Direct and maternal effects on calving ease in heifers and second parity Piemontese cows

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Abstract

Genetic parameters were estimated for direct and maternal effects on calving ease scores of calves born from first and second parity Piemontese cows. The data consisted of 97,493 and 76,478 calving records of first and second parity cows, respectively. Due to computing limitations, estimation of (co)variance components was carried out on samples extracted from the available data files. Five samples of approximately 20,000 first calving records were obtained using a random sampling procedure on herds. Second calving records of sampled heifers were used to create samples of second parity data. (Co)variance components were estimated using a REML animal model procedure considering all known relationships. Calving ease observations consisted of subjective scores into five categories: normal delivery (unassisted), delivery assisted by the farmer, hard pull or veterinary aid, caesarian and fetotomy. The linear model included the fixed effect of herd, age of the dam-sex of the calf, year-season of calving and two random effects: the additive genetic effect of the calf (direct effect) and the additive genetic effect of the dam (maternal effect). Depending upon the sample, estimates of heritability for the direct genetic effect in first parity cows ranged from 0.12 to 0.19. Estimates of heritability for the maternal effect in heifers were lower (0.07-0.11) than those for the direct effect. For second calving data, estimated heritabilities for direct and maternal genetic effects were similar (0.07 and 0.08, respectively). Genetic correlation between direct and maternal effects was highly negative (-0.40) in both heifers and second parity cows.

1. Introduction

Calving ease is an economic important trait in beef cattle and its importance is stressed further by current breeding programs used in beef cattle aimed to improve traits that, as daily weight gain and carcass fleshiness, exhibit antagonistic genetic relationships with ease of calving. Even though dystocia, defined as a delayed and difficult parturition, is not necessarily associated to loss of the calf or of the dam, increased costs, due to additional farmer labour, veterinary fees, subsequent health and fertility problems, and negative effects on production traits, are generally expected when difficult births occur. From a biological point of view, calving performances are affected by two components (Meijering, 1986): the ability of the dam to give births easily (maternal effect) and the ability of the calf to be born easily (direct or fetal effect). Literature estimates of heritability for direct and maternal effects on calving ease are generally low and a number of studies reported antagonistic genetic relationships between direct and maternal effects. Thus, selection for reducing calving problems due to direct effects (size of the calf) only, is expected to exert negative effect on the maternal component. An additional problem related to calving performance is the different genetic nature of dystocia in heifers compared to multiparous cows. In the Piemontese breed, selection of young bulls for beef traits is based on results of the performance testing program. Genetic evaluation for the direct effect on calving ease of selected bulls is based on calving records of the progeny originated by matings with cows whereas use of young bulls on heifers is avoided. Hence, selection for the direct effect relies mostly on calving records from cows.

Most studies on calving ease in dairy cattle have found correlations between calving performance and production traits close to zero. Conversely, in beef cattle, traits, like daily gain and muscularity, exhibit unfavourable genetic associations with calving ease (Meijering, 1986). As a consequence, a negative correlated response in calving performance is expected when selection programs aimed to improve such traits are applied.

This study was aimed to investigate the genetic aspects of calving performance in the Piemontese breed and to estimate genetic parameters for direct and maternal effects on this trait separately in heifers and cows.

2. Materials and methods

2.1 Data and editing procedures

The data used in this study consisted of 97,493 and 76,478 calving records of first and second parity Piemontese cows, respectively. Calving records were collected in 1,993 herds between 1989 and 1996. Calving records were removed when gestation length or sex of the calf was unknown and when calving score was missing. Permissible range of age at calving was from 21 to 37 months in heifers and from 31 to 65 months in second parity cows. Records from twin births were excluded from the data used in the following analyses. Calves were required to have both the sire and the dam known. Calving performance was scored into five categories: normal delivery (unassisted), delivery assisted by the farmer, hard pull or veterinary aid, caesarian and fetotomy. Based on preliminary analyses, two seasons of calving (November-April and May-October), and four gestation length classes (260-280, 281-290, 291-300, and 301-320 d) were defined. Age at calving data were grouped in 8 and 15 classes for heifers and cows, respectively.

