Analysis of calving traits with a multitrait animal model with a correlated direct and maternal effect

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Abstract

Since 2007 two new systems are in place to record calving data, calving ease and birth weight from all parities. With the old survey system, calving data were recorded mainly from second calf cows and with the new systems information of all calvings is recorded, including first parity. Quality of the data from the new systems is sufficient. Therefore, genetic parameters have been estimated for calving traits with a multitrait animal model including a direct and maternal effect. Calving traits in primiparous cows were regarded as different traits than calving traits in multiparous cows. In this study the traits calving ease, gestation length and birth weight were investigated. Heritabilities range from 0.034 to 0.068 for calving ease, from 0.048 to 0.405 for gestation length and for birth weight from 0.035 to 0.115. The direct effect is more heritable than the maternal effect. The genetic correlations for the direct effect for the same trait between primiparous and multiparous cows are close to unity (> 0.95) but differ in genetic variances, whereas the genetic correlations for the maternal effect for the same trait between primiparous and multiparous cows are high (0.80). Calving ease and birth weight show high correlations within and between parities.

1. Introduction

In 2007 two new systems were introduced in the Netherlands to record the calving traits calving ease and birth weight. These new systems replaced the survey system. With the survey system data was recorded mainly from second calf cows. With the new systems data is received from cows of all parities. Data recorded through these systems are of good quality and are already used in the current breeding value estimation for calving traits. The current genetic model for the breeding value estimation for calving traits is a single trait sire-maternal grandsire model with correlated direct and maternal effects. With the extra data collected in the new systems it is possible to use data more efficient in the breeding value estimation. The records from primiparous cows could be used as well and data could be evaluated with an animal model.

The aim of this study was to investigate the feasibility of analysing calving traits with a multitrait animal model for primiparous and multiparous cows with a correlated direct and maternal effect.

2. Material and Methods

2.1 Data collection

Data collection of the birth process has changed in recent years in the Netherlands. In the past, NRS offered bull owners a service to collect birth process data of a bull's offspring. Until the end of 2006, the possibility existed to collect information through the so-called survey system. With the Survey system the bull owner himself or NRS, on behalf of the bull owner, sent a birth survey to the farmer. This was done shortly before the offspring of the bull was born. The survey contained questions about calving ease and birth weight. Farmers were asked to complete the survey and return it to the bull controller. The surveys were processed in the Dutch database (or Information System). However, since the beginning of 2007 birth process data are stored when a farmer reports the birth of a calf through the Voice Response System (VRS) or the Notification System (Dutch: Meldsysteem – MS), which is a part of VeeManager (CattleManager) on the CRV website. When reporting the birth of a calf with VRS or MS, the farmer indicates the calving ease. The scoring into categories is the same as the classification of the survey system.

2.2 Trait definitions

Calving ease is scored in six categories: 1 – easy, 2 – normal, 3 – hard pull, 4 – caesarean, 5 – fetonomy and 6 – other veterinary aid. For this study and in the routine breeding value estimation the number of classes is reduced to 4. This is done by adding score 6 to 3 and score 5 to 4.

The gestation length is calculated from the difference between the insemination date and the calving date.

In the survey, the birth weight of calves was scored in 12 classes of 5 kg each. The lowest class was for calves of 22 kg and less, the next class is 23-27 kg, etc. The highest class was for calves of 73 kg or more. The farmer gave a score to the weight class of the calf born. For the breeding value estimation these weight classes were converted into kilograms again. When reporting the calf with VRS or MS the farmer enters the estimated or weighted weight in kilograms.

2.3 Data edits

Data from animals born from 2002 onwards were used. The information of a birth recording should be complete, i.e. the farm where the calf is born is known, the sex of the calf is known, the parity number is known, the sire of the calf is known, the calving ease category is known. Records from herdbook registered calves with at least 75% Holstein genes, with a gestation length between 260 and 300 days were used in this study. The birth weight of the calf was between 20 and 75 kilograms. The calf was not born as part of a multiple birth. The dam of the calf should have at least 75% Holstein genes.

