Proc. Assoc. Advmt. Anim. Breed. Genet: 26: 427-430

PRELIMINARY ANALYSIS OF IMMUNE COMPETENCE TRAITS IN NORTHERN AUSTRALIAN TROPICALLY ADAPTED BEEF BREEDS

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SUMMARY

Immune competence traits (cell-mediated and antibody-mediated immune responsiveness) were evaluated in northern Australian tropically-adapted beef breeds. A total of 784 Brahman, Droughtmaster, and Santa Gertrudis steers were recorded at weaning for the two traits. The development of a statistical model showed year of birth and breed were significant ($P<0.05$) for both immune competence traits. For the cell-mediated immune response, the starting (day 0) live weight and the baseline skin thickness ratio was also significant. Heritability estimates were low to moderate for both traits, with 0.18 and 0.22 for cell-mediated and antibody-mediated immune responses, respectively. These preliminary results indicate that genetic variation exists for these immune competence traits in tropically adapted beef breeds. Further research is required to determine if selecting for immune competence in tropical breeds also improves profit by improving production, health (i.e. reduced reliance on antibiotics to prevent or treat disease) and welfare traits.

INTRODUCTION

Disease has welfare, production and cost implications for beef enterprises. Immune competence traits have been developed for the genetic evaluation of general disease resistance in the Angus Australia national genetic evaluation (Hine *et al*. 2019). Animals with higher immune responses are expected to better resist disease challenges, resulting in fewer losses and improved performance. In Angus, the traits have been estimated to be moderately heritable, with estimates ranging between 0.25 and 0.42 (Hine *et al*. 2019; Reverter *et al*. 2021a; Reverter *et al*. 2021b). Reverter *et al*. (2021a) found immune competence traits generally had small to moderate genetic correlations with production traits. The strongest genetic correlation indicated that animals with low antibody-mediated immune responses had higher weaning (r_g=-0.35) and yearling weights (r_g=-0.39). Hine *et al*. (2021, 2022) compared animals with low and high immune responses and, although not significant due to the study's size, reported animals with low immune responses had higher mortality and disease rates in the feedlot. Immune competence has not been evaluated in northern Australian tropically adapted beef breeds. This paper investigates if the immune competence traits are heritable in Australian tropically adapted beef breeds.

MATERIALS AND METHODS

Animal Data. Immune competence traits were recorded on 784 northern Beef Information Nucleus (BIN) steers from three tropically adapted beef breeds (Brahman n=342, Droughtmaster n=307, and Santa Gertrudis n=135). The northern BIN steers were the males born in the Repronomics project, an extensive reference population targeting female reproduction traits and collecting many phenotypes from birth to slaughter (Johnston *et al*. 2017). Animals were born across two years at two Queensland Department of Primary Industries research herds: Spyglass Beef Research Facility (110 km north of Charters Towers, QLD) and Brian Pastures Research Facility

* A joint venture of NSW Department of Primary Industries and Regional Development and the University of New England

(18 km east south-east of Gayndah, QLD).

Four Repronomics cohorts had immune competence traits measured at weaning over 14 days, following the protocols described by Hine *et al*. (2019). In brief, two traits were measured: cell-mediated immune response and antibody-mediated immune response. On day 0 of the test, animals were removed from their dam, weighed and vaccinated with the Zoetis bovine Ultravac 7in1 vaccine. The magnitude of delayed-type hypersensitivity responses in the skin (caudal fold) under the tail was used to assess cell-mediated immune response. On day 14, a baseline skin thickness measurement was taken with callipers on the tail's caudal fold on both sides. Steers were injected with a small amount of saline on one side (control site) and 7in1 vaccine on the other (test site). Two days later, the skin thickness was measured at the control and test sites, and the cell-mediated immune response was calculated as; cell-mediated immune response = 100 X log(skin thickness at the test site / skin thickness at the control site). The antibody-mediated immune response to a component of the Ultravac 7in1 vaccine was tested via a blood sample taken on day 14. The production of anti-tetanus toxoid serum IgG1 was used to assess the antibody-mediated immune response, and it was reported as 100 X the optical density units (corrected for plate-to-plate variation) measured in the serum. Live weights were recorded on days 0, 14 and 16 of the immune competence test. Minimal data edits were undertaken with just one animal removed because the measured cell-mediated immune response was an extreme outlier (more than two standard deviations higher than the next highest record).