2.2 Statistical methods

Preliminary analyses were carried out using general linear model procedure of SAS and all available calving records. These analyses were performed separately on heifers and second parity cows data. Different linear models were fitted aiming to identify fixed effects that affected variation of calving scores. The ultimate model included the fixed effect of herd, year-season of calving, age of the dam-sex of the calf and gestation length. These effects were included in the mixed model that was used later to estimate (co)variance components.

Estimation of (co)variance components was performed through a REML procedure using the VCE package (Groeneveld, 1996). The mixed model was as follows

$$y = Xb + Z_d d + Z_m m + e$$

where:
y is vector of calving scores
b is a vector of fixed effects
d is a vector of random direct additive genetic effects on calving scores (calf effect)
m is a vector of random maternal additive genetic effects on calving scores (dam effect)
e is a vector of random residuals
X, Z_d, and Z_m are known incidence matrices that link effects to calving scores

The (co)variance structure assumed for the random terms of the model was

$$V \begin{vmatrix} d \\ m \\ e \end{vmatrix} = \begin{vmatrix} A\sigma_d^2 & A\sigma_{dm} & 0 \\ A\sigma_{dm} & A\sigma_m^2 & 0 \\ 0 & 0 & I\sigma_e^2 \end{vmatrix}$$

where:
A is a matrix of additive genetic relationships among animals
I is an identity matrix
σ_d^2 is the additive genetic variance component of direct effects on calving scores
σ_m^2 is the additive genetic variance component of maternal effects on calving scores
σ_{dm} is the additive genetic covariance component between direct and maternal effects
σ_e^2 is the residual variance component

Due to computing limitations, estimation of (co)variance components using all available records was unfeasible. Therefore, samples were drawn from the data file applying a random sampling procedure on herds. Herds were sampled by generating random numbers from a uniform distribution and picking up all calving records pertaining to the herd located, in the list of herds, at the position corresponding to the generated random number.

This sampling was repeated as many times as needed to get a minimum number of 20,000 first calving records in the sample. Five different samples of first calving records were drawn using the aforementioned procedure. Second calving records of sampled heifers were used to create five samples of second parity data.. For each sample, a file including all known relationships among animals was extracted from the pedigree file of the Italian Association of Piemontese Breeders (Anaborapi). No genetic grouping was used in the REML estimation analyses.

3. Results and discussion

3.1 Calving scores and non genetic effects

Frequencies of calving scores in heifers and second parity cows data are reported in Figure 1. Most calvings were scored as assisted by the farmer both in heifers and in second parity cows and frequency of normal deliveries (unassisted) was relatively low. However, it can be hardly stated that assistance during the parturition was a result of more difficult births. Instead, it can be argued that assistance during the parturition is given by the farmer even in calvings that might end with a normal delivery.

Incidence of more difficult births (hard pull, caesarian and fetotomy) was as expected higher in heifers than in second parity cows.

Estimated least squares means of gestation length, age-sex and year-season of calving effects obtained in the preliminary analysis of all available calving records are reported in figures 2, 3 and 4, respectively. Increases in gestation length resulted in more difficult calvings in both heifers and cows (figure 2). Philipsson (1976) reported that the relationship between gestation length and calving ease exhibits threshold properties. However, there is no evidence of a non-linear relationship from the results of the present study. The sex of the calf exerted a major effect on calving performance (figure 3). Male calves had more difficult births than female calves. Difference in calving scores due to the sex of calf effect was much higher in heifers than in second parity cows. These results are in agreement with results from other studies (Meijering, 1986). Age at parturition of heifers had significant effects on calving scores. Calving scores were higher when heifers calved at a young age (figure 3). The magnitude of the age effect in second parity cows was small. With respect to year-season of calving, both heifers and cows that calved in season 1 (November-April) had slightly higher calving scores than dams calving in May-October.