Data reported through VRS or MS had to meet extra demands. The dam of the calf had to be herdbook registered. The calf, if it was alive, had to be herdbook registered, if it was stillborn, it should have been entitled to a herdbook registration. If a farm had more than 10 birth notifications per calendar year, the deviation of the scores for calving ease within a calving year had to be at least 0.20. To avoid a possible error correlation dam-offsping relations were not allowed in the data. This was to eliminate the possible error correlation between calf and dam (Eaglen and Bijma, 2009). Additional edits were set to get a more informative data set for the genetic analysis. Herd-year classes should contain at least 20 calving records of primiparous cows or 50 calving records of multiparous cows. Sires should have at least 50 calving records of primiparous cows and 100 calving records of multiparous cows.

2.4 Statistical analysis

ASREML (Gilmour *et al.*, 2006) was used to estimate variance components. Variance components were estimated with bivariate analyses, using a linear model. Calving records from primiparous cows were analysed with a different model than calving records from multiparous cows. The models used in the different analyses were:

For primiparous cows:
$Y_{ijklmnp} = S_i + A_j + M_k + HY_l + calf_m + cow_n + E_{ijklmnp}$

For multiparous cows:
$Y_{ijklmnop} = S_i + P_j + M_k + HY_l + calf_m + cow_n + perm_o + E_{ijklmnop}$

Where
$Y_{ijklmnop}$ = observation during the birth of a calf for calving ease, birth weight or gestation length
S_i = sex of the calf (fixed)
A_j = age at calving for primiparous cows (fixed, 14 classes; ≤ 22 months, 23 … 33 months, ≥ 34 months)
P_j = parity number for multiparous cows (fixed, 9 classes; parity 2-9 and parity ≥ 10)
M_k = month of calving (fixed, 12 classes)
HY_l = herd x year of calving (fixed)
$calf_m$ = born calf (random)
cow_n = dam of the calf born (random)
$perm_o$ = permanent environment for multiparous cows (random)
$E_{ijklmnop}$ = residual (random)

The observations on calving ease were transformed to an underlying normal distribution to account for differences in frequencies. The transformation was stratified through data collection (Survey System, VRS, MS), parity (primiparous, multiparous) and three year period. The pedigree was traced back two more generations starting from the calf or dam.

3. Results and Discussion

3.1 Data characteristics

Data characteristics of the analysed data are shown in Table 1. The total number of records was 146,613. The number of cows with observations as primiparous and multiparous cow was 11,268.

Table 1. Data characteristics of genetic analysis

	Primiparous	Multiparous
Records	42,968	114,913
Herdyears	2,643	3,545
Age classes	14	

Parities		9
Sires	190	909
Dams	42,968	98,401

In Table 2 the frequency distributions of calving ease are shown for primiparous and multiparous cows. Primiparous cows have more difficult calvings (11.2%; score 3 and 4) than multiparous cows (5.0%). Primiparous cows have less easy calvings as well. Table 3 presents the descriptive statistics for gestation length and birth weight. Primiparous cows have a two day shorter gestation length and born calves are 2.6 kg lighter compared to multiparous cows.

Table 2. Frequency distribution of the calving ease scores for primiparous and multiparous cows

	Frequency (%)			
Score	1	2	3	4
Primiparous	43.2	45.6	10.6	0.6
Multiparous	53.1	41.9	4.8	0.2

Table 3. Descriptive statistics of gestation length and birth weight

	primiparous		multiparous	
	mean	sd	mean	sd
Gestation length (days)	278.8	5.3	280.8	5.2
Birth weight (kg)	39.0	5.0	41.6	5.4

3.2 Heritabilities

Estimated heritabilities, genetic correlations and genetic variances are shown in Table 4. For all traits the direct heritability is higher than the maternal heritability, especially for gestation length. For gestation length it seems that the calf causes more variation in gestation length than cows, indicating clearly that the calf mainly controls gestation length. This is in accordance with the biological assumption that the calf initiates the parturition. For primiparous cows the heritabilities for calving ease are higher than for multiparous cows, whereas the heritabilities for gestation length and birth weight are nearly the same for primiparous and multiparous cows. Genetic variances for calving ease are 1,5 times higher for primiparous cows compared to multiparous cows. For calving ease the estimated heritabilities are in the range used by other countries in the routine genetic evaluations (Interbull, 2009).

