DEVELOPMENT OF A NEW BREEDPLAN OBJECTIVE BODY COMPOSITION EBV TO ALLOW SELECTION TO IMPROVE COW SURVIVAL

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ABSTRACT

This study presents a new method to describe body composition in lactating cows which is under examination as the basis for a new BREEDPLAN EBV. A phenotypic prediction model was applied to generate predicted cow body composition (CBC), fitting body condition score in 1252 lactating Brahman females at their second mating as the dependent variable, with cow liveweight weight (WT), hip height (HH), scanned P8 fat depth (P8) and eye muscle area (EMA), as predictors, along with significant fixed effects. All main effects were significant in the final model as were the effects of P8*P8 and LWT*EMA. The final model included these terms, along with significant fixed effects, and had an r^2 of 0.82. CBC was calculated applying coefficients generated from the final model, when fitted with animal as random to account for genetic effects. Heritabilities for objective cow body composition traits ranged from 0.43 to 0.75 and CBC had a heritability of 0.52. This was substantially higher than the heritability estimated for cow body condition score submitted to BREEDPLAN for lactating Brahman cows at weaning of their calves (0.16). CBC presents a new opportunity to include a trait in the BREEDPLAN evaluation to describe the genetic difference in body composition for breeding females, and an indirect means for selection to improve cow survival.

INTRODUCTION

Australia's beef producing environments are characterised by seasonal feed quality and quantity, which can see females enter the mating season in sufficiently low body condition to impact reproductive performance and, in extreme situations, survival. Fordyce *et al.* (1990), in a rare study of actual cow survival under extreme drought conditions in northern Australia, showed a strong phenotypic relationship of lower cow body condition score at the start of supplementary feeding with lower chance of survival ($P < 0.05$) to the end of the study. Results from the Beef CRC (Wolcott *et al.* 2014) showed that cow body condition score assessed by experienced technicians was heritable in Brahman females at first calving, and at the start of their second annual mating as first lactation cows, 3.4 months later ($h^2 = 0.27$ and 0.48 respectively). That study also showed that body condition across the lifetime of a cow was at its lowest at the start of mating 2, with first-lactation cows losing an average of 52kg liveweight, 14cm^2 scanned eye muscle area, 5mm scanned P8 fat depth while gaining 0.6cm hip height from pre-calving measurements to the start of their second annual mating. The inclusion of cow body condition in the BREEDPLAN evaluation has been a topic of research for some time, and early results (Johnston *et al.* 1996) showed the trait was moderately heritable ($h^2 = 0.14$ to 0.21) when assessed by breeders scoring lactating Angus and Hereford females recorded at the weaning of their calves. As a consequence, breeders submitting mature cow weight records, at the weaning of their calves, for BREEDPLAN analysis have been encouraged to collect and submit body condition score (evaluated on a five point, 1 – 5 scale) at the same time. The study also concluded that including objective cow fat depth may be a better means of describing cow body composition than condition score for genetic evaluation. More recently, Granleese and Clarke (2019) evaluated body condition scores submitted by Angus breeders at the weaning of their calves, and reported a very similar heritability ($h^2 = 0.16$), and concluded that adequate genetic variation existed for the trait to be improved by selection in that breed.

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This study aimed to develop a new means of describing cow body composition based on objective measurements collected in the reference population for Australian beef breeders, and to contrast the genetic parameters for this new trait with those for body condition score assessed by breeders, in lactating females, at the weaning of their calves.

MATERIAL AND METHODS

Reference population cow management and body composition traits. The animals evaluated for this component of the study were from the Beef CRC's Northern Breeding Project, and the subsequent Repronomics™ project (n = 535 and 717 respectively) and comprised lactating Brahman females, as they entered their second annual mating. Breeding and management of Beef CRC females up to their first mating was described by Barwick *et al*. (2009), and Johnston *et al*. (2014) described cow management and traits recorded from their second annual mating, while Johnston *et al*. (2017) described management and recording protocols for Repronomics™ cows. In both projects, females were first mated as two year olds, at an average age of 25 months.

At the start of the second annual mating period (at an average of 37 month of age) objective body composition measurements of liveweight (LWT) hip height (HH), scanned P8 fat depth (P8) and eye muscle area (EMA); along with a subjective body condition score (BCS on a 15 point, 1- to 5+ scale) were recorded for all females (Wolcott *et al*. 2014). Models for cow body composition traits included fixed effects which described cohort (year and location of birth), property of origin, month of birth with the age (in months) and sex of the calf at foot at the time of recording, and all first order interactions. Final models for each trait were determined by sequentially removing non-significant terms (P> 0.05) terms. Variance components were estimated using ASReml (Gilmour *et al*. 2009), fitting animal as random with relationships described using a three generation pedigree.

