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GENETIC PARAMETERS OF GESTATION LENGTH WITH EARLY IN LIFE GROWTH TRAITS IN AN AUSTRALIAN WAGYU POPULATION

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SUMMARY

Wagyu selection has typically ignored the trait of gestation length with selection focus primarily on carcase quality. As a result, the gestation length in Wagyu is one of the longest of the beef cattle breeds averaging 287.5 days. The objective of this study was to estimate the heritability of gestation length and its correlation with weight traits in an Australian Fullblood Japanese Black (Wagyu) population. Gestation length was found to have a heritability of 0.37, with only weak correlations with early in life weight traits. The maternal heritability of gestation length of 0.04 was much lower than the direct heritability reflecting that this is a trait of the calf. The genetic correlation between the maternal effects was considerably higher than that between additive and maternal effects (0.28 with birth weight and 0.81 with yearling weight). Due to the moderate heritability of gestation length and in general favourable correlations with weight traits, it would be possible to select simultaneously on both gestation length and early in life growth traits.

INTRODUCTION

Wagyu or Japanese Black cattle are well known for their high marbling characteristics, with a large selection emphasis on this trait in Australia. However, due to selection being heavily focused on marbling, there may have been detrimental effects on other traits. One of these traits is gestation length, with Wagyu having one of the longest gestation lengths among beef cattle breeds of 287.5 days (Ibi *et al.* 2008). These longer gestations result in detrimental effects on both the calf and the cow due to increased rates of dystocia and a shorter time for the cow to recover after calving prior to rebreeding, which can affect pregnancy rates (Stachowicz *et al.* 2023). The objective of this study was to estimate genetic parameters for gestation length and investigate the relationship between gestation length and early in life growth liveweight traits (birth weight, weaning weight and yearling weight).

MATERIALS AND METHODS

The phenotypic and genotypic data were provided by 3D Genetics, a Fullblood Wagyu Bull breeding program located in Northern New South Wales running ~2000 breeders. The breeding program started in 1997 and has been growing every year since. The phenotypic data include gestation length (GL), birth weight (BW), weaning weight (WW) and yearling weight (YW). A description and summary of traits are included (Table 1).

Genotyping was conducted over 20 years, initially with microsatellites and then over the last decade utilising SNP genotypes; as a result, multiple SNP chip arrays have been utilised. These arrays include Illumina 777k, Illumina GGPLD V3 30K, Illumina GGPLD V4 30K, Illumina ICB 50K, Illumina GGP 100K and Weatherby's Scientific Versa50K. There were 10,830 SNPs common across all chips with 8,675 animals, which were imputed up to GGPLD30K (21,791 SNPs) using Minimac4 (Howie *et al.* 2012). Genotype data was filtered to exclude duplicate animals and SNPs with less than 1% minor allele frequency. The heterozygosity fraction (Het) was calculated as the proportion of imputed heterozygote SNPs for each individual animal.

Table 1. Description and summary of traits included in the analysis

Trait	Acronym	Description	Mean	Standard deviation	No. of records	No. of Unique Dams
Gestation length	GL	Time interval between conception and parturition for Artificial Insemination	286.9	5.59	2,434	1,438
Birth weight	BW	Weight within 24 hours of birth	28.6	4.45	4,957	2,006
Weaning weight	WW	Weight at age 121-300 days	151.4	39.75	6,026	2,169
Yearling weight	YW	Weight at age 301-500 days	307.6	69.55	4,306	1,663

Statistical Analysis. Genetic parameters were estimated through a series of univariate and bivariate models using ASREML-R (Butler *et al.* 2023). The genomic relationship matrix was calculated using VanRanden's first method (VanRaden 2008) which included 8,675 animals in the GRM for analysis.

Dam joining number, dam class, sex, contemporary group and heterozygosity fraction (Het) were included as fixed effects when appropriate for the trait (Table 2). Dam class was split into heifers for 2-year-old cattle; mature for 3 to 10-year-old cattle and old for cattle older than 10 years old. Birth group was defined as birth year and birth windows which was split into early, mid and late birthing windows (A, B and C). Birth group was used to account for age differences within each birth year. The number of contemporary groups ranged from 32 for birth weight to 187 for yearling weight (Table 2). The univariate and bivariate models had the additive and maternal effects fitted to calculate the heritability and maternal effect for all traits except for YW. When appropriate, genetic correlations were also estimated between the maternal components of the traits.

Table 2. Fixed effects, contemporary-group definition for each trait included in the analysis

Trait	Fixed effects	Contemporary group	Number of contemporary groups
GL	Sex, Dam joining number, Het	Birth year, Gestation length management group	55
BW	Sex, Dam class, Het	Birth group, birth weight management group	32
WW	Sex, Dam class, Het	Birth group, birth and weaning weight management group	86
YW	Dam class, Het	Birth group, sex, weaning and yearling weight management group	187

RESULTS AND DISCUSSION

Gestation length (GL) was moderately heritable (0.37) in this population (Table 3). This heritability estimate was similar to other published estimates, which ranged from 0.27 to 0.53 (Baco *et al.* 1998; Ibi *et al.* 2008; Oyama *et al.* 2004), with Oyama *et al.* (2011) estimating a weighted mean of 0.35. The maternal heritability was low (0.04) with no permanent maternal environmental variance (Table 3). The low maternal heritability was consistent with previous studies (0.04 to 0.14; Ibi *et al.* 2008; Oyama 2011), with Oyama *et al.* (2011) estimating a weighted mean of 0.09. The lower maternal heritability would indicate that the dam has little influence over GL but rather is directly impacted by the additive genetic effects of the calf.

