Relationships between Calving Traits in Heifers and Mature Cows in Australia

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Abstract

Genetic correlations between the calving traits of dystocia, calf size and fate and gestation length are calculated for Holstein Friesian mature cows and heifers. The fixed effects of calf sex, cow age and month of calving indicated that winter (especially August) is associated with longer gestation lengths, larger calves and increased calving difficulty. The correlations for the same direct trait between heifers and mature cows varied from 0.78 (dystocia) to 0.96 (gestation length). All the correlations between the direct traits were positive. This means that EBVs calculated largely from mature cows are of relevance to heifers. Maternal-direct correlations were generally negative, but the correlation between the sire and the maternal grandsire effects were positive. This suggests that the use of an easy calving bull by farmers will result in easier calvings from his daughters.

Introduction

Dystocia (or calving difficulty) is of importance in many countries because of concerns for the welfare of the cow, her calf and the herdsman attending the cows, and also because of the loss of profits due to reduced cow survival, fertility, production calf survival and genetic gain, and increased labour costs.

Conditions in Australia differ from those countries where most genetic analyses of calving difficulty have been carried out. Our herds are large (averaging about 200 cows), our climate is warm to hot, our cows are mainly pasture fed, and typically yield about 6000 litres from mature cows. The average life in a herd is about five lactations. Most heifers are naturally mated to Jersey bulls who do their own heat detection and generally produce easy calvings. The resulting crossbred calves are usually sold soon after birth and are of little or no worth. As a consequence, replacement cows are now starting to be in short supply. Mating Holstein heifers with Holstein bulls that have low levels of calving difficulty would be beneficial in that it would increase the number of replacement heifers and accelerate the rate of genetic gain.

Dairy farmers want EBVs for calving ease when bulls are mated to heifers to be as accurate as possible, despite the fact that few heifer calvings to Holstein bulls are recorded. They also worry that selection for direct calving ease may produce heifers which increase dystocia when they themselves give birth. Therefore the aims of this paper are:

- To estimate the genetic correlation between calving ease in heifers and in mature cows, so that if r_g is high, data from mature cow calvings can be used to predict breeding values for dystocia in heifers.
- To estimate genetic parameters among dystocia, calf size, calf survival and gestation length, so that a multiple trait analysis can be used to evaluate EBVs.
- To estimate the correlations between the sire and maternal grandsire effects on these traits.

To accomplish these aims we calculated the heritabilities and correlations among 16 traits i.e the sire and maternal grandsire effect on dystocia, calf size, calf fate and gestation length in heifers and in mature cows.

Materials and Methods

A dataset of 801,652 calving records was provided by the Australian Dairy Herd Improvement Scheme (ADHIS), from data collected between 1986 and 2002. Records of calvings of AI bred Holstein cows that had been mated by artificial insemination to Holstein bulls were selected and then edited to exclude twins, father daughter matings, inductions and abortions, incomplete records, herds with less than ten records or that only used one calving class, sires with fewer than nine records, and cows that could not be identified as either heifers or mature cows. The remaining 134,141 records were used in the analysis.

The traits that were measured were calving difficulty, calf size, calf fate and gestation length. Calf size was measured by the seven category ADHIS scale shown in Table 1.

An 'ok' calving is where the cow is healthy and undamaged, and no intervention of any kind was required. An example of an 'unobserved - not ok' calving is when a cow that has given birth to a calf unsupervised, but has obviously had some problem: she may have a prolapsed uterus or calving paralysis when she is found by the farmer (our cows usually calve down in large pastured areas). The assistance of a veterinarian is always required for surgical calvings, but may also be required for some very difficult calvings. There is anecdotal evidence to suggest that the majority of surgical calvings are also malpresentations.

Table 1. ADHIS calving scores and simplified scores used in the analysis.

description	ADHIS calving ease score	simplified grouping	score	% of records
unobserved - not ok	1	some difficulty	2	1.7
unobserved - ok	2	ok	1	59.4
observed - ok	3	ok	1	24.4
observed - easy pull	4	some difficulty	2	9.0
observed - very difficult	5	grim	3	4.0
observed - surgical	6	grim	3	0.1
observed - malpresentation	7	some difficulty	2	1.3

The calving difficulty scale was reduced to three classes for the analysis: normal calving, some difficulty and very difficult calving (= grim). Calf size was measured subjectively on farm with a five class scale (1 = tiny, 2 = small, 3 = normal, 4 = big, 5 = huge). Calf fate was scored as dead or alive, though farmers did not have clear guidelines on the time limit. Gestation length was measured in days from mating to calf birth, with gestation lengths that were not between 260 and 300 days (approximately three standard deviations from the mean) excluded. Herd-year seasons were from January to June and July to December. The same matrix of relationships among sires and maternal grandsires (20,807 individuals) was used in all analyses. A summary of the dataset is given in Table 2.

