# Evaluating Maternal Traits in the Austrian Murboden Cattle: Genetic Parameters and Inbreeding Depression

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## Abstract

The endangered Murboden cattle breed is local to Styria, a province in Austria. After having successfully followed a compulsory mating advice program, the effective population size of the Murboden has grown to proportions that may allow genetic selection. Murboden farmers are interested in using genetic selection to improve calving performance and relevant weight traits. Calving is a key event on any cattle farm, with both economic and animal welfare consequences when complications arise. Although mostly reported in highly selected breeds, problematic calving performance is also a worry to the unselected dual-purpose Murboden. This study presents genetic parameter estimates for calving ease, birth weight and 200-day weight in Murboden cattle. Furthermore, a potential effect of inbreeding on the breeds' phenotypic performance is evaluated. Results show a moderate direct and maternal heritability (0.17±0.04; 0.07±0.02) and a significant negative direct-maternal genetic correlation for calving ease (-0.44±0.10). Heritabilities of birth weight and 200-day weight, respectively, are considerable (direct: 0.49±0.05; 0.31±0.03, maternal: 0.11±0.03; 0.17±0.02) with negative direct-maternal genetic correlations (-0.57±0.05; -0.37±0.13). A significant effect of dam inbreeding was detected on calving ease whereas animal inbreeding significantly affects birth weight and 200-day weight. By categorizing the inbreeding coefficients of the calf and dam in six ascending classes it was shown that performance worsens as inbreeding coefficients become larger. Results of this study reveal significant genetic variation in calving performance and weight traits of the Murboden breed which allows for genetic selection. The detected inbreeding depression on all traits suggests a double advantage of a future extension to the mating advice program which combines restriction of inbreeding with selection on estimated breeding values.

## 1. Introduction

For a number of years, Austrian farmers of the local Murboden cattle breed have been following a strict compulsory mating advice programme which is supported by state subsidies and organised by the Austrian Association for Rare Endangered Breeds (ÖNGENE 2008). By restricting the co-ancestry between mates, inbreeding coefficients of the next generation are kept low which consequently ensures a decrease in inbreeding rate and an increase in effective population size. Success of the programme is demonstrated by the fact that the effective population size of the Murboden population has grown considerably. Actually, the population has grown to such a size that, alongside mating on low co-ancestry, the estimation of breeding values and thus genetic selection has become a possibility.

Murboden farmers mainly express interest for genetically improving calving performance and weight traits in their breed, given that it is mostly kept for beef (ÖNGENE, 2008). Calving is a key event on any cattle farm with consequences of poor calving extending from high veterinary costs to reduced performance, compromised animal welfare and even the loss of individuals. High prevalence of difficult calving is identified in beef and dairy cattle breeds worldwide (Ramirez-Valverde *et al.*, 2001). This study however shows that calving problems are not limited to large cattle breeds which undergo intensive selection. 200-day weight is an important trait for the breed ad Murboden beef is currently sold as a popular and exclusive product in a large Austrian supermarket chain. A first attempt to estimate genetic parameters for calving ease (CE) in the Murboden was carried out by Manatrinon *et al.* (2009). However, at this time there were only a restricted number of records available. This study attempts to estimate the genetic parameters for calving performance for a second time, in addition to parameters for birth weight (BW) and 200-day weight, using the current much larger dataset. Additionally, this study considers a potential influence of inbreeding on the performance of the Murboden.

## 2. Material and Methods

### *2.1. Data description*

Murboden calving and weight records were provided by ZuchtData EDV-Dienstleistungen GmbH, Vienna, Austria and collected between 2000 and 2013. Data contained records from 737 herds, offspring of 845 sires and 7267 dams and grand offspring of in total 414 maternal grandsires (MGS). Data were checked on inconsistencies and apparent errors in SAS v9.1 (SAS Institute, 2006) and restricted to single births only, representing parities 1-10. Contemporary groups were restricted to a minimum number of 3 records/sire, 3 records/MGS and 3 records/herd*year. Records showing a gestation length of >299 days were discarded. Age of dam at calving ranged from a minimum of 16 months (1$^{st}$ parity) to a maximum of 162 months (10$^{th}$ parity). CE was recorded on a 5 grade scale, ascending in difficulty. The five CE categories were defined as: 1. Easy; 2. Normal; 3. Difficult; 4. Caesarean and 5. Embryotomy. As the last category, embryotomy, is likely caused by different genetic factors than the remaining categories, this category is dismissed from the study. Birth weight was farmer recorded and 200-day weight was derived from weights recorded between 90 and 280 days of age. The final dataset consisted of 25,154 records, originating from 500 herds and representing 450 sires, 313 MGS and 5,919 dams, with an accompanying pedigree of ~ 260,000 individuals (10 generations deep). In total, 20% of the calving records originated from first parity calvings. Table 1 presents the CE frequencies in the edited dataset whereas Table 2 presents the weight trait means.

