Relationships Between Conformation Traits and Traits of the Calving Complex in Dairy Cows

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Introduction

The complex of calving is of great interest to dairy farmers due to the need for healthy and vital calves and even more for healthy and cows capable for high production yields. In general, calving traits exhibit only low heritabilities. Additionally, the correlation between the direct and the maternal component of calving ease and stillbirth has to be assumed as being negative. In Mecklenburg-Vorpommern a contract herd scheme for progeny testing with special emphasis on the recording of functional traits was implemented. For the complex of calving, a precise documentation of the parturition including weighing of all calves at birth, be alive or stillborn, was established. Furthermore, for all cows a linear scoring of conformation traits is included in the entire recording system.

Dadati *et al.* (1985) and Cue *et al.* (1990) pointed out that relationships between conformation traits and calving ease do exist. Since conformation traits are well documented and moderately heritable, such traits may be of aid in selection decisions. In the present study, a first step consisted of an estimation of variance components for the main traits of the calving complex, i.e. stillbirth, dystocia, birth weight, and gestation length. In a second step, the influence of selected conformation traits on the calving traits was evaluated. In this step, conformation traits were added to the model as additional fixed effects.

Material and methods

Data from October 2005, i.e. the start of the contract herd testing scheme, to October 2009 was used. Only singleton births out of Holstein heifers with known calving parameters and conformation were considered in this evaluation. Routine classification of all cows did not start before 2007, therefore the amount of observed calvings with conformation records in the first two years was somewhat reduced. Calvings with a birth weight lower than 31 kg were excluded due to the risk of unphysiological circumstances at birth. Furthermore, data from one herd had to be excluded because of irregularities. In total, the data included 12,029 calvings from 546 sires-of-calf and 577 maternal grandsires-of-calf from 21 herds.

Stillbirth and Dystocia were defined as binary traits. A calf was considered as stillborn if dead at birth or dead within 48 hours postpartum. Dystocia was assumed at least one assisting person was needed for the delivery. Overall incidences were 8.85 % and 46.4 %, for stillbirth and calving ease, respectively. The raw means of birth weight and gestation length were 41.6 kg and 279.5 days, respectively.

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For the binary traits a threshold model was used, for birth weight and gestation length a linear model was applied. In a first model, components of variance were estimated for the sire of the calf as well as for its maternal grandsire. The effects of herd (21), year-season (12, seasons: 1=January-April, 2= May–August, 3=September-December), sex of the calf (2), and age at calving of the dam (9) were considered as fixed effects.

In addition to the fixed effects as given above for the first model, a second model considered conformation scores of the dam of the calf by adding one of the following conformation traits at a time: body depth, chest width, rump angle, rump width, hock quality, udder depth, and stature. Conformation scores were included as main fixed effects after grouping the scores from the original 1 to 9 scale such that five classes were formed. Scores 1 and 2, 3 and 4, 5, 6 and 7, and 8 and 9 formed the five classes. The newly formed classes for the traits analyzed have the following meaning with respect to the extreme classes 1 and 5: Body depth – shallow and deep chest width - narrow and wide, rump angle - high pins and extreme slope, rump width - narrow and wide, hock quality - coarse and smooth, and udder depth - below hocks and shallow. Stature as originally measured in centimetres was summarized into five classes with the thresholds 141, 145, 147 and 150 cm. Variance components were estimated using ASReml (Gilmour *et al.* 2008) while for fit statistics of the fixed effects the Glimmix procedure (SAS, 2002) was applied.

Results and discussion

Direct and maternal heritabilities and the genetic correlation between the direct and maternal component were calculated from the estimated variance components as described by Willham (1972) (see Table 1). Heritability estimates for stillbirth and dystocia are higher than commonly reported in literature. Reasons for this finding could be the precise documentation in the contract herds and also the fact that semen of young bulls was used in these herds in a substantially higher fraction than commonly found. For stillbirth, the genetic part of the maternal component seems to be the more important than the direct genetic component while for dystocia, the opposite was found. For dystocia, birth weight, and gestation length maternal effects in general are of lesser importance than direct effects. It has to be considered that the direct effect of dystocia is strongly influenced by birth weight.

