CALVING TRAITS AND THEIR RELATIONSHIP WITH PRODUCTION, CONFORMATION AND WORKABILITY TRAITS IN HOLSTEIN-FRIESIAN COWS

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SUMMARY
It has been well established that the genetic correlations between calving traits are positive, ie longer gestation lengths are associated with increased calf size, greater incidence of calving problems and higher calf mortality. However, correlations of calving traits with other traits could be of economic importance, indeed some breeding companies market bulls for calving ease on the basis of low liveweight Australian Breeding Values (ABVs). We found that there was an association between calving ease ABV, fertility and liveweight, (large liveweight is associated with increased calving difficulty and reduced fertility), and increased calf size, greater liveweight and reduced fertility were all associated with each other. However, increased gestation length was not associated with increased mature cow liveweight, even though it was associated with larger calf size.
Keywords: Genetic correlation, sire evaluation, dystocia, dairy cattle.

INTRODUCTION
The genetic evaluation of dairy bulls is a complex procedure. Some traits are based on carefully measured production, such as protein kilograms produced per standardised daughter lactation. Other traits (such as daughter muzzle width) are assessed subjectively by professional classifiers. Some genetic correlations between these traits are known, having been calculated from multivariate analyses (e.g. Veerkamp *et al.* 2001). However the relationship between some pairs of traits is unknown, especially if those traits are considered to have little inter-relationship. This may be calculated using correlations between ABVs: this is only a valid comparison when bulls have infinite numbers of progeny records. A relationship between apparently unrelated traits could be important because selection for one trait may have negative effects on selection for another trait.

MATERIALS AND METHODS
Holstein-Friesian bull ABVs were obtained from the Australian Dairy Herd Improvement Scheme (ADHIS). [ABVs are generally (but not always) estimated breeding values (EBVs): they may also be Predicted Transmitting Abilities (PTAs). which are half of EBVs, thus having smaller ranges. ABVs are generally EBVs because this increases the apparent differences between bulls, aiding marketing, except for some traits such as calving ease]. PTAs for gestation length, calf size and dystocia were calculated from ADHIS data using ASREML (Gilmour et al. 2002), from a dataset of 134,141 calving records resulting from artificial insemination of Holstein-Friesian cows with semen from Holstein-Friesian bulls. Details of the editing, models and univariate and multivariate analyses may be found in McClintock

[*] AGBU is a joint venture of NSW Department of Primary Industries and the University of New England

(2004). Only bulls that had reliabilities of 0.45 for calving and production traits were selected for this analysis. This restriction avoids the use of bulls that have predicted breeding values estimated only on ancestors. Thus the bulls used in this analysis had over a million daughters recorded for most production traits, and highly reliable production EBVs and calving trait PTAs for most traits, including Australian Profit Rankings (APR) and Australian Selection Index (ASI).

Ideally, possible correlations between traits of economic value should be estimated using full multivariate analyses, but these are beyond the scope of this project. Instead, Pearson correlations have been calculated using estimated bull breeding values for bulls with reliabilities greater than 0.45 for production and calving traits. Pearson correlations between traits will generally be less than genetic correlations unless the bulls all have very large numbers of progeny. Standard errors of correlations were calculated as $\sqrt{1/n}$ (M Goddard *pers.com*) where n was the number of bulls. The correlations between the breeding values for a wide range of traits of the 195 bulls were estimated using a statistical package.

This analysis was originally produced to establish possible relationship between calving traits and other apparently unrelated traits, in the absence of time and resources to complete full genetic correlations between all pairs of traits. However, correlations between other traits, produced by the analysis as co-products, are also presented in this paper.

RESULTS AND DISCUSSION

Table 1. Comparison of genetic correlations estimated using ASREML and correlations between PTAs (195 sires with reliabilities greater than 0.45)

	Genetic Analysis		PTA Pearson correlation	
	Calf size	Dystocia	Calf size	Dystocia
Gestation length	0.49	0.45	0.35	0.26
Calf size	-	0.8	-	0.71

Table 1 contains results from bivariate REML analyses and the equivalent Pearson Correlations. We found that longer gestation length was associated with larger calf size and increased dystocia, but that this was smaller when EBV/PTA Pearson correlations were estimated (Table 1). So, as expected, the Pearson correlations were generally smaller than the genetic correlations, but they can be used as a guide providing the reliabilities of bull proofs (as EBVs or PTAs) are high enough. The sire PTA/EBV correlations are presented in Table 2. Correlations that are significantly different from zero are shown in bold.. The first three columns of numbers refer to calving traits. The other columns are the correlations for the EBVs for other traits. In general there may be correlations between traits within the same groups such as production, conformation or workability traits, so APR and ASI are highly correlated with each other and with protein and fat yields. There are fewer significant correlations between traits in different groups: calving traits are less correlated with other traits such as milk volume or survival.