**Table 1.** Calving ease frequencies.

| | Frequencies | | |
|---|---|---|---|
| | Total | 1$^{st}$ parity | 2$^{nd}$–10$^{th}$ parity |
| 1. Easy | 70.38% | 57.16% | 74.51% |
| 2. Normal | 23.94% | 31.20% | 21.44% |
| 3. Difficult | 5.43% | 10.91% | 3.94% |
| 4. Caesarean | 0.25% | 0.73% | 0.11% |

**Table 2.** Weight means.

| | Mean (kg) ± std |
|---|---|
| Birth weight | 40.63 ± 4.65 |
| 200-day weight | 231.43 ± 60.18 |

### *2.2 Statistical analyses and inbreeding statistics*

CE, BW and 200-weight are all maternal traits, which means that the phenotype is affected by both the calf (direct effect, ease of birth, calf birth weight, calf 200-day weight) and the dam (maternal effect, ease of calving, dam effect on BW, dam effect on 200-weight). Both the direct and maternal effect consists of an environmental and genetic component. The direct-maternal genetic covariance represents the genetic relationship between an animal's direct effect (as a calf) and maternal effect (as a dam, when female). Variance components were estimated with linear univariate animal models using ASREML (Gilmour *et al.*, 2006).

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z}_d\mathbf{a}_d + \mathbf{Z}_m\mathbf{a}_m + \mathbf{Z}_{hy}\mathbf{h}_{hy} + \mathbf{Z}_{pe}\mathbf{p}_{pe} + \mathbf{e}_i$$

where, $\mathbf{y}$ is a vector representing the observations for CE (transformed to mean z-values on the underlying normal distribution), BW or 200-W; $\mathbf{X}$, $\mathbf{Z}_d$, $\mathbf{Z}_m$ , $\mathbf{Z}_{hy}$ and $\mathbf{Z}_{pe}$ are known incidence matrices for non-genetic, and direct and maternal genetic, herd-year and permanent environmental effects, respectively; $\mathbf{b}$ is a vector of non-genetic effects, $\mathbf{a}_d$ is a vector of the random direct additive-genetic effects of the calf, $\mathbf{a}_m$ is a vector of the random maternal additive-genetic effects of the dam, $\mathbf{h}_{hy}$ is a vector of random herd-year effects, $\mathbf{p}_{pe}$ is a vector of permanent environmental effects and $\mathbf{e}$ is a vector of residuals. Vectors $\mathbf{a}_d$ and $\mathbf{a}_m$ were assumed to follow a multivariate normal distribution, with MVN(0, $\mathbf{G} = \mathbf{G_0} \otimes \mathbf{A}$) where,

$\mathbf{G_0}$ was a 2 x 2 direct-maternal variance-covariance matrix, $\otimes$ is the Kroneck product of matrices, and **A** was the relationship matrix. $\mathbf{e_i}$ were assumed to be MVN(0, $\mathbf{R}_e \sigma_e^2$), where $\mathbf{R}_e$ denotes the residual 2 x 2 variance covariance matrix and $\sigma^2_e$ is the residual variance. Non-genetic effects in the CE and BW model included: sex of the calf*parity interaction, year*month of calving interaction; age of the dam (months)*parity interaction, herd, and the interaction of herd*year of calving treated as a random factor in addition to a random permanent environment term. Non-genetic fixed effects in the 200-W model included: parity, Sex*Age at recording, quadratic effect of Age at recording, year*month of recording and herd whereas random terms equalled the CE and BW model. Table 3 shows the inbreeding coefficients of calves, dams and sires in the edited dataset which were calculated by RelaX2 (Strandén and Vuori, 2006), ranging from 0 to 0.298. All inbreeding coefficients, from calves, sires and dams, were fitted in the model as a fixed effect to evaluate their effect on the phenotype. Figure 1 shows the decreasing inbreeding rate and increasing effective population size (Ne) of the Murboden population in the last decade.

