Estimation of Additive Genetic Variance of Reproduction Traits in Austrian Simmental

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Abstract

Heritabilities and genetic correlations were estimated in first, second and all parities for dystocia and stillbirth for the Austrian Simmental population. Method $\Re$ was applied to estimate the (co)variance components with a linear animal model. In total, 1,399,990 calving records were analyzed. There were 363,097 first- and 274,486 second-parity records. The largest pedigree file consisted of 1,842,324 animals. Both traits were recorded categorically, 4 and 2 classes for calving ease and stillbirth, respectively. The model contained direct and maternal genetic effects. For calving ease, estimates of heritability for direct genetic effects were (in %), 9.26, 2.52 and 4.22 for first, second and all parities, respectively. For maternal effects, the estimated heritabilities were smaller, 4.49, 2.40 and 1.99, respectively. Genetic correlations between direct and maternal effects were negative as expected, -0.26, -0.52 and -0.35, respectively. Estimated heritabilities of both direct and maternal effects were much lower for stillbirth. For direct effects, heritabilities were, in %, 1.73, 0.47 and 0.57, respectively; for maternal effects, estimations were 1.54, 0.37 and 0.56, respectively. Finally, genetic correlations were -0.04, -0.30 and -0.06, respectively. In consequence, heritabilities were clearly heterogeneous over parities and this should be taken into account in the evaluation model.

Introduction

In dual purpose breed as Austrian Simmental, dystocia and stillbirth rates affect the profitability of herds. Philipsson (1976a) or Philipsson et al. (1979) summarized the economical consequences of dystocia and stillbirth. Major costs associated with these traits result from loss of calf (Philipsson, 1976c). Groen et al. (1998) insisted also on the impact on animal welfare and consumer acceptance. Therefore, both traits were included in the total merit index implemented in Austria (Miesenberger et al., 1998).

As a consequence of a less favorable ratio between calf size and pelvic dimensions of the dam, frequencies of dystocia and stillbirth were reported to be higher in first parity than in later parities (e.g., Carnier et al., 2000; Meyer et al., 2001). Carnier et al. (2000) concluded that for calving ease heritabilities were heterogeneous between heifers and cows but that genetic correlations in different parities were very high.

The objectives of this study were to estimate variance components for calving ease and stillbirth in Austrian Simmental 1) with the official model considering all parities together; 2) only for first calving records and 3) for second calving records.

Material and Methods

Data

The data used for this study was provided by the Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter (ZAR). It consisted of 1,409,520 calving ease and stillbirth records, recorded from begin 1992 through end 1999. Calving ease was recorded in five classes: 1 for easy calving (no help necessary), 2 for normal calving (help of one person necessary), 3 for difficult calving, 4 for caesarean section and 5 for embryotomy. Classes 4 and 5 were joined for data analysis. Stillbirth was recorded as 1 if the calf was still alive 48 hours after parturition, 5 if the calf was born dead and 6 if the calf died within 48 hours after calving. Classes 5 and 6 were also joined for analysis so that stillbirth was a all-or-none trait: dead or alive.

The following edits were applied to the data: age at first calving had to be between 21 and 40 months inclusive and age at second calving had to be comprised between 31 and 55 months inclusive. Application of these edits resulted in deletion of 9530 records. Stillbirth was not recorded in Tyrol, therefore data from this region were discarded for analysis of stillbirth. Original pedigree file consisted of 2,092,227 Simmentals.

Model

The official Austrian genetic evaluation model was used in this study:

$$\mathbf{y}=\mathbf{X_h h}+\mathbf{X_m m}+\mathbf{X_s s}+\mathbf{X_a a}+\mathbf{Z_p p}+\mathbf{Z_d d}+\mathbf{Z_i i}+\mathbf{e} \qquad [1]$$

where **y** = vector of insemination results; $\mathbf{X_h}$, $\mathbf{X_m}$, $\mathbf{X_s}$ and $\mathbf{X_a}$ = known matrices relating insemination results to fixed effects; **h** = vector of herd by year of calving fixed effects; **m** = vector of month of calving fixed effects; **s** = vector of fixed effects of sex of calf; **a** = vector of fixed effects defined for age at calving (20 groups for heifers from 21 to 40 months of age; 25 groups second calving from 31 months to 55 months of age; after second calving, 1 group per parity); $\mathbf{Z_p}$ = known matrix relating insemination results to permanent environment of the cow random effects; **p** = vector of permanent environment of the inseminated cow random effects; $\mathbf{Z_d}$ = known matrix relating insemination results to additive genetic direct effects (calf); **d** = vector of genetic direct effects; $\mathbf{Z_i}$ = known matrix relating insemination results to additive genetic indirect effects (maternal or cow effects); **i** = vector of genetic indirect effects and **e** = vector of residuals.