3.2 Genetic parameters and effect of data sampling

Characteristics of sampled data sets are reported in table 1. Average number of first calving records per year and per herd was 2.72. Due to the small average herd size and to avoid use of herd classes, the herd-year effect was not included in the model of analysis and a choice of fitting herd and year-season as separate effects was made. Nearly 78% of heifers had the opportunity of a second calving. Total number of animals considered in the analysis ranged from 53,381 and 66,132.

Estimates of (co)variance components obtained in the analysis of heifers calving performance are reported in table 2. Estimates of additive genetic variance components for direct effects were higher than those for maternal effects in all the five samples. Heritability estimates for direct effects on calving scores ranged from 0.12 to 0.19. Variation of heritability estimates for maternal effects due to sampling of data was lower. The estimated genetic correlation between direct and maternal effects on calving scores was negative in all the five samples but the size of the correlation was greatly influenced by the sampling of data. The magnitude of the estimate ranged from -0.55 to -0.27. Average heritability for direct effects was nearly two times higher than that for maternal effects.

Genetic parameters recovered in the analysis of second parity cows data are in table 3. The effect of sampling of data on estimated parameters was lower than that observed for heifers calving scores. Values of heritability estimates for the direct effect on calving scores in cows were nearly half the values obtained with heifers data. These estimates fit well in the literature ranges (Thompson et al., 1981; Groen et al., 1995, Groen et al. 1998).

Changes in maternal effect heritability were small. Again, the correlation between direct and maternal genetic effects was negative and its magnitude was similar to that obtained in analyses of heifers calving data.

4. Conclusions

This study estimated genetic parameters for calving scores in Piemontese heifers and second parity cows. Genetic variation of direct effects on calving performance in heifers was much higher than that observed in second parity cows. No evidence of differences in genetic variation of maternal effects between Piemontese heifers and cows was found. The genetic correlation between direct and maternal effects on ease of calving was negative.

Further investigations on the genetic relationship between calving performance of heifers and of cows are needed.

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Philipsson, J. 1976. Studies on calving difficulties, stillbirth and associated factors in Swedish cattle breeds. III. Genetic parameters. *Acta Agriculturae Scandinavica* 26:211-220.

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    of dam and maternal effects for dystocia in Holsteins.
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Table 1. Characteristics of sampled data sets

	heifers					cows				
sample	1	2	3	4	5	1	2	3	4	5
Records	20,031	20,007	20,001	20,009	20,021	15,547	15,417	15,996	15,700	15,967
Animals[(*)]	65,125	66,132	65,352	64,950	65,482	53,831	54,234	54,933	54,270	55,292
Herds	910	935	933	891	926	908	935	932	885	926

(*) Including animals without records

Table 2. Estimates of genetic parameters for direct and maternal effects on calving scores in first parity cows

	Sample					
	1	2	3	4	5	Average
Direct variance	0.081	0.084	0.132	0.089	0.130	0.103
Maternal variance	0.067	0.073	0.065	0.045	0.049	0.060
Direct - maternal covariance	-0.028	-0.036	-0.051	-0.017	-0.025	-0.031
Residual variance	0.520	0.510	0.497	0.513	0.488	0.506
h^2 direct	0.121	0.126	0.191	0.137	0.195	0.154
h^2 maternal	0.100	0.109	0.094	0.069	0.073	0.089
r_g direct-maternal	-0.386	-0.459	-0.549	-0.269	-0.315	-0.396

Table 3. Estimates of genetic parameters for direct and maternal effects on calving scores in second parity cows