Table 1: Heritabilities and genetic correlations of the calving traits

	Stillbirth	Dystocia	Birth Weight	Gestation Length
h^2_{direct}	0.17 ± 0.05	0.26 ± 0.04	0.37 ± 0.04	0.50 ± 0.05
$h^2_{maternal}$	0.29 ± 0.07	0.18 ± 0.05	0.10 ± 0.03	0.12 ± 0.03
$r_{g\ direct\text{-}maternal}$	-0.47 ± 0.18	-0.28 ± 0.16	0.02 ± 0.15	-0.18 ± 0.12

Table 2 presents the back-transformed values of the least square means of the fixed effects for classes of conformation scores of the dams along with the significance (P-value) of the effect. For stillbirth and dystocia three conformation traits could be identified to have a significant influence. For stillbirth, a curvilinear influence of udder depth is observed such that very deep and to an even greater extent very shallow udders lead to higher stillbirth rates.

Table2: Least square means (retransformed values), standard errors and significance of conformation trait effects for calving traits

Trait[1)]	P-value[2)]	Type trait class (LSM ± SE)				
		1	2	3	4	5
				Stillbirth (in %)		
BD	0.20	8.8 ± 3.96	9.4 ± 0.80	10.0 ± 0.77	10.3 ± 0.67	12.4 ± 1.35
CW	0.49	10.3 ± 3.04	10.0 ± 0.77	9.4 ± 0.71	10.7 ± 0.71	11.1 ± 1.76
RA	0.10	8.2 ± 1.95	11.5 ± 0.84	9.8 ± 0.67	9.7 ± 0.72	10.8 ± 3.06
RW	0.23	7.3 ± 1.84	11.0 ± 0.78	9.7 ± 0.72	10.2 ± 0.72	9.1 ± 1.69
HQ	0.10	13.2 ± 1.50	10.5 ± 0.72	10.0 ± 0.76	9.4 ± 0.77	9.1 ± 1.42
UD	*	10.3 ± 2.35	9.0 ± 0.79	9.7 ± 0.77	10.3 ± 0.68	12.9 ± 1.16
ST	0.12	10.9 ± 1.04	9.6 ± 0.68	11.3 ± 0.84	9.4 ± 0.77	10.6 ± 1.45
				Dystocia (in %)		
BD	0.21	55.4 ± 6.82	51.6 ± 1.56	51.5 ± 1.48	53.7 ± 1.33	55.1 ± 2.15
CW	0.51	47.9 ± 4.96	54.1 ± 1.49	52.7 ± 1.43	52.3 ± 1.37	53.4 ± 2.91
RA	*	55.3 ± 3.62	55.0 ± 1.48	52.8 ± 1.36	51.3 ± 1.43	47.7 ± 4.81
RW	*	61.5 ± 3.43	54.3 ± 1.43	52.7 ± 1.44	51.5 ± 1.41	51.6 ± 3.00
HQ	0.05	57.4 ± 2.23	53.2 ± 1.39	53.2 ± 1.47	51.7 ± 1.53	48.5 ± 2.67
UD	**	58.9 ± 3.82	55.7 ± 1.57	52.4 ± 1.51	52.4 ± 1.35	49.2 ± 1.86
ST	0.06	55.8 ± 1.79	53.7 ± 1.39	51.9 ± 1.51	51.2 ± 1.53	52.0 ± 2.46
				Birth weight (in kg)		
BD	***	40.9 ± 0.53	41.1 ± 0.13	41.1 ± 0.13	41.5 ± 0.12	41.9 ± 0.18
CW	***	40.4 ± 0.38	41.2 ± 0.13	41.1 ± 0.13	41.5 ± 0.12	42.0 ± 0.23
RA	0.21	41.2 ± 0.28	41.3 ± 0.13	41.3 ± 0.12	41.4 ± 0.13	41.9 ± 0.37
RW	***	40.4 ± 0.28	41.0 ± 0.13	41.2 ± 0.13	41.6 ± 0.12	42.0 ± 0.23
HQ	***	41.9 ± 0.18	41.5 ± 0.12	41.4 ± 0.13	41.1 ± 0.13	40.3 ± 0.21
UD	***	41.3 ± 0.30	41.7 ± 0.14	41.4 ± 0.13	41.3 ± 0.12	40.5 ± 0.15
ST	***	40.1 ± 0.15	41.0 ± 0.12	41.4 ± 0.13	42.0 ± 0.13	42.5 ± 0.19
				Gestation length (in days)		
BD	***	279.1 ± 0.60	279.0 ± 0.18	279.3 ± 0.17	279.6 ± 0.16	279.7 ± 0.21
CW	**	279.0 ± 0.43	279.2 ± 0.17	279.3 ± 0.17	279.6 ± 0.16	279.6 ± 0.27
RA	0.06	279.8 ± 0.32	279.5 ± 0.17	279.4 ± 0.16	279.3 ± 0.17	279.2 ± 0.41
RW	**	278.8 ± 0.32	279.2 ± 0.17	279.4 ± 0.17	279.5 ± 0.17	279.9 ± 0.28
HQ	0.16	279.2 ± 0.22	279.5 ± 0.17	279.5 ± 0.17	279.3 ± 0.17	279.0 ± 0.25
UD	***	279.0 ± 0.35	279.6 ± 0.18	279.4 ± 0.17	279.4 ± 0.16	278.9 ± 0.19
ST	***	279.0 ± 0.19	279.2 ± 0.17	279.4 ± 0.17	279.8 ± 0.17	279.8 ± 0.24

