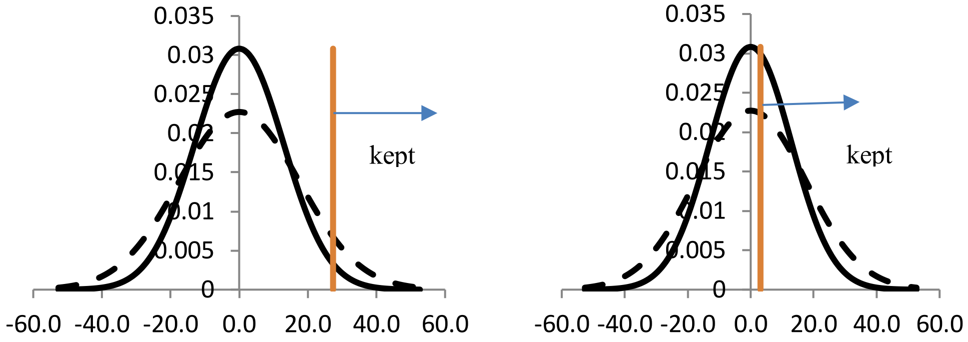

Figure 1. Proportion of candidates versus index value. The Angus Breeding Index (solid line) and extended index (dashed line) with 70% of animals measured for daily methane production (DMP). The proportion of kept males (left) with DMP measurements is higher than for females (right)

The total combined BO value increased by 36% as the proportion of cattle with DMP estimates increased from 0 to 100%, while the responses for ABI, DMP and DFI all became lower, which is in the desired direction for DMP and DFI. It is therefore best to have DMP measurements for all candidates when the cost of measurement is disregarded. However the current estimated cost of measuring DMP was high ($54.64/head, R. Hegarty, pers. comm.), which resulted in it being unprofitable to measure any candidates for DMP.

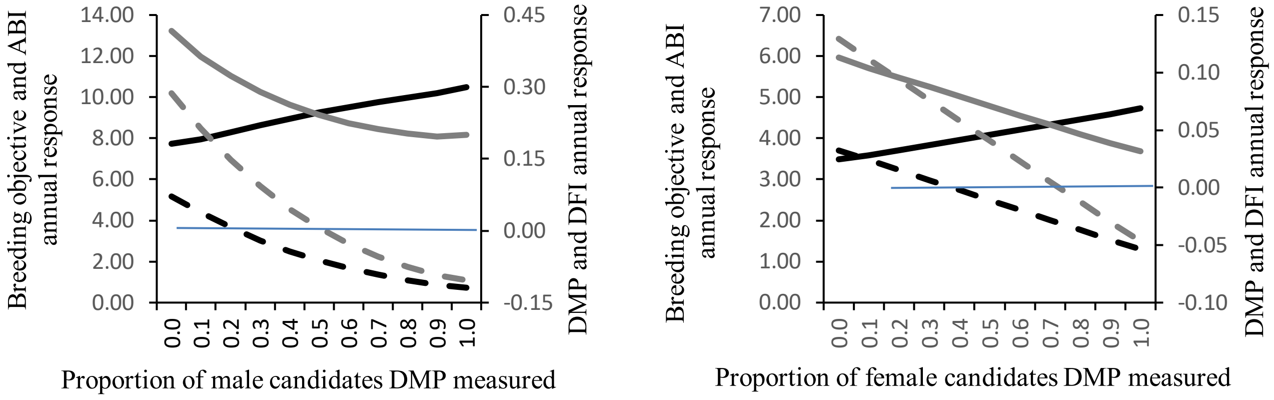

Figure 2. Annual response (per head per year) in males (left) and females (right) in combined breeding objective (BO: $, black, solid line), Angus Breeding Index (ABI: $, grey, solid), daily methane production (DMP: kg CO_2e/d, black, dashed), and daily feed intake (DFI: kg/d, grey, dashed) versus the proportion of candidates measured for DMP. Average generation length (3.4 years) was used, so the total response is the average of the male and female responses

The highest BE ($41.80 per head) for the DMP test occurred when 38% of males and no females had DMP estimates (Figure 3). At $41.80 additional gains equal costs but DMP and DFI would be lower than when no candidates have DMP measures (Figure 2). Thus the economic situation (NPV) would be no better at this BE with DMP measurement but the environment would be improved from lower methane emissions.

A reduction of DMP from male selection only occurred when at least 23% of males had DMP measures or when 38% of females had DMP measures from female selection. A reduction of DFI from male selection only occurred when at least 52% of males had DMP measures or when 73% of females had DMP measures from female selection (Figure 2: trait intersection with zero line).

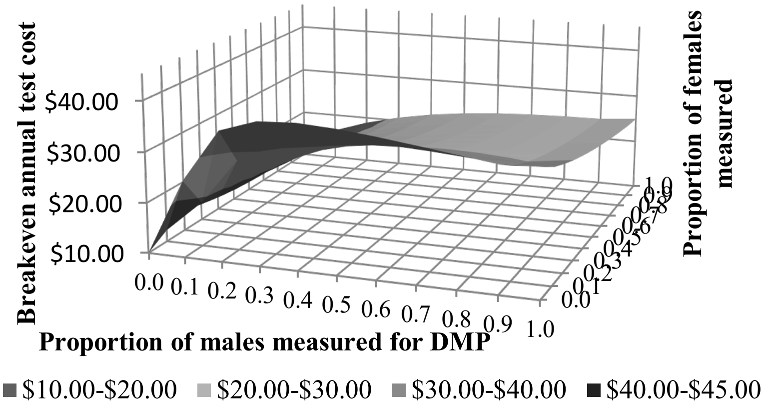

Figure 3. Response in breakeven cost ($/head) to variations in the proportions of males and females measured for daily methane production (DMP) when discounted gains over 20 years with 10 years of measurement were calculated

Robinson and Oddy (2016) also explored incorporating DMP measurements in BOs which included DFI for cattle, where slaughter weight rather than an industry index was modelled as the first trait. However, only the estimated genetic gains per head for a single round of selection with a selection intensity of 1 were calculated. They therefore didn't study profit, only relative gain, so the optimum proportion of animals to measure for DMP, taking into account costs, was not calculated. They also found that the greatest benefit of including DMP in the BO was as a proxy for DFI. Two stage selection for DMP is difficult if animals choose themselves whether to visit the DMP measurement device and ABI values may not be known at the time of DMP measurement.

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