Statistical analyses. Statistical models were developed with a pooled breed dataset, using PROC MIXED in SAS (SAS Institute, 2007); sire was fitted as random, and fixed effects were tested with step-wise elimination until only significant ($P<0.05$) terms remained. The initial model considered as class effects the birth cohort (a concatenation of herd and year of birth) and sire breed, and as linear and quadratic covariates, the day 0 live weight for both traits and the baseline skin thickness ratio for the cell-mediated immune response trait. In addition, all first-order interactions were tested for significance. In Repronomics, cows were naturally mated for their first two parities, and for subsequent parities, were AI mated. In the current dataset, there was confounding between sire and mating type, and thus also dam age. Therefore, dam age was not considered in statistical models. The least squares means were calculated for significant fixed effects for each trait.

Genetic parameter and heritability estimates were obtained for each trait from a univariate mixed linear animal model using ASReml (Gilmour *et al*. 2021). The significant fixed effects identified above were fitted for all traits except day 0 live weight. For day 0 live weight, the model fitted cohort and sire breed as class effects, animal age as a covariate, and animal and the dam permanent environment as random effects. Three generations of pedigree were used, and 80 sires were represented with an average half-sib family size of 9.7, ranging from 1 to 42.

RESULTS AND DISCUSSION

On day 0 of the immune competence test, steers were, on average, 186 days old and 212.5kg. Cell-mediated and antibody-mediated immune responses were normally distributed, with averages of 28.93 100 X log(mm) and 90.61 100 X optical density units, respectively (Table 1). Variation was recorded in cell-mediated and antibody-mediated immune responses, with coefficients of variation of 29.8% and 18.8%, respectively.

Cohort (i.e. herd year) and sire breed were significant for both traits, with day 0 live weight and baseline skin thickness also significant for the cell-mediated immune response. Cohort least squares means indicated no difference in the immune responses at the two herd locations within the same year, but that birth cohorts born in 2023 had lower immune responses compared with the 2022 birth cohorts. Sire breed least squares means are presented in Table 2 and indicate that Santa Gertrudis animals had significantly higher cell-mediated immune response than Droughtmaster and Brahman, which were not significantly different from each other. For antibody-mediated immune response,

Santa Gertrudis and Brahman animals were not significantly different from each other but had significantly higher antibody-mediated immune responses than Droughtmaster. Linear covariate solutions showed that animals with increased cell-mediated immune response had decreased day 0 live weight and increased baseline skin thickness. The negative relationship between cell-mediated immune response and day 0 live weight aligns with the genetic correlations reported by Reverter *et al*. (2021a). Sire solutions (results not shown) showed variation in immune responses between sires. There was as much variation in sire solutions within a breed as there was across breeds, with all breeds having sires with higher and lower solutions for immune competence traits.

Table 1. Summary statistics, phenotypic (V_p) variance and heritability estimates for immune competence traits recorded on tropically adapted beef breeds

Trait	N	Mean	Std	Min	Max	V_p	h^2
Age at test day 0 (days)	783	186.0	21.9	118	228		
Weight at test day 0 (kg)	782	212.5	33.1	118	316	453.11	0.58 (0.12)
Skin thickness at test day (log(mm))	783	-0.003	0.03	-0.11	0.09		
Cell-mediated immune response (100 X log(mm))	783	28.93	8.61	5.65	55.22	63.03	0.18 (0.09)
Antibody-mediated immune response (100 X optical density units)	783	90.61	17.02	22.77	127.67	276.91	0.22 (0.09)

