Proc. Assoc. Advmt. Anim. Breed. Genet: 26: 339-342

GENETIC PARAMETER ESTIMATION OF CARCASE QUALITY PHENOTYPES MEASURED WITH CAMERAS IN AUSTRALIAN WAGYU

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SUMMARY

Computer image analysis is increasingly important in carcase evaluations to determine pricing in beef markets. Images captured by cameras can accurately predict carcase traits such as marble score and eye muscle area. As technology develops, older camera models are being replaced as newer versions are developed. This study estimated genetic parameters for carcase traits using the MIJ-30 camera and compared it to estimates based on the older Mirror-type camera. Traits investigated were hot standard carcase weight, AUS-MEAT marble score, HK-333 Japanese mirror-type camera fineness index and MIJ-30 fineness index. Univariate animal models were used to estimate variance components and heritabilities. Bivariate analysis was done to make pairwise comparisons between traits and estimate correlations. Traits were moderately heritable (0.33 – 0.58). The genetic correlation between the fineness index of the two cameras was 0.55 ± 0.19, indicating that measures from each camera should be treated as separate traits for genetic evaluation. This work supports the need to continuously validate newer carcase evaluation technologies to better understand evolving traits and how to incorporate them into genetic evaluations.

INTRODUCTION

In Australia, the value of a carcase is predominantly based on its weight. However, carcase components are often marketed based on their predicted eating quality (Pethick *et al.* 2021). After harvest, AUS-MEAT chiller assessments are carried out to grade carcasses and evaluate expected eating quality. In Wagyu carcases, much emphasis is placed on marbling as an indicator of quality. A shift in assessment from evaluating marbling as a standalone measure, towards incorporating other quality measures to assess carcase pricing, such as eye muscle shape and marbling fineness, has been slowly adopted. Consideration for these factors is given with downstream markets and use in mind. This was investigated in Japanese Black and Crossbred steers in Japan (Kuchida *et al.* 2003; Takeo *et al.* 2016). A significant price difference was shown between high and low marbling fineness carcases. Especially in lower marble score (Japanese body marble scores 4 – 2) carcases. The greatest price difference was observed for carcases graded as Japanese body marble score 2, with a ¥140 per kg difference (roughly about 1.73 AUD per kg) between low and high marbling fineness. Allowing factors other than weight and visual grading to be considered for carcase pricing is expected to become a routine practice as retailers and restaurants attempt to provide consistent and high-quality eating experiences to their customers. Therefore, it is important to estimate their genetic relationship with already established systems such as AUS-MEAT assessed traits.

The Australian Wagyu Association (AWA) uses carcase cameras to routinely collect carcase data, including marble score, marble fineness, and eye muscle area, which is genetically evaluated by BREEDPLAN (AWA, www.wagyu.org.au). The HK-333 Japanese mirror-type camera was initially used by AWA to record carcase traits, starting in 2008. Traits recorded include eye muscle area, marbling percentage, marbling fineness, fatness, marbling particle proportionality, and muscle and fat colour. Genetic parameters for the mirror-type camera carcase traits were estimated and found to be moderate to highly heritable, along with high genetic correlations with corresponding

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

AUS-MEAT carcase measurements (Zhang *et al.* 2015; Zhang and Banks 2019). Since 2018, AWA has used the compressed lightweight MIJ-30 (Meat Image Japan) camera to replace the mirror-type camera. The camera uses a cloud-based system to predict carcase grading (MIJ, www.mij-labo.co.jp).

This study aimed to estimate the genetic parameters of hot standard carcase weight, AUS-MEAT marble score, the MIJ-30 fineness index and the HK-333 Japanese mirror-type camera fineness index and their genetic relationship. These genetic parameters will be used to assess how the MIJ-30 fineness index trait can best be included in genetic evaluations so that fineness measurements from both technologies can contribute to genetic evaluations.