1) type trait effect: BD=body depth (1 shallow, 5 deep), CW=chest width (1 narrow. 5 wide), RA=rump angle (1 high pins, 5 extreme slope), RW=Rump width (1 narrow, 5 wide), HQ=hock quality (1 coarse, 5 smooth), UD=udder depth (1 below hocks, 5 shallow), ST=stature (thresholds 141, 145, 147, 150 cm)
2) Type 3 test of fixed effects * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

For dystocia, as could be expected, a sloped and wide rump of the dam is advantageous. Also, clearly more shallow udders lead to less calving problems. Furthermore, the filling of

the sub cells at the margin classes 1 and 5 is somewhat critical and thus standard errors for these classes are high.
In general, the effect of conformation traits of the dam on the traits birth weight and gestation length is relatively small, although mostly significant. What can be deduced from the results for birth weight and gestation length is that heavier and taller cows, characterized by a deep body, a wide chest, a wide rump, and a taller stature appear to have longer gestation lengths and higher birth weights of their calves.
On the other hand, slim cows that in turn have slim hocks tend to have lighter calves and less stillbirth rates. Although on the border of being significant, the effect of hock quality on stillbirth rate and dystocia is quite pronounced with a difference of 4.1 % in stillbirth rate and a difference of 8.9 % in dystocia between the extreme classes of hock quality. Also, there is a nonsignificant but strong tendency for cows with extreme deep body depth to cause more stillbirths.

Conclusion

The results show that a precise documentation in supervised contract herds facilitates to detect genetic differences between animals with respect to stillbirth and dystocia. Hence, contract herds are helpful for progeny testing and will be of value as a basis for collecting phenotypes for the purpose of genomic selection. However, what has contributed to the increase of heritabilities compared to literature values also is the fact that in this study only first calvings were considered. This underlines that it will be necessary to analyze first calvings instead of restricting an analysis to later calvings only.
For birth weight and gestation length, estimates are in agreement with previous studies. The results from the present study also reveal a substantial genetic antagonism between direct genetic and maternal genetic effects. Conformation significantly does influence the calving traits although the differences mostly are within a minor range. Very deep, tall and wide cows exhibit more calving difficulties, higher birth weights of their calves and longer gestation lengths. While these extreme conformation scores may be desirable in older cows, for young cows in their first lactation these extremes are undesirable.

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