# Estimation of Phenotypic and Genetic Parameters and Effect of Some Factors on Birth Weight in Brown Swiss Calves in Turkey Using MTDFREML

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**Abstract:** The objective of this study was therefore to assess the influence of the age of dam, sex of calf, birth type, season and year of birth of the calf on birth weight and to estimate phenotypic and genetic parameters for birth weight for Brown Swiss cattle in Turkey using Multiple Trait Derivative Free Restricted Maximum Likelihood (MTDFREML). A total of 1437 calf birth weight records of Brown Swiss cows raised at Altınova State Farm in Konya Province were used for estimation of phenotypic and genetic parameters for calf birth weight. Phenotypic and genetic parameters were estimated by MTDFREML programme using a Single Trait Animal Model (STAM). The model included additive direct effect, maternal permanent environment and errors as random effects, birth type, sex of calf, season of birth, year of birth and age of dam as fixed effects. Calf birth weight least square mean was determined as $39.20 \pm 2.42$ kg, the direct heritability ($h^2_a$), maternal heritability ($h^2_m$) and the repeatability (r) of calf birth weight were calculated as $0.12 \pm 0.06$, $0.15 \pm 0.006$ and $0.12 \pm 0.06$, respectively. The breeding value of dam, sire and calves were calculated. Minimum and maximum breeding value of calves and its accuracy were $-1.037 \pm 0.66$, $0.979 \pm 0.68$, $0.41$ and $0.45$, respectively. The effect of birth type, sex of calf, season of birth, year of birth and age of dam on calf birth weight were significant ($P<0.01$).

**Key Words:** Birth weight, Brown Swiss, Breeding value, Repeatability, Heritability

## Introduction

One of the important breed characteristics in cattle breeding is calf birth weight. Since birth weight is considered as an initial reference point with regard to subsequent development of individual as well as other characteristics, this trait is of critical importance to cattle industry. It is demonstrated that calves having too small live weight at birth may lack vigor and tolerance to external condition, whereas various degrees of dystocia may occur in calves that are too large at birth. Besides these extremes, heifers having high birth weight grow fast and produce more beef (Bakır et al., 2004). These heifers also can reach mature weight to produce offspring at an earlier age and subsequently, milk production as described from Ilaslan *et al.,*(1978). In addition to these statements, some researchers were demonstrated similar evidence (Kaygısız et al., 1995; Kaygısız, 1998; Akbulut et al., 1998; Akbulut et al., 2001).

A study of birth weights as a measure of the prospective value of the calf is therefore justified since it is one of the first measures that can be obtained and also one of the easiest to record with reasonable accuracy (Dawson, 1965).

Growth in beef cattle has been extensively studied in part because of the economic value of growth in this type of farmed livestock. However, growth in dairy cattle has not been studied so extensively, particularly the genetic component of growth. Groen and Vos (1995) estimated the heritability of growth at different stages prior to first calving in Holstein heifers, and Korver et al., (1991) estimated genetic parameters for feed intake and feed efficiency in growing Holstein heifers. Demeke et al., (2003) estimated heritabilities for BW at various stages of life for a range of European and indigenous breeds and their crosses in Ethiopia (Coffey, 2006).

Genetic selection in dairy cattle is applied to traits that are measured during the animal's productive life, mostly those recorded during early productive life as genetic evaluations are best calculated from unbiased, early data. Consequently, much genetic research on correlated responses has focused on traits that change after lactation has started. For example, Pryce et al., (1999) showed that selection for yield would result in a decline in fertility and an increase in mastitis and lameness, as the genetic correlation between yield and these traits is unfavorable (Coffey, 2006). The practice of calving dairy heifers for the first time at 24 months of age has been adopted as a result of research and extension demonstrating the economic benefits Hoffman and Funk (1992).

In order to avoid any detrimental effects and negative physiological activities of animals, the animals should be used as possible as early age to produce maximum yield in the later yields.

The objective of this study was therefore to assess the influence of the age of dam, sex of calf, birth type, season and year of birth of the calf on birth weight and to estimate phenotypic and genetic parameters for birth weight for Brown Swiss cattle in Turkey using MTDFREML.