Table 2. Breed least squares means (standard error) for cell-mediated and antibody-mediated immune response for tropically adapted beef breeds

Trait	Brahman	Droughtmaster	Santa Gertrudis
Cell-mediated immune response (100*log(mm))	28.37 (0.59)[a]	26.95 (0.62)[a]	35.41 (0.94)[b]
Antibody-mediated immune response (100*optical density units)	94.07 (1.23)[b]	86.41 (1.30)[a]	92.10 (1.96)[b]

Subscripts within trait represent least squares means significantly different based on 95% confidence intervals.

Preliminary variance component estimates (Table 1) showed that immune competence traits had low to moderate heritability estimates of 0.18 (0.09) and 0.22 (0.09) for cell-mediated and antibody-mediated immune responses, respectively. Day 0 live weight was estimated to have a strong heritability of 0.58 (0.12). Maternal effects could not be fitted and tested for significance for all traits due to the current data structure. Therefore, the day 0 live weight heritability may be inflated as it will likely include maternal effects. Heritability estimates for cell- and antibody-mediated immune response from the current study were lower than those reported for Angus. Cell-mediated immune response heritability in Angus was estimated to range between 0.25 (Reverter *et al*. 2021b) and 0.31 (Reverter *et al*. 2021a), with a phenotypic variance of 63.64 (Reverter *et al*. 2021a), which was very similar to phenotypic variance estimates in the tropically adapted beef breeds in the current study. Antibody-mediated immune response heritability in Angus was estimated to range between 0.32 (Hine *et al*. 2019) and 0.42 (Reverter *et al*. 2021a), with a phenotypic variance of 541.45 (Reverter *et al*. 2021a), which was much higher than the phenotype variance estimated in the current study. The studies in Angus cattle adjusted the immune competence traits by age, whereas in this study, the traits were weight-adjusted. However, variance components when the traits were age-adjusted (results not shown) were similar to those from weight-adjusted traits. The antibody-mediated immune response coefficient of variation in the study by Reverter *et al*. (2021a) was much higher (32.0%) than the current study (18.8%), corresponding to the higher phenotypic variance estimated.

A further cohort of animals will be recorded for immune competence, and carcase data will be

recorded for all animals. This expanded dataset will then be used to increase the accuracy of the heritability estimates and estimate the genetic relationships with carcase traits of economic importance. Survival and health records, where available, will also be considered to understand the relationship between immune competence traits and health and welfare traits. These preliminary estimates indicate that the traits will respond to genetic selection and, if shown to be genetically related to traits of economic importance or improved health and welfare outcomes, may be useful for the genetic improvement of tropically adapted beef breeds.

CONCLUSIONS

This preliminary study showed that the immune competence traits were heritable in tropical beef breeds and would respond to genetic selection. However, further research with a larger dataset is required to increase the accuracy of the heritability estimates and to determine if genetic selection for immune competence will lead to improved animal production, health and welfare. An additional year of immune competence data is planned, and steers will be backgrounded, finished, and carcase data collected. With the larger dataset, the availability of carcase records and female reproduction records from sisters, the genetic correlations between immune competence and carcase and female reproduction traits will be estimated. Survival and health records, where available, will also be considered.

ACKNOWLEDGEMENTS

The authors acknowledge funding from MLA (projects B.NBP.0759, P.PSH.1221, P.PSH.0743, P.PSH.0774 and L.GEN.2201) and the contributions of Australian Brahman Breeders' Association Limited, Droughtmaster Australia and a consortium of Santa Gertrudis breeders. Thank you to the collaborating organisations and the large team involved in designing, running, and collecting data. Thank you to Brad Hine and Aaron Ingham for their work in developing the protocols for recording immune competence and to CSIRO for collecting the immune competence phenotypes.

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