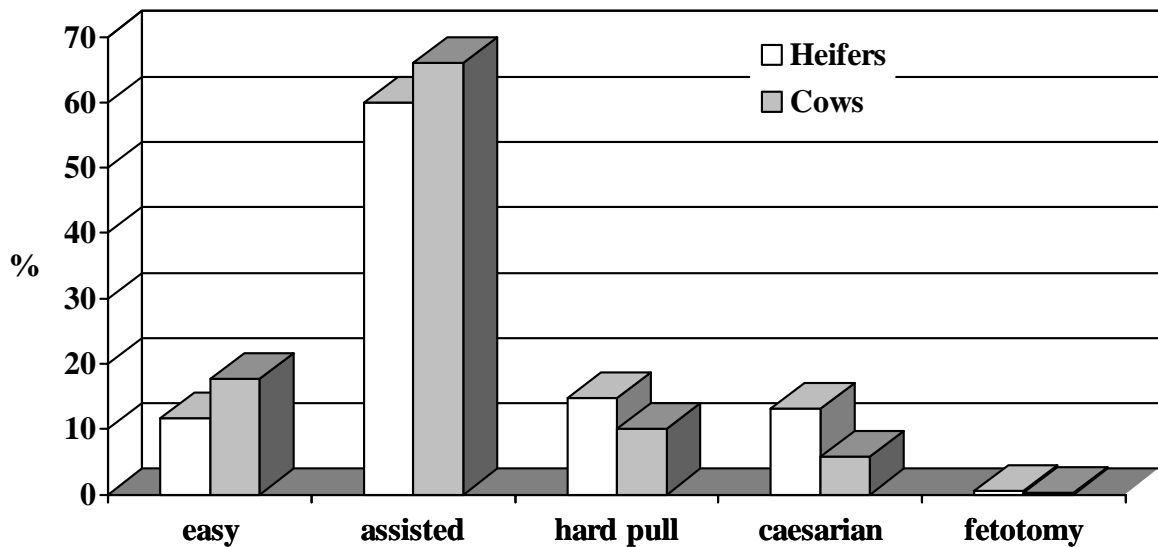|	Sample					
	1	2	3	4	5	Average
Direct variance	0.030	0.041	0.021	0.027	0.051	0.034
Maternal variance	0.033	0.039	0.031	0.040	0.048	0.038
Direct - maternal covariance	-0.013	-0.017	-0.009	-0.013	-0.023	-0.014
Residual variance	0.416	0.405	0.430	0.423	0.386	0.412
h^2 direct	0.062	0.085	0.043	0.056	0.105	0.070
h^2 maternal	0.069	0.080	0.064	0.082	0.099	0.079
r_g direct-maternal	-0.402	-0.423	-0.354	-0.382	-0.471	-0.413

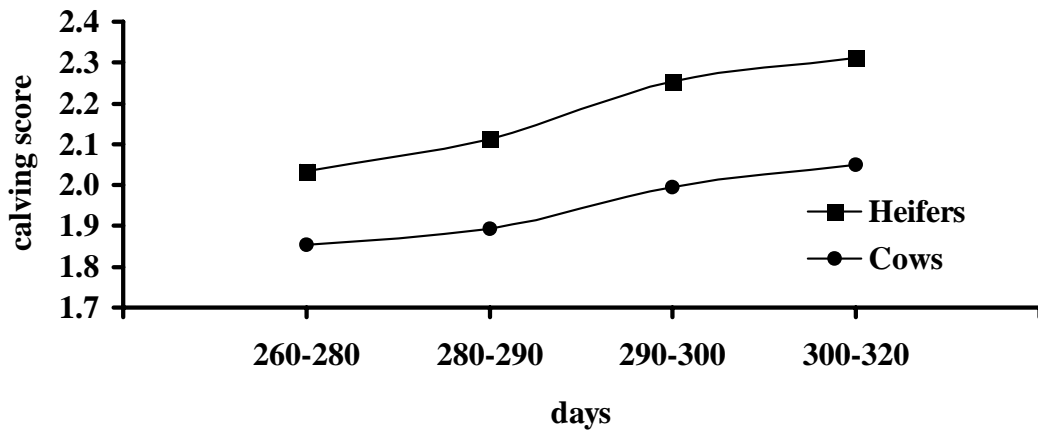***Figure 1.*** Frequency of calving scores