## Material and Method

A total of 1437 birth weight records of Brown Swiss calves raised in the intensive conditions at the Altınova State Farm in Konya Province. Records covered the period from 1993 to 1998. The 1437 calves, 618 dams and 42 sires constituted pedigree data. Data were analyzed with a derivative-free algorithm Smith and Graser (1986) using MTDFREML. To ensure global convergence, the algorithm by Boldman et al., (1995) was restarted with estimates until the log likelihood did not change at the fourth decimal. The solutions given are from the final round of iteration. A maternal permanent environmental effect was included to account for repeated measures. Data were analysed by least squares techniques using the general linear models procedure of Harvey (1987). The differences between the factor levels were determined using the Duncan multiple comparison test (Düzgüneş, 1993). Experiment was carried out according to Selcuk University Faculty of Agriculture guidelines.

The full model in the analysis is included the fixed effects of birth type (1 and 2), sex of calf (1 and 2), season of birth (1, 2, 3 and 4), year of birth (1993, 1994, 1995, 1996, 1997 and 1998), age of dams (2, 3, 4, 5, 6, 7 and 8) and the random effects of individuals and errors.

Variance components were estimated using the following animal model:

$$Y = X\beta + Za + Wm + Sp + e$$

where;

Y = a vector of the observations,

β = a vector of fixed effects (birth type = 1(single) and 2 (twin); sex of calf = 1 (male) and 2 female); season of birth = 1 (spring), 2 (summer), 3 (autumn) and 4 (winter); year of birth = 1993, 1994, 1995, 1996, 1997 and 1998)

a = a vector of animal direct genetic effects

m = a vector of random maternal genetic effects

p = a random vector of maternal permanent environmental effects

e = a vector of random error

To estimate heritability ($h^2$) and repeatability (r) the following equation was used:

$$h^2 = \sigma_a^2 / (\sigma_a^2 + \sigma_m^2 + \sigma_{am} + \sigma_p^2 + \sigma_e^2)$$

$$r = \sigma_a^2 + \sigma_p^2 / (\sigma_a^2 + \sigma_m^2 + \sigma_{am} + \sigma_p^2 + \sigma_e^2)$$

The mixed model equations (MME) for the best linear unbiased estimator (BLUE) of estimable functions of **b** and for the best linear unbiased prediction (BLUP) of **a, m** and **p** in matrix notation were as follows:

$$\begin{vmatrix} X'X & X'Z & X'W & X'S \\ Z'X & Z'Z+A^{-1}\alpha_1 & Z'W+A^{-1}\alpha_2 & Z'S \\ W'X & W'Z+A^{-1}\alpha_2 & W'W+A^{-1}\alpha_3 & W'S \\ S'X & S'Z & S'W & S'S+I\alpha_4 \end{vmatrix} \begin{vmatrix} \hat{b} \\ a \\ m \\ p \end{vmatrix} = \begin{vmatrix} X'y \\ Z'y \\ W'y \\ S'y \end{vmatrix}$$

Where $\alpha_1 = \sigma_e^2/\sigma_a^2$, and $\alpha_2 = \sigma_e^2/\sigma_{am}$, $\alpha_3 = \sigma_e^2/\sigma_m^2$ and $\alpha_4 = \sigma_e^2/\sigma_p^2$

## Results and Discussion

Unadjusted mean and standard deviation (SD) for CBW was 39.20 ± 2.42 kg, Table 1. The estimated mean of CBW was higher than those found for beef cattle by Dawson (1965); and also the present mean was lower than those reported for Holstein by Plum (1965). The estimated mean of CBW was similar those found for Brown Swiss by *Yanar* et al., (1999), (38.50) using another herd of Brown Swiss in Turkey. The differences between this informed means can be due to the difference between breeds or some macro environmental conditions.

| Traits | Mean | s.d. | CV % | Estimates | *CBW* |
|---|---|---|---|---|---|
| Calf Birth Weight | 39.20 | 2.42 | 6.19 | **- 2 log L** | *3643.758* |
| **Observations** | | | | $\sigma_a^2$ | *0.54844* |
| No. of records | 1437 | | | $\sigma_m^2$ | *0.69107* |
| No. of cows | 618 | | | $\sigma_{am}$ | *-0.61564* |
| No. of sires | 42 | | | $\sigma_p^2$ | *0.0000716219* |
| No. of dams | 77 | | | $\sigma_e^2$ | *3.98718* |
| Animals in relationship matrix ($A^{-1}$) | 2097 | | | $h_a^2$ | *0.12 ± 0.06* |
| Mixed Model Equations (MME) | 4834 | | | $h_m^2$ | *0.15 ± 0.006* |
| No. of iterations | 35 | | | $r_{am}$ | *-1.00 ± 0.289* |
| | | | | *r* | *0.12± 0.06* |