The heritability of the liveweight traits ranged from 0.21 to 0.46, with all having low standard errors (Table 3). WW had the lowest heritability (0.21) but the highest maternal heritability (0.24). The various liveweight trait heritability estimates agreed with published estimates (Ibi *et al.* 2008; Lopez *et al.* 2020; Mehrban *et al.* 2021; Oyama 2011).

Maternal effects were evident for BW and WW with maternal heritabilities of 0.08 and 0.24, respectively (Table 3). WW had the largest maternal heritability of all the traits; in breeding programs that WW maternal effect is referred to as MILK. This would indicate that the ability of the mother has a large effect on WW and should be selected for in a breeding program. It is well recognised within the commercial Wagyu industry that Wagyu dams have poor milking ability which can have a detrimental effect on calf survival (Australian Wagyu Association 2025). YW did not have any maternal genetic variance in this population, so it was removed from the model.

Table 3. Additive, maternal and residual estimates alongside heritability and direct maternal heritability with standard errors in brackets

Trait	Additive variance	Maternal genetic variance	Residual variance	Heritability	Maternal heritability
GL	9.96	0.90	15.86	0.37 (0.03)	0.04 (0.02)
BW	7.50	1.31	7.42	0.46 (0.02)	0.08 (0.01)
WW	154.63	170.99	395.59	0.21 (0.02)	0.24 (0.02)
YW	352.14	-	776.27	0.31 (0.02)	-

The genetic correlation between GL and BW was 0.25 (Table 4), which is a weak, positive correlation. The phenotypic correlation was also weak and positive correlation (0.25, Table 4). The estimates herein are lower than those estimated by Lopez *et al.* (2020) in Hanwoo cattle of 0.51 for genetic correlation, however; the phenotypic correlation is similar (0.21). These correlations between GL and BW would indicate, a small increase in BW would occur as GL increases. BW is treated as an optimal trait in breeding programs, as such that BW is controlled to reduce calving issues; however, not lowering BW that it starts to effect calf survivability. This is evident in the Australian Wagyu Association Breeder Feeder Index placing a non-linear economic value on BW (Australian Wagyu Association 2025). Therefore, the genetic correlation between GL and BW could be favourable or unfavourable depending on the population mean. If the population mean is small for BW, the correlation would be favourable; however, if the population mean is large for BW, the correlation would be unfavourable. Even though the correlation is weak, the impacts GL could have on BW need to be considered in selection.

The genetic correlation between BW maternal and GL was uncorrelated at 0.02 however with a large standard error (Table 4); meaning these two traits have no impact on each other. Despite this low correlation, there was a high positive genetic correlation between BW maternal and GL maternal of 0.81 indicating strong association between the two traits. Despite the correlation being high between those two traits the maternal heritabilities were low (0.04 for GL and 0.08 for BW). As the heritability is low for the maternal component of BW and GL this has little impact in a breeding program however should be still considered in selection decisions.

The genetic correlation between GL and both WW (-0.09) and YW (-0.09) were both weak and negative. (Table 4). These estimates are similar to Lopez *et al.* (2020) of -0.09 for both genetic and phenotypic correlation. These correlations between WW and YW with GL were favourable but weak. This weak association between the traits means GL could be selected independently of weight traits in a breeding program.

Table 4. Genetic and phenotypic correlations for weight traits with gestation length for both additive and maternal effects.

Trait	Genetic correlation Additive	Genetic correlation Maternal	Phenotypic correlation
BW Additive	0.25 (0.06)	0.26 (0.19)	0.25 (0.05)
BW Maternal	0.02 (0.12)	0.81 (0.20)	
WW Additive	-0.09 (0.08)	-0.25 (0.07)	-0.11 (0.04)
WW Maternal	0.12 (0.21)	0.28 (0.21)	
YW Additive	-0.09 (0.07)	0.12 (0.21)	-0.15 (0.03)

The genetic correlation between WW maternal (often referred to as MILK) and GL was 0.12 for additive and 0.28 maternal (Table 4). These maternal genetic correlations are weak but positive, meaning a small increase in GL would occur as WW maternal increases. The Wagyu breed is well known for displaying poor milking ability and longer gestation length. These weak, positive maternal genetic correlations should be considered in a breeding program as they are unfavourable and selection on one trait could cause them to move in the wrong direction. WW maternal and GL are both components in a Wagyu breeding program that breeders are concerned about and even though the correlation is weak still need to be considered in breeding programs.

CONCLUSION

Gestation length can increase birthing difficulty due to increased birth weight and decrease pregnancy rates. The direct heritability and maternal heritability of gestation length (GL) was estimated to be 0.37 and 0.04 respectively. These heritability estimates demonstrate it is possible to make genetic gain by selecting for reduced gestation length. Further, the genetic and phenotypic correlations were in general weak with early in life weight traits which indicates it is possible to select simultaneously for higher growth and shorter gestation length.

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