**Table 3.** Inbreeding level of calves, dams and sires.

| | Proportion of individuals | | |
|---|---|---|---|
| Inbreeding coeff.(F) | Calves | Dams | Sires |
| F = 0 | 25.04% | 45.87% | 41.56% |
| 0 < F < 0.0625 | 72.90% | 51.62% | 56.31% |
| 0.0625 ≤ F < 0.125 | 1.33% | 2.50% | 1.24% |
| 0.125 ≤ F < 0.1875 | 0.61% | 0.84% | 0.88% |
| 0.1875 ≤ F < 0.25 | 0.48% | 0.47% | 0.36% |
| F ≥ 0.25 | 0.57% | 0.45% | 0.36% |
| Mean F (STD) | 0.013 (0.03) | 0.0097 (0.03) | 0.0088 (0.02) |
| Min ; Max | 0 ; 0.375 | 0 ; 0.289 | 0 ; 0.25 |

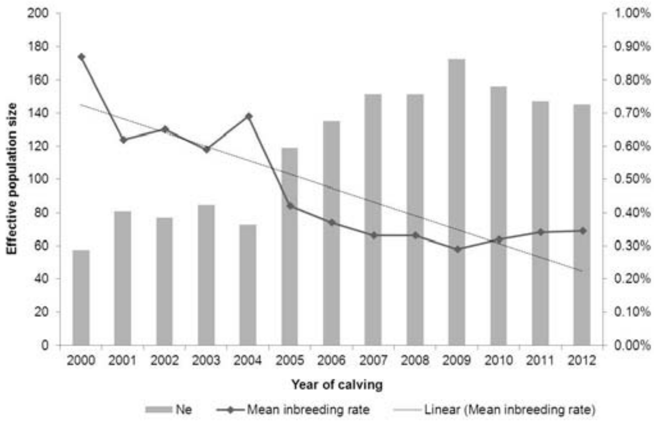


**Figure 1.** Diagrammatic representation of the mean inbreeding rate and effective population size per year of calving.

## 3. Results and Discussion

### *3.1 Genetic parameters*

Table 3 presents the estimated genetic parameters for CE. Both the direct and the maternal CE heritability are estimated relatively high compared to for example the Holstein-Friesian (8% direct, 3% maternal, Eaglen *et al.*, 2012). This is positive as genetic progress will be faster when the trait is selected upon. The heritabilities are however not out of range of estimates published in literature, especially for beef cattle (Ramirez-Valverde *et al.*, 2001), which gives confidence in the analyses. Furthermore, the genetic direct-maternal correlation for CE is estimated at approximately -0.44. A negative direct-maternal genetic correlation is commonly found in CE and does cause some concerns for selection. It primarily means that selection on solely direct or maternal breeding values are discouraged as total response to selection could be lower or in the opposite direction as intended (Eaglen *et al.*, 2012). Instead, selection on a total breeding value i.e. direct+maternal is more sensible. Comparison of the results from this study with the parameters estimated by Manatrinon *et al.* (2009) demonstrates the importance of increasing datasets for the estimation of, in particular maternal variances and covariances, for calf performance traits given their relatively low heritabilities.

The heritabilities for BW and 200-weight are presented in Table 4 and 5. They are considerable, conform literature estimates on weight traits (Koots *et al.*, 1994). The maternal heritability on weight traits shows the significant genetic influence of the dam on both BW and 200- weight. The direct-maternal genetic correlations of BW and 200-day weight are, again, moderate and negative placing emphasis on an appropriate inclusion of these traits in any future selection indices,

**Table 4.** Estimated heritabilities (diagonal) and genetic correlations (off-diagonal) between direct and maternal calving ease (CE).

| | CEd | CEm |
|---|---|---|
| Calving Ease direct (CEd) | **0.18 ±0.04*** | |
| Calving Ease maternal (CEm) | -0.41±0.12* | **0.11 ±0.02*** |

* P<0.05

**Table 5.** Estimated heritabilities (diagonal) and genetic correlations (off-diagonal) between direct and maternal birth weight (BW).

| | BWd | BWm |
|---|---|---|
| Birth weight direct (BWd) | **0.49 ±0.05*** | |
| Birth weight maternal (BWm) | -0.57±0.05* | **0.31 ±0.03*** |

* P<0.05

**Table 5.** Estimated heritabilities (diagonal) and genetic correlations (off-diagonal) between direct and maternal 200-day weight (200-w)

| | 200-wd | 200-wm |
|---|---|---|
| 200-day weight direct 200-wd) | **0.11 ± 0.03*** | |
| 200-day weight maternal (200-wm) | -0.37±0.13* | **0.17 ±0.02*** |

* P<0.05

*3.2 Inbreeding depression*

Reduction of phenotypic performance due to inbreeding is termed inbreeding depression. In this study we have evaluated inbreeding depression in direct and maternal CE, BW and 200-weight.