MATERIALS AND METHODS

Carcase traits. Carcase traits included were hot standard carcase weight (kg), AUS-MEAT marble score (0-10), Mirror-type camera fineness index (count/cm^2) and MIJ-30 camera fineness index. The Mirror-type camera analysed images captured using the HK-333 imaging device and BeefAnalyserII software developed in Japan. The HK-333 fineness index counts the number of intramuscular fat streaks per cm^2 in the ribeye area, limited to particle sizes ranging from 0.01 to 0.5 cm^2 (Zhang *et al.* 2015; Lee *et al.* 2018). The MIJ-30 camera uses BeefAnalyserII software and measures the fineness index by dividing the sum of the circumference of the marbling flecks by the square root of the eye muscle area with a greater result indicating finer marbling [*Translated from Japanese to English using Google Translate*] (Shimabukuro *et al.* 2022).

Data access and editing. Pedigree and carcase data were extracted from the AWA BREEDPLAN database for 32,605 animals with recorded carcase traits from 1,661 unique sires. The data was manipulated using R software version 3.6.0 (R Core Team 2023) using packages readr and dplyr. Outliers were removed and defined as observations with more than three standard deviations from the mean. The site where the eye muscle area was measured varied between contemporary groups. Carcase camera measurements were taken at the 5th/6th rib, 6th/7th rib, 10th/11th rib and 12th/13th rib sites, which was accommodated in the analyses through the contemporary group (CG) effect in the model. Other factors accounted for in CG include pre-harvest factors (such as herd, year, sex and management group), harvest date and harvest group. After data editing, 2,104 animals with the mirror-type camera fineness index remained, with 325 unique sires represented. Of these, one sire had more than 100 progeny, 62 sires had less than 100 but more than 10 progeny, 162 sires had less than 10 progeny, and 100 sires had single progeny. For the MIJ-30, 6,384 animals with fineness index remained after data editing, and 689 unique sires were represented. Of these, three sires had more than 100 progeny, 188 had less than 100 but more than 10 progeny, 367 had less than 10 progeny, and 131 had single progeny.

Statistical models. The animal model was applied to estimate genetic parameters. Variance components and heritabilities were estimated by REML using ASREML software (Butler *et al.* 2023). CG was fitted as a fixed class effect. Hot standard carcase weight was adjusted for harvest age, by fitting harvest age as a linear and quadratic covariate. All other carcase traits were adjusted for carcase weight, by fitting carcase weight as a linear and quadratic covariate. A three-generation pedigree was used for the analyses. Bivariate analysis was performed in pairs to estimate genetic correlations between the reported traits.

RESULTS AND DISCUSSION

Table 1 displays descriptive statistics for the investigated carcase traits. Table 2 shows the genetic parameters for the estimated carcase traits. All the traits were moderately heritable, estimates were 0.43, 0.58, 0.33 and 0.49 for hot standard carcase weight, AUS-MEAT marble score, mirror-type camera fineness index and MIJ-30 fineness index, respectively. Despite differences in dataset size these heritabilities are similar to estimates obtained using a subset of this data in 2022, no estimates for the MIJ-30 fineness index were reported (G. M. Jeyaruban, personal communication, 28 January 2025). A larger number of records were available for the current study, with 53.02% and 53.73% more records for hot standard carcase weight and AUS-MEAT marble score, respectively. The heritability for the MIJ-30 fineness index was estimated by Tamagawa *et al.* (2024) for different muscles which ranged from 0.49 to 0.69. The heritability estimate for MIJ-30 fineness index falls within the lower end of the range of heritabilities provided from the reported study.

Table 1. Descriptive statistics for carcase traits from the Australian Wagyu Association

	No. Sires	N	Mean	sd	Min	Max
Hot standard carcase weight (kg)	1543	25,154	424.40	49.05	266.80	580.0
AUS-MEAT marble score (0-10)	1485	23,665	7.89	1.69	3.0	12.0
Mirror-type camera fineness index	325	2,104	2.59	0.60	0.94	4.65
MIJ-30 fineness index	689	6,384	5.59	1.05	1.53	9.86

