GENETICS OF FEMALE FERTILITY IN WAGYU CATTLE USING FIELD DATA

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SUMMARY

Wagyu breeders mainly focus on carcase characteristics when making breeding and selection decisions. The objective of this study was to estimate heritabilities based on pregnancy test records as these are collected as part of standard management practice. Traits included pregnancy rate heifer and cow, body condition score (heifer and cow) and age at first pregnancy, with heritabilities of 0.06, 0.11, 0.07, 0.07 and 0.09 respectively. In this study, pregnancy rates were continuously high (mean >86%). The heritability of pregnancy rate traits were low. As the expected increase in fertility in this population by genetic approaches will be slow, opportunites for reproductive improvement on these particular traits will be limited.

INTRODUCTION

Little attention has been paid to the genetics of fertility in Australian Wagyu for two reasons, (1) Wagyu females are generally highly fertile and (2) males are predominately used as terminal sires. Literature suggests that fertility traits of most beef breeds, including Wagyu, have low to moderate heritability (Oyama *et al.* 2011; Buddenberg *et al.* 1989; Toelle and Robinson 1985). Improving male and female fertility will improve herd productivity. Immediate gains in herd performance can be made by culling non-pregnant cows; however, this is inefficient due to the low selection differential and the low accuracy of selecting on fertility phenotypes. Higher selection intensity is possible through the sire pathway (Baeza-Rodríguez *et al*. 2018). Heritability of fertility traits reported in the literature are population-specific and highly dependent on the actual component of fertility under investigation. In Australia, breeding programs use traits such as days to calving or calving interval to assess fertility in temperate production systems which have low to moderate heritability (Gutiérrez 2002; Johnston and Bunter 1996), while age at puberty and *post partum* anoestrus are highly heritable (Engle *et al.* 2018; Johnston *et al*. 2009). Pregnancy testing is routinely used to make management decisions and can provide information much earlier than days to calving or calving interval. In this study, we estimated heritability for fertility traits using pregnancy test information as a first step to assess their value for standard genetic evaluation.

MATERIALS AND METHODS

Pregnancy test data from 4,278 heifers and 6,047 cows were collected between 2011 and 2019. All animals were pedigree recorded and raised in an extensive environment in Queensland.

Data collection and editing. Heifer Pregnancy Rate (HPR) reflects a female's ability to become pregnant during her first breeding season as a yearling. Age At Pregnancy (AAP) is the age at which she conceives. Both of these are calculated from their first pregnancy test. Cow Pregnancy Rate (CPR) is the resultant pregnancy rate of subsequent parities. At the time of pregnancy testing, heifers and cows are scored for Body Condition Score (BCS) on a scale from 1-5. In this population, the BCS ranged from 2-4 with an average of 3. The number of records used in the analysis, heifer and cow, are shown in Table 1.

Table 1. Number of records and summary of phenotypic data recorded for heifers and cows

Heifers				Cows		
Year brand	N	Mean HPR	Mean AAP	Year brand	N	Mean CPR
2013	552	0.90	524	2011	1785	0.89
2014	911	0.88	508	2012	1248	0.91
2015	1068	0.86	492	2013	1155	0.93
2016	1035	0.92	533	2014	1114	0.95
2017	712	0.90	499	2015	745	0.95

Statistical analyses. Analyses were performed using univariate sire models for HPR & CPR and an animal model for BCS and AAP. The R software package MCMCglmm was used for all models (Hadfield 2010). The MCMC chain was run for 200k iterations with the first 20k used for burn-in. Due to the binary nature of pregnancy rate, observations were converted to an underlying normal distribution using a probit link function which restricts the residual variance to 1, all other traits were analysed as continuous outcomes. Fixed effects in the mixed effects included year and month of birth (BYM), measurement date (MD) and the age of the animal in years (AGE). The general form of the equations in the model was as follows:

$$y=Xb + Za +e,$$

where y is a vector of observations for the trait, X and Z are incidence matrices relating observations to in **y** to levels of fixed effects in **b**, and random solutions in **a,** respectively, and **e** is a vector of residual effect solutions. Variances and mean of the random effects were assumed to be as follows:

$$\text{var(e)} = I\,\boldsymbol{\sigma}\,2\text{e},\ \ \text{var(a)} = A\,\boldsymbol{\sigma}\,2\text{a}$$

where **A** is the numerator relationship matrix, and E(**a**) = $E(\boldsymbol{u})$ = 0. The models used were:

HPR, CPR & AAP: Y = BYM + body condition score + MD + sire

BCS: Y = BYM + body condition score + MD + AGE + animal

RESULTS AND DISCUSSION

Heritability estimates of HPR and CPR, BCS, and AAP are shown below in Table 2.