Table 2. Correlations between EBVs and PTAs for bulls with EBV reliabilities greater that 0.45 for production and calving traits of their daughters. (se ±0.07)

	dystocia	size	gestation length	APR	ASI	protein	protein%	milk volume	fat	fat%	overall type	mammary systems	stature	udder texture	bone quality	angularity	muzzle width
size	0.71																
gestation length	0.26	0.35															
APR	-0.11	-0.18	-0.23														
ASI	-0.06	-0.07	-0.17	0.89													
protein	-0.03	-0.04	-0.15	0.76	0.81												
protein%	-0.07	-0.06	-0.11	0.56	0.66	0.25											
milk volume	0.02	0.01	-0.07	0.30	0.28	0.74	-0.47										
fat	-0.04	-0.06	-0.10	0.62	0.72	0.36	0.32	0.11									
fat%	-0.05	-0.05	-0.01	0.19	0.28	-0.33	0.60	-0.72	0.61								
overall type	0.21	0.20	-0.00	0.13	-0.05	0.08	-0.24	0.24	-0.02	-0.21							
mammary systems	0.15	0.14	-0.00	0.14	-0.03	0.08	-0.16	0.18	-0.04	-0.17	0.92						
stature	0.30	0.40	-0.10	-0.05	-0.11	0.03	-0.24	0.19	-0.10	-0.22	0.53	0.42					
udder texture	0.09	0.09	-0.07	0.10	-0.01	0.09	-0.18	0.21	0.03	-0.15	0.73	0.75	0.51				
bone quality	-0.03	-0.08	-0.10	0.05	-0.06	-0.01	-0.15	0.09	0.00	-0.07	0.47	0.48	0.40	0.85			
angularity	0.04	-0.02	-0.07	0.03	-0.05	0.02	-0.17	0.14	0.00	-0.11	0.51	0.52	0.34	0.84	0.88		
muzzle width	0.12	0.20	0.02	-0.11	0.01	0.06	-0.07	0.11	-0.02	-0.10	-0.03	-0.13	0.05	-0.23	-0.44	-0.33	
body length	0.23	0.32	-0.14	0.01	-0.01	0.12	-0.16	0.22	-0.05	-0.21	0.35	0.27	0.80	0.28	0.19	0.14	0.11
body depth	0.08	0.19	0.20	-0.26	-0.11	-0.13	-0.06	-0.08	-0.02	0.05	0.09	-0.03	-0.01	-0.22	-0.40	-0.28	0.41
chest width	0.07	0.17	0.15	-0.15	-0.04	-0.06	0.01	-0.06	-0.03	0.03	-0.02	-0.12	-0.11	-0.48	-0.68	-0.57	0.46
rump length	0.24	0.32	-0.02	-0.05	-0.08	0.07	-0.26	0.25	-0.05	-0.23	0.44	0.32	0.74	0.33	0.24	0.20	0.11
foot angle	0.27	0.37	-0.04	-0.04	-0.04	0.06	-0.06	0.10	-0.13	-0.17	0.20	0.16	0.35	0.10	-0.03	-0.05	0.11
fore attachment	0.06	0.02	-0.00	0.00	-0.22	-0.15	-0.21	0.01	-0.13	-0.10	0.79	0.74	0.37	0.46	0.30	0.31	-0.03
rear attachment	0.21	0.16	0.02	0.02	-0.07	0.00	-0.13	0.10	-0.05	-0.11	0.60	0.72	0.37	0.53	0.38	0.37	-0.19
rear attach width	0.11	0.09	0.06	0.15	0.21	0.31	-0.02	0.30	0.10	-0.18	0.37	0.48	-0.00	0.28	0.01	0.17	0.16
centre ligament	0.12	0.16	-0.03	0.16	0.02	0.12	-0.09	0.17	-0.05	-0.17	0.80	0.87	0.38	0.74	0.50	0.51	-0.17
teat placement	0.01	0.04	-0.08	0.20	0.05	0.11	-0.05	0.13	0.03	-0.08	0.58	0.65	0.20	0.45	0.29	0.30	-0.14
teat length	0.03	0.08	0.25	-0.31	-0.18	-0.25	-0.08	-0.17	-0.02	0.12	-0.23	-0.24	-0.07	-0.24	-0.22	-0.20	0.10
milking speed	0.09	-0.06	-0.20	0.25	0.07	0.09	0.02	0.07	0.02	-0.04	0.33	0.30	0.17	0.36	0.31	0.31	-0.01
temperament	0.06	0.03	-0.08	0.29	0.10	0.13	-0.05	0.16	0.11	-0.05	0.39	0.34	0.17	0.20	0.06	0.09	0.05
likeability	0.12	0.06	-0.16	0.41	0.19	0.33	-0.09	0.36	0.09	-0.23	0.57	0.49	0.32	0.45	0.27	0.29	0.04
survival	0.06	-0.05	-0.14	0.55	0.20	0.34	-0.08	0.36	0.09	-0.22	0.59	0.51	0.37	0.43	0.34	0.29	-0.17
cell count	0.09	0.11	-0.01	-0.20	0.02	0.03	0.08	-0.03	-0.09	-0.04	-0.13	-0.13	-0.08	-0.02	-0.06	-0.01	0.12
fertility	-0.30	-0.31	-0.17	0.20	0.07	-0.02	0.33	-0.25	-0.13	0.11	-0.27	-0.22	-0.20	-0.39	-0.28	-0.37	-0.12
live weight	0.29	0.44	0.03	-0.18	-0.14	-0.05	-0.20	0.10	-0.10	-0.15	0.45	0.29	0.77	0.19	-0.03	-0.01	0.33