The permanent environment variances for multiparous cows were 0.023 for calving ease, 1.16 for gestation length and 0.78 for birth weight.

3.3 Genetic correlations

Genetic direct-maternal correlations within parity per trait are not significantly different from zero, except for the calving ease for multiparous cows (-0.39).

Genetic correlations between traits within parity are weak between most traits. The direct effect of calving ease and birth weight are highly correlated both for primiparous cows (0.94) and multiparous cows (0.96). For multiparous cows the maternal effect of calving ease and birth weight is highly correlated as well (0.73).

Genetic correlations between parities per trait are high for the direct effect as well as for the maternal effect. Genetic correlations for the direct effect are close to unity. Genetically the direct effect of a trait is the same between parities. The genetic correlations for the maternal effect are about 0.80. Genetically the maternal effect is not the same between parities.

Genetic correlations between different parities and between different traits are positive for all correlations between the direct effects or between the matenal effects. The direct effect for calving ease and birth weight are highly correlated between parities (≥0.94). The direct-maternal correlations between different parities and different traits are smaller and some are negative.

4. Conclusions

For the traits calving ease, gestation length and birth weight it is possible to estimate genetic parameters with an animal model containing a direct and maternal effect. Genetic variances and heritabilities are different for primiparous and multiparous cows. Therefore, traits are treated differently for primiparous and multiparous cows. The direct effect is highly correlated between parities (>0.95). In a multiple trait breeding value estimation reliability is added, because all data from both primiparous and multiparous cows can be used. Ranking of bulls for the direct effect is nearly the same in primiparous and multiparous cows. The maternal effect is also highly correlated between parities (0.80). However ranking of bulls is not the same in primiparous and multiparous cows.

5. References

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Table 4. Heritabilities, genetic variances and genetic correlations within and between parities (primiparous (1) *vs.* multiparous (2+)) for calving ease (CE), gestation length (GL) and birth weight (BW) for direct the direct and maternal effect (heritabilities bold).

	CE 1		GL 1		BW 1		CE 2+		GL 2+		BW 2+		
	Dir	Mat	Dir	Mat	Dir	Mat	Dir	Mat	Dir	Mat	Dir	Mat	Gen.var
CE 1													
Dir	**0.068**												0.041
Mat	0.25	**0.048**											0.029
GL 1													
Dir	0.24*	0.41*	**0.391**										9.40
Mat	0.01	0.16	0.09	**0.062**									1.50
BW 1													
Dir	0.94*	0.26	0.29*	0.07	**0.095**								1.05
Mat	0.01	0.24	0.16	0.39*	0.14	**0.035**							0.39
CE 2+													
Dir	0.96*	0.20	0.46*	0.22	0.99*	-0.04	**0.052**						0.027
Mat	-0.33*	0.82*	0.01	0.18	-0.24	0.60*	-0.39*	**0.034**					0.017
GL 2+													
Dir	0.31*	0.01	1.00*	0.05	0.47*	0.12	0.39*	-0.12	**0.405**				10.29
Mat	-0.11	0.69*	0.21*	0.80*	-0.04	0.26	0.16	0.43*	0.18	**0.048**			1.21
BW 2+													
Dir	0.94*	0.22	0.43*	0.22	0.99**	0.12	0.96*	-0.01	0.40*	0.03	**0.115**		1.55
Mat	-0.22	0.16	0.06	0.35*	-0.18	0.84*	-0.04	0.73*	0.06	0.39*	-0.14	**0.036**	0.49

* P < 0.05; ** fixed at boundary