Low genetic and phenotypic correlations were estimated between hot standard carcase weight and the other reported carcase traits. Genetic and phenotypic correlations between hot standard carcase weight with the mirror-type camera fineness index and the MIJ-30 fineness index, respectively, were estimated to be not significantly different from zero. This is not unexpected as the carcase quality traits were adjusted for carcase weight. However, the models could not converge fully, which could be because the carcase quality traits were adjusted for carcase weight and thus have genetic correlations with carcase weight that were close to zero. When adjusting all the traits for harvest age, non-zero correlations (ranging from -0.13 to 0.07) between carcase weight and the other traits were obtained, and the models completely converged (data not shown). AUS-MEAT marble score was positively correlated (phenotypic and genetic) with both fineness indices. The AUS-MEAT marble score was highly correlated genetically with the MIJ-30 fineness index (0.83 ± 0.03). Based on the definition provided for the MIJ-30 fineness index, it was expected that a greater marble score would coincide with a higher fineness index. That is because as more fat streaks are fitted into the same area of the eye muscle in increasing marble score, the total fat streaks' circumference also increases, which increases the fineness index. Also, with the same number of marbling streaks but with more area covered in marbling per streak, the marbling score will increase, but so will the circumference of the streaks. Hence, there is a direct connection between the marbling score and the MIJ-30 camera fineness index.

Table 2. Phenotypic variances (V_p), genetic correlations (standard error) above the diagonal, phenotypic correlations (standard error) below the diagonal and heritabilities (standard error) on the diagonal for carcase traits from the Australian Wagyu Association

	V_p	Hot standard carcase weight	AUS-MEAT marble score	Mirror-type camera fineness index	MIJ-30 fineness index
Hot standard carcase weight (kg)	1150.50	0.43 (0.03)	0.003 (0.05)	0.02 (0.15)*	-0.05 (0.08)*
AUS-MEAT marble score (0-10)	2.17	-0.001 (0.01)	0.58 (0.03)	0.33 (0.13)	0.83 (0.03)
Mirror-type camera fineness index	0.23	-0.01 (0.04)*	0.33 (0.03)	0.33 (0.09)	0.55 (0.19)
MIJ-30 fineness index	0.62	-0.02 (0.02)*	0.63 (0.01)	0.25 (0.06)	0.49 (0.05)

* The model did not fully converge.

The mirror-type camera fineness index positively correlates with the MIJ-30 camera fineness index phenotypically (0.25 ± 0.06) and genetically (0.55 ± 0.19). Kuchida *et al.* (2018) reported a high phenotypic correlation (0.954) between the two cameras. However, that study is not comparable, as Kuchida *et al.* (2018) used the same index trait definition for both cameras, while this current study defines each camera's fineness index differently. No comparable literature on the genetic correlation between the two index traits could be found. The moderate genetic correlation indicates that these traits are different and should be treated as such in genetic evaluations. Reporting for the carcase marbling fineness index EBV from the evaluation should be on the MIJ-30 scale as this is the current technology for measurement, and the mirror-type camera traits will decline in significance as this technology has been superseded and no longer used for measurement in Australian Wagyu. These two traits share a similar trait name, i.e. fineness index, which can give the impression that they are similar traits. However, comparison of the definitions clearly indicate that the way the two cameras measure the fineness index trait is different. The two fineness index measures are expected to be related as 'number of fat streaks' is a contributing metric to the mirror-type camera fineness index, and the sum of the circumference of all fat streaks is a metric in the MIJ-30 camera fineness index.

CONCLUSIONS

The high genetic correlation between the AUS-MEAT marble score and the MIJ-30 fineness index aligns with the MIJ-30 trait definition, as more fat streaks correspond to a higher marble score. The fineness index of the mirror-type camera and the MIJ-30 camera are heritable. The two traits are moderately correlated, indicating that they should be treated as different traits in a genetic evaluation. As newer technology becomes available, future research should continue to validate the recorded traits and how to accurately incorporate them into genetic evaluations.

ACKNOWLEDGEMENTS

The authors acknowledge receiving the Dr Michael J Bradfield Memorial Scholarship, co-funded by the University of New England and the Agricultural Business Research Institute. Furthermore, the Australian Wagyu Association and the Agricultural Business Research Institute are acknowledged for providing access to the BREEDPLAN data.

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