$\sigma_a^2$ = *Additive genetic variance*, $\sigma_m^2$ = *Maternal genetic variance*, $\sigma_{am}$ = *Maternal genetic covariance*, $\sigma_p^2$ = *Permanent environmental variance*, $\sigma_e^2$ = *Temporary environmental variance*, $h_a^2$= *Direct heritability*, $h_m^2$= *Maternal heritability*, $r_{am}$ = *Direct-maternal genetic correlation* r = *Repeatability*, -2 log L= *log likelihood*

**Table 1.** Estimation of (co)variance components, genetic parameters and data structure, unadjusted mean (kg), standard deviation (s.d.) and coefficient of variation (CV%), number of mixed model equations and number of iterations for Calf Birth Weight (CBW)

The heritability estimates was 0.12 for calf birth weight (Table 1). The heritability estimates found in this study was lower than some informed literature finding as Plum (1965); Ahunu (1997); Burrow (2001); Coffey (2006); Demeke (2003) and some informed literature finding was similar such as Dawson (1965); Demeke (2003); Kaygısız (1998); Bakır et al., (2004).

Repeatability of birth weight estimates (Table 1) was 0.12 in herd. Similarly, the repeatability estimates found in this study was lower than some informed literature finding as Euclides et al., (1991); Ulusan (1992); Bakır et al., (2004) and the repeatability estimates found in this study was bigger than as defined by Bakır and Söğüt (1998). According to this result, It can be said that the genetic variation is low, therefore mass selection will be ineffective in respect of birth weight in this herd. Instead, the regulation of environmental conditions may be recommended.

Table 2 shows the mean calf birth weight and standard deviations, $R^2$ value, total and residual sum of squares of calf birth weight according to birth type, sex of calf, season of birth, year of birth and age of dam. The

effect of birth type, sex of calf, season of birth, year of birth and age of dam on CBW was significant (P<0.01). Single born calves were heavier 2.71 kg than twins born calves and male calves heavier 1.14 kg than female born calves. Calves born in winter had the greatest birth weight and calves born in autumn had the least birth weight. The abundance of the fresh and dry feed in summer and autumn might have resulted in this phenomenon. Year by year, the birth weight decreases steadily but not necessarily linearly. This might be caused by the deterioration of the conditions of the farms and/or increased familiarization within herd. The birth weight increased with the increase of the maternal age. This increase continued up to 6 years then decreased again.

| Birth type | N | LSM ± SD | Year of birth | N | LSM ± SD |
|---|---|---|---|---|---|
| Single (1) | 1331 | 39.57 ± 0.68[a] | 1993 | 216 | 38.81 ± 0.17[a] |
| Twin (2) | 106 | 36.86 ± 0.21[b] | 1994 | 201 | 38.15 ± 0.18[b] |
| **Sex of calf** | | | 1995 | 225 | 38.53 ± 0.17[ab] |
| Female (1) | 669 | 37.64 ± 0.12[a] | 1996 | 269 | 38.27 ± 0.16[b] |
| Male (2) | 768 | 38.78 ± 0.12[b] | 1997 | 223 | 38.06 ± 0.17[b] |
| **Season of birth** | | | 1998 | 303 | 37.46 ± 0.16[c] |
| Spring (1) | 463 | 38.09 ± 0.14[b] | **Age of dam** | | |
| Summer (2) | 349 | 38.28 ± 0.15[ab] | 2 | 304 | 37.10 ± 0.16[c] |
| Autumn (3) | 307 | 37.93 ± 0.15[b] | 3 | 322 | 37.72 ± 0.15[b] |
| Winter (4) | 318 | 38.55 ± 0.15[a] | 4 | 278 | 38.48 ± 0.16[a] |
| | | | 5 | 201 | 38.55 ± 0.17[a] |
| **R² value** | **Residual sum of square** | **Total sum of square** | 6 | 135 | 38.91 ± 0.20[a] |
| 0.237 | 6447.134797 | 8444.475992 | 7 | 83 | 38.30 ± 0.25[ab] |
| | | | 8 | 114 | 38.43 ± 0.22[a] |