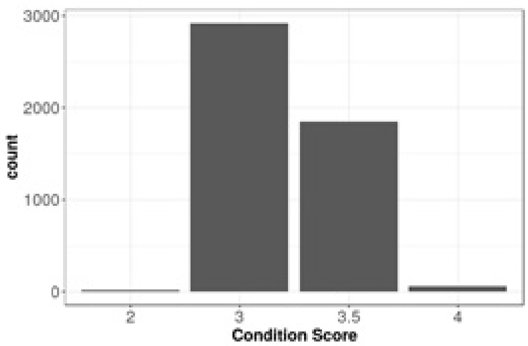
Table 2. Heritability estimates for Wagyu female fertility traits

	Heifer		**Cow**	
	h^2	95% CI	h^2	95% CI
HPR/ CPR	0.06	0.00, 0.26	0.11	0.03, 0.22
AAP	0.09	0.04, 0.14		
BCS	0.07	0.04, 0.11	0.07	0.00, 0.15

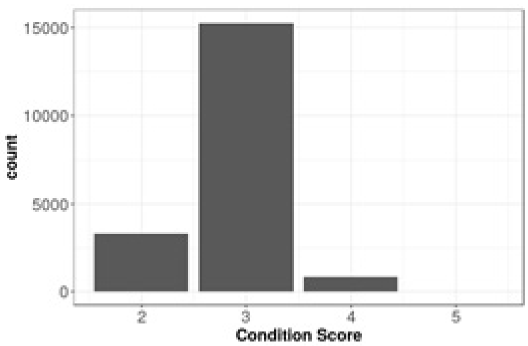
Heritability estimates for all traits were low, and therefore agree with estimates from other studies (Oyama *et al.* 2011; Buddenberg *et al.* 1989; Toelle and Robinson 1985). Heritability of age at first calving was low in studies in Japanese Black Cattle and other breeds such as Herefords and Angus, whereas in tropical cattle, age at first calving and age at puberty have been recorded as moderately to highly heritable (Johnston *et al*. 2009; Gutiérrez *et al*. 2002; Oyama *et al*. 2002; Toelle and Robinson 1985). The differences in heritability are likely due to influences of the environment and breed differences. For example, heritability estimates for age at calving range from 0.8 in temperate environments to 0.3-0.5 under tropical conditions. The pedigreed Wagyu herd studied was managed so to optimise reproductive performance, including nutrition, which may have impacted upon BCS and potentially masked the genetic variation in Wagyu HPR/ CPR. As a result, very little phenotypic variance or genetic variance was observed in this trait.

Pregnancy rate and age at first pregnancy have limited value in selecting for increased fertility in this population. To increase fertility multiple avenues could be explored, some would require changes in management practice; others would require additional measurements to be taken. One approach would be to switch to a trait such as days to calving. This would require recording bull in and out dates as well as a more consistent approach to management and disposal of pregnant females. Alternatively, traits such as age at puberty and post-partum anoestrus could be explored as these could be measured before pregnancy testing and would therefore not be impacted by culling or animal transfers (Johnston *et al*. 2009).

Body condition score is as an indicator of the nutritional status of an animal. Several researchers have reported positive phenotypic correlations between conception rates and high BCS (Selk *et al*. 1988). The distribution of body condition scores for both heifers and cows are shown below in Figure 1.



Heifers



Cows

Figure 1. Distribution of BCS across all heifers (left) and cows (right) at pregnancy test

However, in this study we found a small correlation between BCS and HPR/ CPR, which could be due to the small variation of BCS within contemporary groups, or the management practice of not mating young females with low BCS.

CONCLUSIONS

Heritabilities of Wagyu female reproductive traits were estimated from pregnancy test data in a stud herd managed to optimise reproductive rate. Heritability estimates were low, and at the lower end of those in the literature. This is likely to be due to the lack of phenotypic variance potentially masking genetic differences in fertility. To successfully implement a genetic improvement program for fertility in this population would require development of alternative fertility traits. Traits such as days to calving and utilising ultrasound measurement to more precisely identify age at puberty or *post partum* anoestrus may be beneficial.

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