Predicted cow body composition (CBC). A phenotypic prediction equation was developed in SAS (SAS Institute Inc., Cary, NC, USA). Cow condition score assessed in lactation females at the start of their second mating season (BCS) was fitted as the dependant variable with the initial models including LWT, HH, P8 and EMA as covariates, and their first order interactions. The initial models also included fixed effects, which described the cows' year of birth and the location in which they were managed (cohort), their month of birth and property of origin, along with the month of birth of their calf at foot and its sex. The final model was arrived at by sequentially removing non-significant terms (P> 0.05) terms, and contained the main effects of LWT, EMA, P8 and EMA, and interactions of P8*P8 and LWT*EMA (r^2 = 0.82). Significant fixed effects described the cows' cohort, their property of origin, the month in which they were born, along with the month of birth and sex of their calf at foot, and first order interactions of cohort*month of birth, property of origin*month of birth and cohort*calf month of birth.

This model was fitted in ASReml, with animal as random to account for genetic effects, and with the specification that solutions for fixed effects and covariates be estimated setting the mean to zero. CBC was calculated applying the resulting solutions for LWT, EMA, P8 and EMA, P8*P8 and LWT*EMA to produce a prediction of lactating cow into mating 2 body composition in the units of body condition score. A particular advantage of this method is that it allowed the application of nonlinear relationships of objective traits with body condition score, which would not be accommodated in a multi-trait genetic model where objective traits were included in the evaluation and genetic co-variances allowed to describe their relationship with body condition score.

Industry cow body condition score. Breeders have been encouraged to submit condition score recorded on a six point 1 (poor) to 6 (fat) scale for lactating females at the weaning of their calves (WBCS), to allow genetic parameters for the trait to be estimated (BREEDPLAN 2022). Records for the trait collected from 2010 were extracted from the BREEDPLAN database for these analyses. The records analysed for this component of the study were limited to those assessed and submitted by breeders (N = 1,693), and excluded WBCS recorded in reference and research populations, by more experienced technicians, to specifically describe the genetic parameters for records coming from the industry. An important difference between the mating 2 records analysed for the reference population and those from industry was the range in ages at which the latter were collected, with industry females ranging from 2.5 to 10.5 years of age. A very small proportion of females had multiple records, but those beyond their first record were removed from the analysis as there was insufficient data to run an effective repeatability model. Estimation of genetic parameters for WBCS applied the modelling methods described by Graser *et al*. (2005) for mature cow weight, fitting contemporary group, age at measurement, the age of the cow's dam at her birth, and the age and sex of the calf weaned when the record was collected. Variances were estimated in ASReml (Gilmour *et al*. 2009), fitting animal as random with relationships described using a three generation pedigree.

RESULTS AND DISCUSSION

By focusing on body composition in lactating cows as they enter their second annual mating, the intention was to describe females at the time of greatest challenge to their ability to maintain energy reserves. Table 1 presents descriptive statistics, variance components and the resulting heritability (and its standard error) for the traits examined in this study. Lactating first calf Brahman cows averaged 402.5kg liveweight, had an average of 3.5mm of P8 fat, 43.7cm^2 EMA, and an average BCS of 2.5 at this critical stage in their development.

Table 1. Number of records (N), mean and standard deviation (sd), additive (σ^2_a) and phenotypic (σ^2_p) variances, heritabilities (h^2) and their standard error (se) for predicted mating 2 body composition in lactating first calf Brahman females, and it's component traits, and for industry submitted cow body condition score at weaning (of their calves)

Trait[1]	Units	N	Mean	sd	σ^2_a	σ^2_p	h^2	se
LWT	kg	1,252	402.5	56.5	734.7	1301.9	0.56	0.10
HH	cm	1,252	138.5	7.8	13.2	18.3	0.72	0.09
P8	mm	1,252	3.5	2.6	1.7	3.9	0.45	0.09
EMA	cm^2	1,252	43.7	9.9	16.8	38.9	0.43	0.10
BCS	0-15 score	1,252	2.5	0.6	0.06	0.15	0.43	0.07
CBC	0-15 score	1,252	2.4	0.4	0.05	0.09	0.52	0.10
WBCS	1 to 6	1,693	3.1	0.6	0.05	0.33	0.16	0.06

[1] LWT, HH, P8, EMA and BCS describe measures of liveweight, hip height, ultrasound scanned P8 fat depth and eye muscle area, and body condition score recorded in lactating females as they enter their second annual mating respectively. CBC is predicted cow body composition at mating 2, and WBCS is body condition score submitted by Brahman breeders for lactating females at the weaning of their calves.