[a,b] *Means in a column with different superscripts differ (P <0.01).*

**Table 2.** The least squares means (LSM) and standard deviations (SD), $R^2$ value, total and residual sum of squares of calf birth weight according to birth type, sex of calf, season of birth, year of birth and age of dam

Breeding value for calves, sires and dams ranged from -1.037 and 0.979, -1.130 and 0.884, -1.612 and 1.470, respectively. Its accuracies ranged from 0.41 to 0.45 for CBV's, 0.53 to 0.57 for SBV's and 0.22 to 0.52 for DBV's, respectively (Table 3). Direct-maternal genetic correlation ($r_{am}$) value was found to be -1.00 ± 0.289. This indicates that maternal component must be taken into account in selection.

| | Birth Weight (kg) | | |
|---|---|---|---|
| | **CBV's** | **SBV's** | **DBV's** |
| Minumum | -1.037 ± 0.66 | -1.13 ± 0.63 | -1.612 ± 0.72 |
| Maximum | 0.979 ± 0.68 | 0.884 ± 0.61 | 1.470 ± 0.63 |
| Range | 2.016 | 2.02 | 3.082 |
| Accuracy | 0.41 to 0.45 | 0.53 to 0.57 | 0.22 to 0.52 |

**Table 3.** Range of predicted breeding values of calves (CBV's), sires (SBV's) and dams (DBV's) and their accuracy for birth weight (kg)

If there is a problem in regard to vitality because of low birth weight, a selection can be done for high breeding value in order to increase of vitality. In addition, Table 3 shows that importance of dam, since it gave the higher range of breeding values for birth weight. Thus, selection of dam for the next generation would lead to higher genetic improvement in the herd. Also, Table 3 shows that the accuracy of the estimates of sire breeding value was higher than the accuracy of dam breeding values and calve breeding value, which may be due to the higher number of progeny per sire.

The breeding values (EBV) were estimated according to MTDFREML and the trends in breeding values according to years are presented in Figure 1.
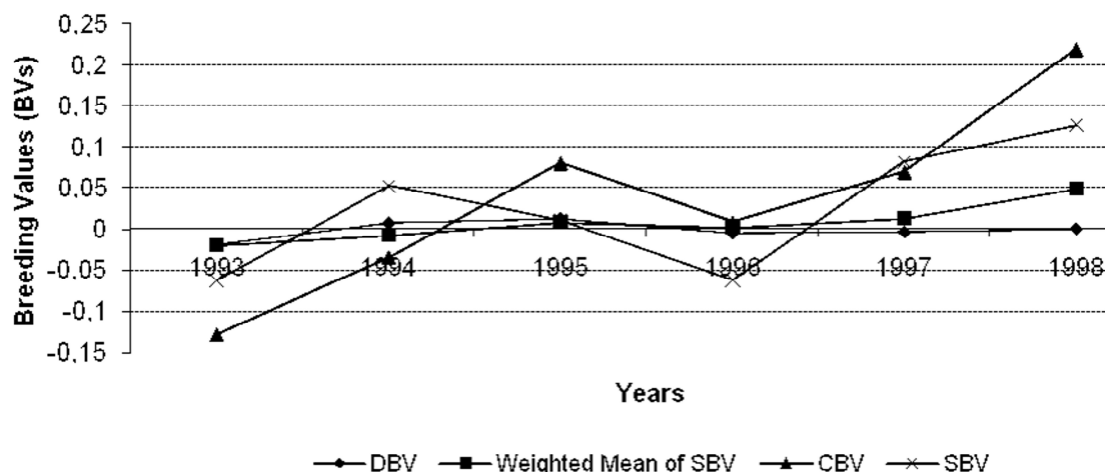
**Figure 1.** Mean breeding values of birth weight for DBV, Weighted Mean of SBV, CBW and SBV according to the years.

According to Figure 1, it can be seen positive trends in breeding value of CBVs and weighted mean of SBVs. However, no positive or negative trends in DBVs have been observed among the years. A selection in the years, the use of bull breeding activity to determine whether the correct choice in selection for weighted mean of SBVs has been calculated. It can be seen that, looking at the values of both weighted mean of SBVs and SBVs in the same years, bulls used in breeding programs are chosen correctly. In this situation, success of selection from 1993 to 1998 has been increased. To obtain high birth weight, animal breeding values should be determined, environmental conditions must be well organized and the selection of animals must be done in a proper manner. From time to time to calculate genetic parameters and selection must be made according to these criteria.

# Acknowledgments

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