Figure 2. Effect of gestation length on calving scores
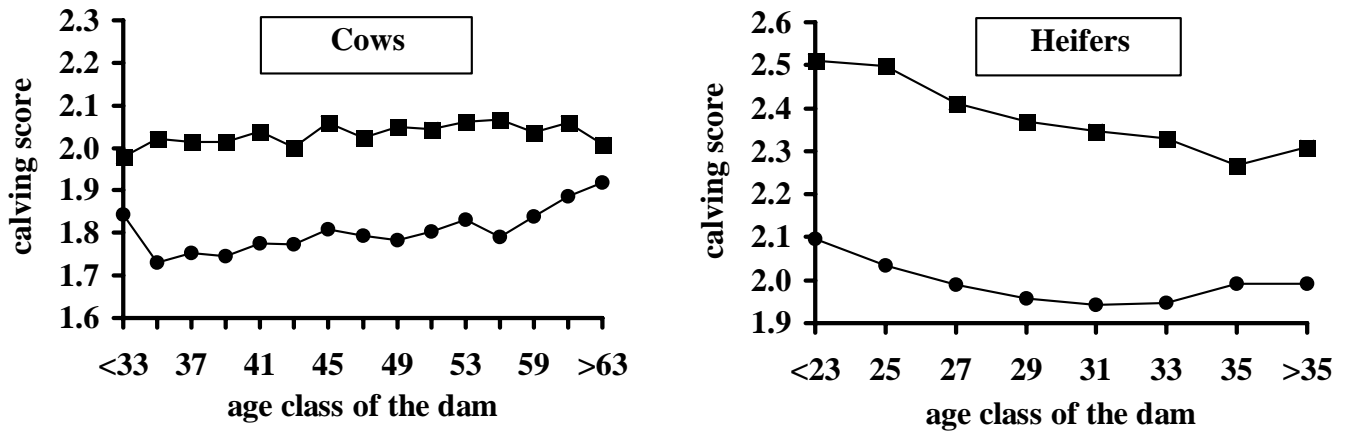

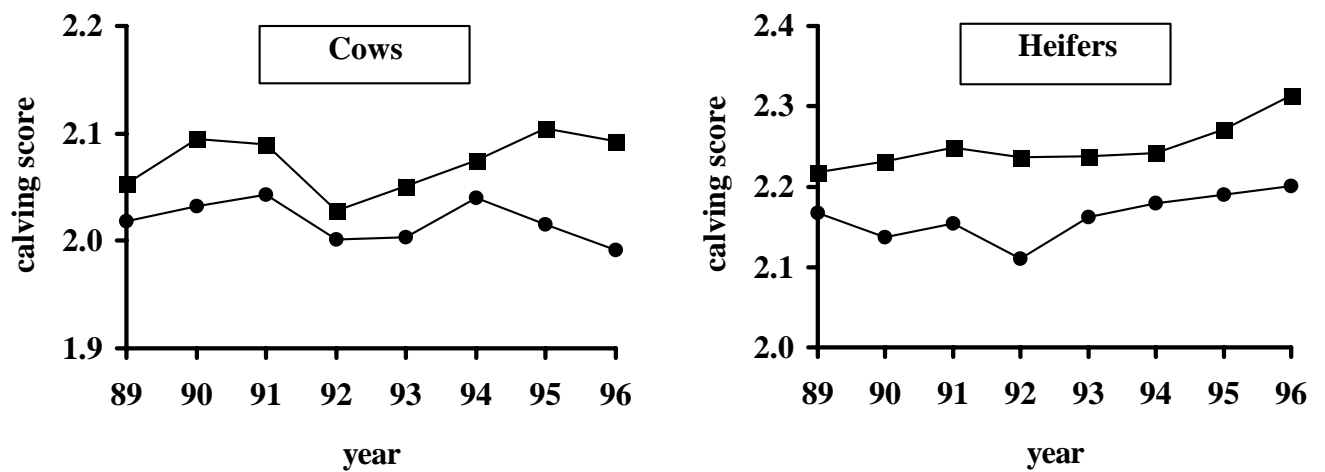*Figure 3.* Effect of age at parturition and sex of the calf (■ male calf ● female calf)

Figure 4. Effect of year-season of calving (■ November-April ● May-October)