The (co)variance structure was:

$$\mathrm{Var}\begin{bmatrix}\mathbf{p}\\ \mathbf{d}\\ \mathbf{i}\end{bmatrix}=\begin{bmatrix}\mathbf{I}\sigma^2_{\mathbf{p}} & \mathbf{0} & \mathbf{0}\\ \mathbf{0} & \mathbf{A}\sigma^2_{\mathbf{d}} & \mathbf{A}\sigma_{\mathbf{di}}\\ \mathbf{0} & \mathbf{A}\sigma_{\mathbf{di}} & \mathbf{A}\sigma^2_{\mathbf{i}}\end{bmatrix} \qquad [2]$$

where $\sigma^2_{\mathbf{p}}$ is the permanent environment variance, $\sigma^2_{\mathbf{d}}$ is the additive genetic direct variance associated with the calf effect, $\sigma^2_{\mathbf{i}}$ is the additive genetic indirect variance associated with the maternal or cow effect, and $\sigma_{\mathbf{di}}$ is the additive genetic covariance between the calf effect and the maternal effect, **I** is an identity matrix and **A** is the additive relationship matrix.

For analysis of first or second calving records separately no permanent environment was included in the model.

Method

No threshold model was implemented because of software availability (especially for large data sets). Estimation of variance components was based on Method $\Re$ for (co)variance estimation as described in Druet et al. (2001). Method $\Re$ was chosen because it offered the possibility to analyse the whole population and because use of large data sets can be recommended when heritability is low or when frequencies (as stillbirth) are low. Convergence criterion for estimation of full and partial solutions with PCG was $1*10^{-12}$ for calving ease and $1*10^{-16}$ for stillbirth. Ten independent random samples were analysed.

Results

Data description

Data consisted of 1,399,990, 363,097 and 274,486 calving records across all parities, for first calving and for second calving, respectively. In consequence of discarding Tyrol records for stillbirth, data sets were reduced to 1,265,681, 320,201 and 245,822 stillbirth records respectively.

Number of caesarean sections and embryotomy were low, under 0.5 %. Stillbirth rate was very low compared to US Holstein where, in 1996, it was up to 13.2 and 6.6 % in primiparous and multiparous cows respectively (Meyer et al., 2001). Martinez et al. (1983) found similar rates: 10.5 % and 5.6 % of stillbirth for primiparous and multiparous cows respectively.

Table 1. Frequencies (in %) of dystocia and stillbirth

Parity	Calving ease score				Stillbirth
	1	2	3	4	
1	28.6	62.7	8.3	0.4	4.1
2	34.7	62.0	3.2	0.1	2.2
3	34.6	62.4	2.9	0.1	2.1
4	34.9	62.1	2.9	0.1	2.2
5	34.7	62.2	3.0	0.1	2.3
6+	34.9	61.9	3.1	0.1	2.7

Normal calving was the most frequent, around 62 % across all parities. As expected, difficult calving and stillbirth were more frequent in first parity (e.g., Philipsson, 1976a; 1976b; Carnier et al., 2000) than in later parities (see Table 1). In first parity, difficult calving and caesarean (including embryotomy) were more than twice as frequent as in later parities, indicating large differences of expression of the trait. In later parities, frequencies of easy, normal and difficult calving appeared to remain constant. Stillbirth incidence in first parity was nearly two times more frequent than in later parities. However, there was a slight increase of stillbirth in late parities probably due to the cows getting less fit. For instance, weak labour is reported to be more frequent in older cows (Meijering, 1984).

Variance components

Fixed and random effect classes for calving ease in different analyses are given in Table 2. After editing and deleting redundant information, pedigree files included up to 2,059,471 animals. For stillbirth, these numbers were slightly reduced due to elimination of records from Tyrol.

Table 2. Number of levels of different effects in the three models for stillbirth analysis

Effect	1st calving	2nd calving	All records
Herd*year	104275	99125	127361
Sex	6[1]	6	6
Month	12	12	12
Age at calving	20	25	61
Permanent env.	0	0	521103
Direct effect	925086	764668	1842324
Maternal effect	925086	764668	1842324

[1]sex: 1 = male; 2 = female; 3 = twins male/male; 4 = twins male/female; 5 = twins female/female; 6 =triplets.