After having detected a significant effect of dam inbreeding on CE, fitted as a covariate we categorized the inbreeding coefficients into 6 categories according to Table 6 and estimated a mean CE score by category of inbreeding using the PREDICT statement in ASREML. Table 6 shows a significant increase in CE score as inbreeding coefficients increase. 1% increase in dam inbreeding is associated with an increase of 0.55% in probability for a difficult calving. Or, individuals with an inbreeding coefficient between 6.25% and 12.5% show 5.5% more difficult calvings compared to non-inbred individuals, this percentage increases to 10.28% for individuals with inbreeding coefficients between 12.5% and 18.75%.

For both BW and 200-day weight, the dam inbreeding coefficient proved not to be significant in the model whereas a significant effect was detected for the calf, or animal, inbreeding coefficient. Subsequently, parallel to CE, we categorized the calf inbreeding coefficients into 5 categories according to Table 7 and estimated the mean BW and 200-weight by category of inbreeding. Calf inbreeding showed to significantly reduce BW when comparing mean BW of no inbred calves with mean BW of calves having an inbreeding coefficient >0.1875. 1% increase in animal (calf) inbreeding coefficient is associated with a reduction of 70 grams in BW. Non inbred animals compared to animals inbred >18.75% have a significantly reduced 200-day weight (Table 7). 1% increase in animal (calf) inbreeding coefficient is associated with a reduction of 0.975 grams in 200-day weight.

Studies that attempt to quantify inbreeding depression on calving performance and weight traits in beef cattle are rare and studies in dairy cattle are very limited to the Holstein-Friesian breed (McParland *et al.,* 2007; Adamec *et al.,* 1982). However, the effect found in this study on CE Murboden breed is larger than reported for the Holstein-Friesian breed (McParland *et al.,* 2007; Adamec *et al.,* 1982) and similar to the effect found in first parity Angus cattle (McParland *et al.,* 2008). Calf inbreeding and sire inbreeding did not have a significant effect on either trait which is supported by literature on calf inbreeding effects on CE (McParland *et al.,* 2007, 2008). Calf, or animal, inbreeding effects on weight traits detected in this study are comparable to the inbreeding depression reported by Carolino *et al.* (2008). The moderate inbreeding depression in the weight traits compared to CE confirms the tendency of inbreeding depression to affect functional traits more than production traits.

**Table 6.** Mean CE score per dam inbreeding category.

| Inbreeding Category | Mean Calving Ease Score±[2] |
|---|---|
| 1. ($F^1 = 0$) | $1.28 \pm 0.046^a$ |
| 2. ($0 < F < 0.0625$) | $1.32 \pm 0.046^b$ |
| 3. ($0.0625 \leq F < 0.125$) | $1.39 \pm 0.057^c$ |
| 4. ($0.125 \leq F < 0.1875$) | $1.47 \pm 0.068^c$ |
| 5. ($0.1875 \leq F < 0.25$) | $1.41 \pm 0.266$ |
| 6. ($F \geq 0.25$) | $1.25 \pm 0.126$ |

[1] F=inbreeding coefficient;
[2] Standard error of the mean; [a,b]= P<0.05

**Table 7.** Mean weights per animal inbreeding category.

| Inbreeding Category | Mean BW ±[2] | Mean 200-weight ±[2] |
|---|---|---|
| 1. ($F^1 = 0$) | $41.97 \pm 0.17^a$ | $239.19 \pm 2.51^a$ |
| 2. ($0 < F < 0.0625$) | $41.82 \pm 0.18^a$ | $237.13 \pm 2.42^a$ |
| 3. ($0.0625 \leq F < 0.125$) | $41.33 \pm 0.36^b$ | $233.36 \pm 3.95^a$ |
| 4. ($0.125 \leq F < 0.1875$) | $41.74 \pm 0.50^a$ | $224.55 \pm 4.47^b$ |
| 5. $F \geq 0.1875$ | $40.67 \pm 0.59^c$ | $232.42 \pm 5.42^{a,b}$ |

[1] F=inbreeding coefficient;
[2] Standard error of the mean; [a,b]= P<0.05

## 4. Conclusions

Calving performance in the Murboden is currently worrying. However, this study demonstrated that heritabilities of calving ease are considerable, as are the heritabilities of birth weight and 200-day weight. Hence, genetic progress will be relatively fast assuming the publication of estimated breeding values and the correct implementation of these. Dam inbreeding significantly affects calving ease and is likely to have been a contributor to the current high prevalence of difficult calvings. Calf inbreeding affects birth weight and 200-day weight. Implementation of mating advice programs that simultaneously restrict inbreeding rate and increase the genetic level of the next generation such as ‘Optimum Contribution Selection’ are therefore likely to have a double positive effect on the future performance of the Murboden breed.

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