Table 2. Summary of dataset.

	heifer calvings			mature cow calvings		
Calf sex	♀	♂	all	♀	♂	all
# calving records	7,662	7,143	14,805	61,730	57,606	119,336
calf mortality %	8.47	13.21	10.76	3.6	5.32	4.44
size	2.99	3.16	3.07	3.1	3.21	3.16
dystocia	1.32	1.5	1.41	1.11	1.19	1.15
gestation length days	279.5	280.1	279.8	280.8	281.7	281.3

We used a linear model for this analysis: Djemali (1987) found that whilst sire differences were larger using a threshold model, sire rankings had only minimal differences. Although the best model may theoretically have been a threshold model, from a practical point of view, Phocas (2003) found that a linear model, with herd as a fixed effect, was the best choice for predicting calving difficulty with associated maternal effects.

The analysis was carried out for all pairs of traits, using ASReml (Gilmour, Gogel *et al.,* 2002), to establish starting values for bull variances.

$$Trait1_{ijklmnpqr}\ Trait2_{ijklmnpqr} = \mu + s_i + m_j + \sum_{k=1}^{5} a_m Z_{km} + b_n + mgs_p + hys_q + e_{jklmnpqr}$$

where:

trait n_{ijlmnp} denote one of the ijkpqrth calf's calving trait scores (where the trait is dystocia, calf size, calf fate or gestation, for a heifer or mature dam, scored as described in the text)

μ is the population mean for that trait

s_i denotes the fixed effect of the ith sex

m_j denotes the fixed effect of the jth month of birth of the ijkpqrth calf

a_m denotes the fixed regression coefficient of the cow age at calving on the calving trait

Z_{km} denotes the mth order orthogonal polynomial corresponding to the kth month of age of the cow at calving

b_n denotes the random effect of the nth bull, the sire of the ijkpqrth calf

mgs_p denotes the random effect of the pth bull, as the maternal grandsire of the ijkpqrth calf

hys_q denotes the fixed effect of the qth herd-year-season in which the ijkpqrth calf was born

e_{ijkpqr} denotes the random error associated with the calving of the rth calf of the nth bull and pth mgs of ith sex in the jth month and the qth herd-year-season.

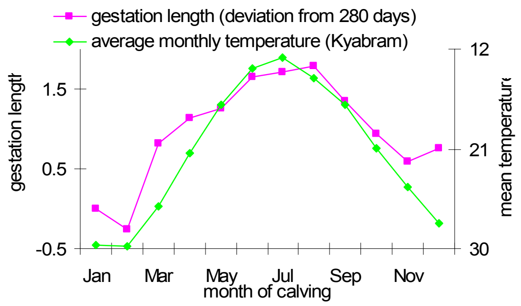
We did multivariate analyses of all pair wise combinations of the traits, with sires and maternal grandsires linked for greater processing speed.

Genetic correlations, heritabilities and standard errors were calculated by ASReml.

Results and Discussion

Calvings were more difficult in the winter months (August) which coincided with the birth of the largest calves, the longest gestation length and the coldest temperatures (Figure 1). Male calves were bigger than female calves, had longer gestation lengths and greater mortality rates, but the differences in mortality rates between the sexes became less marked with increasing cow age. Though our heifers had smaller calves and shorter gestation lengths than the mature cows, they had more difficulty calving and a higher calf mortality rate. Older heifers had easier calvings, lower calf mortality rates and longer gestation lengths than younger heifers, but their calf sizes were similar.

Figure 1. Ambient temperature and gestation length.



Sire and maternal grandsire correlations, together with their heritabilities are shown in Table 3, sire and maternal correlations and heritabilities in Table 4.

Table 3. Sire and maternal grandsire correlations.

r_e	r_g / h^2	heifer sire				heifer MGS				mature sire				mature MGS			
		dystocia	size	fate	gest-ation	dystocia	size	fate	gest-ation	dystocia	size	fate	gest-ation	dystocia	size	fate	gest-ation
heifer sire	dystocia	0.11	0.95	0.59	0.39	0.39	0.69	0.12	failed to converge	0.78	0.81	0.76	0.30	0.29	0.55	0.42	0.27
	size	0.39	0.16	0.26	0.32	0.37	0.45	0.25		0.83	0.96	0.71	0.28	0.36	0.62	0.17	0.14
	fate	0.23	0.15	0.02	0.29	-0.06	-0.08	-0.36	-0.63	0.50	0.17	0.80	0.27	-0.40	-0.24	0.11	0.27
	gestation	0.16	0.18	-0.01	0.51	failed to	converge	0.11	0.80	0.58	0.54	0.69	0.96	0.18	0.16	0.19	-0.03
heifer MGS	dystocia					0.10	0.88	0.78	failed to converge	0.25	0.30	0.27	0.79	0.75	0.56	0.57	0.23
	size						0.03	0.38		0.64	0.57	0.76	0.22	0.61	0.77	0.41	0.48
	fate							0.02	0.66	0.68	0.49	0.61	0.16	0.92	0.38	0.98	0.18
	gestation								0.16	0.27	0.40	0.34	0.83	0.14	0.15	0.03	0.94
mature sire	dystocia									0.04	0.80	0.85	0.45	0.39	0.42	0.49	0.37
	size									0.33	0.10	0.27	0.49	0.53	0.63	0.35	0.34
	fate									0.25	0.07	0.01	0.60	0.34	0.22	0.73	0.15
	gestation									0.09	0.16	-0.01	0.48	0.22	0.34	0.77	0.80
mature MGS	dystocia													0.03	0.44	0.84	0.26
	size														0.04	0.17	0.32
	fate															0.01	0.54
	gestation																0.19