Results for variance components for calving ease are given in Table 3. Heritability presented heterogeneity across parities. At first calving, as expected and in agreement with Meijering (1984) or Carnier et al. (2000), heritability was higher than in later parities: for direct effect, heritability was more than 3 times greater than in second parity and for maternal effect, heritability was nearly as twice as large as in second parity. This may be explained by the fact that at first calving, the feto-pelvic ratio was less favourable than in later parities (Philipsson, 1976b; Meijering, 1984) and therefore, genes responsible for size of the calf and for pelvic dimensions of the dam had more importance. Because of higher heritability at first calving, record of first calvers would lead to more precise evaluation of direct and maternal genetic effects. For evaluation of direct genetic effect, more calvings of older cows should be recorded in order to obtain the same accuracy as would be achieved by testing heifers (Meijering, 1984). But this practise would be too risky. Testing of maternal genetic effects would anyway lead to get first records of heifers and later of cows.

Genetic correlations between first and second calving should be estimated to decide whether or not they should be considered as the same trait or not and to take decision on the best evaluation method.

Table 3. Variances expressed in % of total variance and genetic correlation for calving ease

Parity	Perm. env.	Additive genetic		Genetic correlation
		Direct	Maternal	
1st	/	9.26	4.49	-0.26
2nd	/	2.52	2.40	-0.52
All	1.74	4.22	1.99	-0.35

Direct genetic effects were twice as high as maternal effect in first calving analysis and in all calvings analysis.

Genetic correlation between direct and maternal effects was negative as found in literature indicating possibility of getting a negative response on maternal effects if selection is based at reducing problems consequent to calf size. However, the magnitude of the correlation left space for selection for both traits simultaneously as mentioned by Thompson et al. (1981). In the total merit index, direct calving ease is positively correlated with growth which is an important economic component in dual purpose breed. Therefore, selection for growth in animal results in negative trend for direct effects but also in a positive trend for maternal effects. This antagonistic relation is basically a complicating factor for optimising the selection process. Even if some bulls may be desirable for both traits (Thompson et al., 1981) or if selection for only direct effect do not produce any significant change in dystocia as a maternal trait, response to selection for both traits will be limited in comparison with selection for only one of those traits.

Estimates of (co)variances were especially low for stillbirth (Table 4): under 2 % and 1 % for both direct and maternal genetic effects in primiparous and multiparous cows, respectively. With such a low frequency of stillbirth and a low heritability, stillbirth analysis might benefit from a threshold analysis. Some studies found such low results too, even with higher frequencies of stillbirth, as in Martinez et al. (1983). They estimated heritability to be 0.9 % for all parities in US Holstein cows while incidence of stillbirth was around 6.6 %. Again in Holstein (where incidence is supposed to be higher), Meijering and Postma (1985) found out even smaller estimates: 0.3 % for direct genetic effect over all parities. Results were in range with those reviewed by Meijering (1984) and some other studies on Holstein cows estimated higher heritabilities but stillbirth rate was twice or more as in the Austrian Simmental population. In Simmental, Hagger and Hofer (1990) found heritability of 1 % for direct genetic effect which was very close to those estimated here.

Table 4. Variances expressed in % of total variance and genetic correlation for stillbirth

Parity	Perm. env.	Additive genetic		Genetic correlation
		direct	Maternal	
1st	/	1.73	1.54	-0.04
2nd	/	0.47	0.37	-0.30
All	0.58	0.57	0.56	-0.06

At first calving, heritability was three times larger than for second calving. At second calving, heritability was as low as 0.50 % for both direct and maternal genetic effects, leaving few space for selection. Higher heritability in primiparous cows were also noted by Meijering (1984). No clear difference of amplitude of heritability between direct and maternal effect was found. Genetic correlation at first calving was slightly negative, smaller in magnitude than expected. However, this correlation might be difficult to estimate since all calf that died at birth had no change to express their maternal ability for stillbirth.

Conclusions

Both for calving ease and stillbirth, heritabilities presented clearly heterogeneity across parities. Genetic correlations between parities might be required to decide whether or not different parities should be treated as different traits.

Heritabilities for stillbirth were extremely low, especially in later parities. Therefore, stillbirth evaluation might benefit from information of correlated traits as calving ease. Again, genetic correlations between calving ease and stillbirth would be required to implement a bi-variate evaluation model.

Acknowledgements

T. Druet who is Research Fellow of the National Fund for Scientific Research, Belgium and N. Gengler who is Research Associate of the National Fund for Scientific Research, Belgium, want to acknowledge their financial support.

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