Predicted lactating cow into mating 2 body composition. Phenotypic prediction presents opportunities to describe relationships of objective cow body composition traits with BCS which are not available when all traits are included in the genetic evaluation and associations exploited via their co-variances. The most important was the capacity to model the significant non-linear relationships identified for P8 fat depth and the interaction of liveweight with scanned eye muscle area. The coefficients generated to estimate lactating cow body compositon showed that higher WT, EMA and P8 were associated with higher CBC, while the regression cofficients for HH, P8*P8 and LWT*EMA were negative. The magnitude of coefficients meant that the negative solutions for P8*P8 and LWT*EMA had a moderating effect on positive linear effects for the main traits, resulting in a unit increase in LWT, P8 and EMA being associated with greater increases in CBC in animals at the lower end of the distribution, than was the case for heavier, fatter and better muscled cows. A negative coefficient for HH reflects industry perceptions that taller females require greater energy input to maintain condition, and highlight the importance of having some description of frame size in the breeding objective, and the gentic evaluation, for Australia's beef breeders.

Genetic parameter estimates. Genetic parameters for LWT, HH, EMA, P8 and BCS (Table 1) were consistent with those reported by Wolcott *et al*. (2014) (h^2 = 0.65, 0.62, 0.42 0.67 and 0.48 respectively). Johnston *et al.* (1996) reported a heritability of 0.14 to 0.21 for breeder recorded BCS in Angus and Hereford cows at the weaning of their calves, and this was consistent with the result presented by Granleese and Clarke (2019) (h^2 = 0.16), and that reported here for WBCS submitted by Brahman breeders (h^2 = 0.16). CBC was more heritable (h^2 = 0.52) than BCS (h^2 = 0.43), which reflected the higher heritabilities estimated for component HH and LWT traits (h^2 = 0.72 and 0.56). The capacity of lactating females to have adequate body condition at mating is prominent in the breeding objective for almost all beef breeds and production systems in Australia. A description of cow condition that incorporates objective body composition information is very closely aligned to this objective and presents new opportunities for breeders to select and improve genetic gains.

CONCLUSIONS

CBC describes cow body composition in the units of condition score, which is familiar to Australia's beef breeders, while providing a more objective and heritable description of the trait at a critical time for beef females. By making it a trait of lactating cows only, it is independent of the effects of reproduction and, as such, can be a basis for selection to reduce the risk of wet cows falling to critically low body condition. It also presents the opportunity to monitor genetic cow body composition as selection pressure is applied to improve other aspects of female productivity.

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REFERENCES

Barwick S.A., Johnston D.J., Burrow H.M., Holroyd R.G., Fordyce G. Wolcott M.L., Sim W.D., and Sullivan M.T. (2009). *Anim. Prod. Sci*. **49:** 367.

BREEDPLAN (2022) Recording cow condition score. Available at: https://breedplan.une.edu.au/recording-performance/recording-cow-condition-score/ (Verified 6 February 2023).

Fordyce G., Tyler R. and Anderson V.J. (1990) *Aust. J. Exp. Agric*. **30:** 315.

Gilmour A.R., Gogel B.J., Cullis B.R. and Thompson R. (2009). 'ASReml user guide. Release 3.0.' VSN International: Hemel Hempstead, UK.

Granleese T. and Clarke S.A. (2019). *Assoc. Advmt. Anim. Breed. Genet*. **22:** 393.

Graser H.U., Tier B., Johnston D.J. and Barwick S.A. (2005) *Aust. J. Exp. Agric*. **45:** 913.

Johnston D.J., Chandler H. and Graser H.U. (1996) *Aust. J. Exp. Agric*. **47:** 1251.

Johnston D.J., Barwick S.A., Fordyce G., Holroyd R.G., Williams P.J., Corbet N.J. and Grant T. (2014) *Anim. Prod. Sci.* **54:** 1.

Johnston D.J., Grant, T.P., Schatz, T.J., Burns, B.M., Fordyce, G. and Lyons R.E. (2017) *Assoc. Advmt. Anim. Breed. Genet*. **22:** 393.

Wolcott M.L., Johnston D.J., Barwick S.A., Corbet N.J. and Williams P.J. (2014) *Anim. Prod. Sci.* **54:** 37.