	body length	body depth	chest width	rump length	foot angle	fore attachment	rear attachment	rear attachment	centre ligament	teat placement	teat length	milking speed	temperament	likeability	survival	cell count	fertility
body depth	-0.07																
chest width	-0.02	0.84															
rump length	0.85	0.02	0.01														
foot angle	0.27	0.03	0.10	0.22													
fore attachment	0.25	0.09	0.06	0.31	0.07												
rear attachment	0.25	-0.12	-0.17	0.27	0.19	0.42											
rear attach width	0.06	0.18	0.13	0.13	-0.01	0.13	0.23										
centre ligament	0.24	-0.13	-0.22	0.29	0.21	0.54	0.55	0.32									
teat placement	0.08	-0.04	-0.09	0.08	0.07	0.42	0.16	0.13	0.64								
teat length	-0.01	0.18	0.12	0.03	0.02	-0.18	-0.03	-0.07	-0.23	-0.35							
milking speed	0.09	-0.16	-0.17	0.11	0.16	0.32	0.09	0.04	0.33	0.24	-0.30						
temperament	0.11	0.12	0.12	0.20	0.01	0.32	0.12	0.24	0.25	0.26	-0.22	0.32					
likeability	0.24	0.03	0.02	0.30	0.11	0.42	0.23	0.29	0.40	0.33	-0.34	0.58	0.82				
survival	0.23	-0.32	-0.25	0.27	0.13	0.45	0.32	0.08	0.48	0.38	-0.31	0.40	0.45	0.64			
cell count	-0.09	0.05	0.02	-0.07	-0.04	-0.22	-0.11	0.15	-0.04	-0.13	0.10	0.17	0.06	0.04	-0.26		
fertility	-0.13	-0.14	0.04	-0.26	-0.19	-0.08	-0.21	-0.20	-0.18	-0.04	-0.01	-0.12	-0.13	-0.23	0.05	0.02	
live weight	0.62	0.61	0.53	0.61	0.32	0.35	0.20	0.10	0.19	0.12	0.05	0.03	0.22	0.28	0.10	-0.04	-0.20

The correlations between dystocia and other traits reflect the correlations between the difficulty with which a bull's calf is born and its size (0.71), gestation length (0.26), its adult stature (0.30) and bull daughter fertility (-0.3). Dystocia also has a positive correlation with type (0.21), stature (0.3) and other size related traits: bulls whose calves are more often born with difficulty also tend to produce daughters that are above average type and stature. Calf size has very similar correlations. Shorter gestation length has favourable (i.e. negative) correlations with APR (-0.23), milking speed (-0.2), likeability (-0.16) and fertility (-0.17), and unfavourable (positive) correlations with body depth (0.2) and chest width (0.15). Not surprisingly, some of the highest correlations were found between traits that are components of other traits: ASI is highly correlated with APR (Australian Profit Ranking), both composed partly of protein (kg) and fat (kg), and thus likely to be positively correlated.

Correlations between dystocia and liveweight were positive, and dystocia and fertility negative, whilst liveweight and fertility had a negative correlation: bulls whose calves are born with difficulty also have daughters that are larger and less fertile. Although (mature) liveweight and (calf) size, and (calf) size and gestation length were positive, there appeared to be no correlation between gestation length and liveweight: calves with small birth size due to short gestation length could well have average liveweight. Foot angle (a notoriously difficult trait to measure) was positively correlated with increased dystocia, greater calf size, better overall type, reduced fertility and greater liveweight. Fertility, a trait that is causing increasing concern in the dairy industry, was negatively correlated to many type traits such as bone quality and angularity.

This method has major limitations: this analysis used only a small number of bulls and no accounting is made for generation or relationship effects. It is presented here to stimulate discussion and further analyses.

CONCLUSIONS

Although this method is a relatively unrefined method of estimating genetic correlations, it does suggest areas for future research, such as investigation of the relationship between type and fertility, which appears to be negative (-0.27): the negative correlations between EBVs for type and fertility might suggest that selection for type traits may have the potential to reduce fertility. Australian dairy farmers are currently very concerned about declining levels of fertility. Bulls that have larger calves tend also to have daughters with large mature size; there appears to be no link between gestation length and adult liveweight: bulls that produce smaller, short gestation length calves (that are more likely to be born relatively easily) could well have average or larger mature weight daughters.

ACKNOWLEDGEMENTS

This work was supported by an Australian Commonwealth Government APAI grant and by the Holstein-Friesian Association of Australia. Data was kindly supplied by ADHIS.

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