Table 4. Sire maternal correlations.

r_e	r_g / h^2	heifer sire				heifer maternal				mature sire				mature maternal			
		dystocia	size	fate	gest-ation	dystocia	size	fate	gest-ation	dystocia	size	fate	gest-ation	dystocia	size	fate	gest-ation
heifer sire	dystocia	0.11	0.95	0.59	0.39	-0.14	-0.36	-0.13	failed to converge	0.78	0.81	0.76	0.30	-0.12	-0.03	0.04	0.05
	size	0.39	0.16	0.26	0.32	-0.47	-0.62	0.11		0.83	0.96	0.71	0.28	-0.08	-0.06	-0.20	-0.14
	fate	0.23	0.15	0.02	0.29	-0.42	-0.36	-0.47	> -1	0.50	0.17	0.80	0.27	-0.69	-0.46	-0.39	0.08
	gestation	0.16	0.18	-0.01	0.51	failed to converge		-0.02	-0.28	0.58	0.54	0.69	0.96	-0.13	-0.30	-0.14	-0.03
heifer maternal	dystocia					0.09	0.71	0.81	failed to converge	-0.17	-0.08	-0.18	-0.02	0.76	0.51	0.74	0.19
	size						0.04	0.21		-0.27	0.39	-0.12	-0.10	0.34	0.51	0.26	0.56
	fate							0.04	<1	0.31	0.30	0.30	0.04	0.68	0.19	0.95	0.04
	gestation								0.05	-0.46	-0.14	-0.45	-0.51	0.19	0.38	-0.02	0.88
mature sire	dystocia									0.04	0.80	0.85	0.45	-0.15	-0.03	0.03	0.01
	size									0.33	0.10	0.27	0.49	-0.10	-0.13	0.31	-0.09
	fate									0.25	0.07	0.01	0.60	0.06	0.03	0.38	-0.51
	gestation									0.09	0.16	-0.01	0.48	-0.04	-0.17	0.25	-0.03
mature maternal	dystocia													0.03	0.33	0.87	0.13
	size														0.02	-0.21	0.33
	fate															0.01	0.66
	gestation																0.07

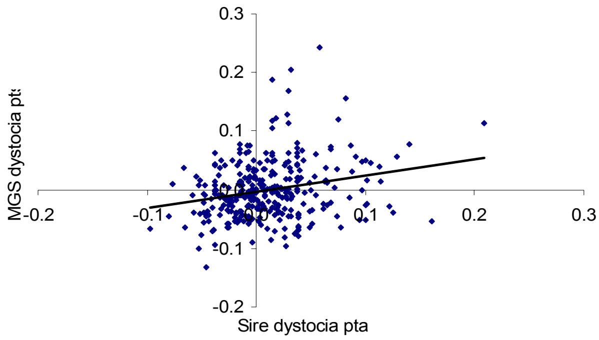
Correlations between the same trait at heifer and mature cow levels were high: 0.78 for dystocia, 0.96 for size, 0.8 for calf fate and 0.96 for gestation length.

Direct traits were positively correlated with each other within parity groups: dystocia in heifers was highly correlated (0.95) with calf size. Longer gestation length was associated with increased size (0.32 for heifers, 0.49 for mature cows), also increased dystocia, and higher calf mortality rates This also applied between heifers and mature cows, (though correlation of calf fate with size and gestation length was not significant for heifer calvings).

Reciprocity of correlations between traits occurred: the correlation between direct heifer dystocia and direct mature cow calf size was about the same as the correlation between direct mature cow dystocia and calf size of heifers (between 0.81 and 0.83).

Correlations between direct and maternal traits were generally negative, and those that were positive (such as many involving calf fate) had large standard errors, indicating they were not significantly different from zero. Correlations were over 0.5 between the same maternal traits at heifer and mature cow levels.

Figure 2. Relationship between sire and maternal grandsire PTAs for dystocia for 320 widely used sires from a breeding cooperative.



The genetic correlations between direct and maternal were negative, in agreement with those found by many other investigators such as (Luo, Boettcher *et al.,* 1999; Philipsson, 1976). However the correlation between sire and mgs effects were mainly positive; this indicates that, if a sire's calvings have little dystocia, his daughters will not experience above normal rates of dystocia when they themselves give birth.

Conclusions

We may use bull calving ease breeding values calculated from mature cows to predict heifer calving ease. Bigger calves have a strong association with dystocia and higher calf death for mature cows and heifers. Farmers can use 'easy calving bulls' without being overly concerned with producing daughters that have difficult calvings. An EBV for daughter calving ease would be useful.

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