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RESEARCH ARTICLE

Estimation of Variance Components and Genetic Parameters for Direct and Maternal Effects on Birth Weight in Brown Swiss Cattle

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ABSTRACT

The purpose of this study was to estimate the variance components and genetic parameters for birth weight in Brown Swiss cattle reared at Malya and Konuklar State Farms, Türkiye. The least square means of birth weight were 39.91±0.005 and 42.26±0.09kg for the calves raised at Malya and Konuklar State Farms, respectively. The effects of calving year, parity and calf sex on birth weight were significant (P<0.05). The effect of calving season on birth weight was highly significant (P<0.01) for Malya State Farm, while it was non-significant for Konuklar State Farm. Direct heritability (h^2_d), maternal heritability (h^2_m), total heritability (h^2_T) and the fraction of variance due to maternal permanent environmental effects (c^2) were 0.09, 0.04, 0.11 and 0.04, respectively for birth weights of the calves raised at Malya State Farms. The corresponding values of birth weight for calves raised at Konuklar State Farm were 0.39, 0.015, 0.29 and 0.018, respectively.

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INTRODUCTION

Brown Swiss cattle are commonly reared for the milk production in Turkey as dairy cattle farms apply all over the world. Although, the main breeding aim of this breed is milk production, male calves are also reared for beef production.

One of the important breed characteristics in cattle breeding is calf birth weight. Same time, birth weight is characterized as growth critter, initially (Akbulut *et al*., 2001). 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. In addition, birth weight is also one of the main criteria for determination of calving difficulty. If birth weight can be estimated, changes dystocia can be decreased even if it is impossible to prevent dystocia completely (Unalan, 2009; Shahzad *et al*., 2010).

Differences in size between calves at birth are sometimes used as an indication of differences between them in vigor, potential growth rate, and mature size. If variations in the size of calves at birth weight are to be considered in selection or mating plans, knowledge of the relative importance of the various sources of this variability can be used for standardizing the non-genetic influences.

It is demonstrated that calves having too small live weight at birth may lack vigor and tolerance to external conditions. Besides these extremes, heifers having high birth weight grow fast and produce more beef (Bakır *et al*., 2004). High correlations between birth weight and first calving age have also been reported (Kaygısız, 1998).

In general, factors affecting birth weight may be grouped into genetic and environmental (Holland and Odge, 1992). Breed, calf sex and genetic abnormalities are considered as genetic factors; and dam age, calving weight of dam, mothering ability, nutritional conditions of dam, litter size, gestation length, calving year, season, geographical region and altitude are considered as environmental factors (Bourdon *et al.,* 1982; Holland and Odge, 1992). In short, the phenotype of an animal's birth weight is the result of the genetic potential and the influence of environment as well as maternal effects (Meyer, 1994; Mandal *et al*., 2008; Tilki *et al*., 2008). Maternal effects are important consideration when evaluating growth performance. A maternal effect is defined as any environmental influence that the dam contributes to the phenotype of her offspring.

On the other hand, many researchers reported the medium heritability estimates for birth weight. Direct heritability estimates for birth weight of Brown Swiss calves given by Kaygısız (1998), Akbulut *et al.* (2001) and Tilki *et al*. (2008) were 0.084, 0.36 and 0.15, respectively. Maternal heritability estimates for birth weight of different cattle breeds reported by Trus and Wilton (1988), Stamer *et al.* (2004), Atil *et al.* (2005) and Tilki *et al. (*2008) were 0.13 to 0.27, 0.07, 0.14 and 0.06, respectively. Similarly, repeatability estimate for birth weight of Brown Swiss calves given by Kaygısız (1998) was 0.102. Having such parameters and (co)variances components is valuable for the characteristics of bred, because direct and maternal genetic effects and their covariance were previously established as important for birth weight in cattle (Tilki *et al*., 2008).

Many of the published heritability estimates for birth weight of Brown Swiss breeds were derived from sire models that did not take into account of additive maternal effects. However, no attempt has yet been made to apply Restricted Maximum Likelihood (REML) procedures for estimation of genetic parameters for birth weight. Improved computer capability with friendly programs allowed the easy use of REML with several animal models to estimate for both genetic and phenotypic variance components of the traits (Tilki *et al*., 2008).

Therefore, the present study was conducted to estimate variance and covariance components due to direct genetic effects and maternal permanent environmental effects for birth weight in Brown Swiss cattle herd raised at Malya and Konuklar State Farms, Türkiye.

MATERIALS AND METHODS

Birth weight data of 7080 Brown Swiss calves reared in two different farms (Malya and Konuklar) were evaluated. Records belonging to the time period between (1987-2008) and (1990-2002) for birth weight (BW) and pedigree information were obtained for Brown Swiss cattle reared in Malya and Konuklar farm, respectively. Information available for each animal in data set comprised of calf, sire and dam identification, sex (male and female), year, calving season and calving parity.

Birth weights were taken within 24 h after calving. Effect of specify on birth weight were studied. Birth weight of calves were analyzed by using the following

$$y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_{ijklm}$$

statistical model,

where, y_{ijklm} = a vector of birth weight observations, μ = the population mean, a_i = the effect of calf year, b_j = the effect of calving season,c_k = the effect of calving parity, d_l = the effect of calf sex, e_{ijklm} = normal, independent, random error. SAS packed program (2000) was used for statistical analysis. Duncan test was utilized in comparisons of sub-groups means.

The following model was employed to estimate genetic parameters within the population (Mrode, 1996):

$$y = X_b + Z_a + W_m + S_{pe} + e$$

Where **y** is a vector of birth weight observation, **b** is a vector of fixed effects, **a** is an unknown random vector of additive genetic effects, **m** is a vector of random maternal additive genetic effects, **pe** is a vector of random maternal permanent environmental effects, **S** is design matrix, **e** is an unknown random vector of residuals, **W** is design matrix, **X** and **Z** are known incidence matrices relating observations to **b** and **a**, respectively.

The variance-covariance structure of the model is as follows:

$$V \begin{vmatrix} a \\ m \\ pe \\ e \end{vmatrix} = \begin{vmatrix} A\sigma^2_A & A\sigma_{AM} & 0 & 0 \\ A\sigma_{AM} & A\sigma^2_M & 0 & 0 \\ 0 & 0 & I_{pe}\sigma^2_{PE} & 0 \\ 0 & 0 & 0 & I_n\sigma_E^2 \end{vmatrix}$$

Where $\boldsymbol{\sigma^2_A}$ is additive direct genetic variance, $\boldsymbol{\sigma_{AM}}$ is the additive direct and maternal genetic covariance, $\boldsymbol{\sigma^2_M}$ is the additive maternal genetic variance, $\boldsymbol{\sigma^2_{PE}}$ is the permanent environmental variance, $\boldsymbol{\sigma^2_E}$ is the residual variance, **A** is the numerator relationship matrix, $\mathbf{I_{pe}}$ an identity matrix with order number of calves, and $\mathbf{I_n}$ an identity matrix with order number of records.

The genetic correlations between direct and maternal genetic effects, direct heritability (h^2_d), maternal heritability (h^2_m), and total heritability (h^2_T) were calculated from the (co)variance componenets at convergence. Total heritability was calculated according to Willham (1980) as:

$$h^2_T = [(\sigma^2_A + 0.5\sigma^2_M + 1.5\sigma_{AM})/(\sigma^2_P)]$$

Genetic parameters, (co)variance components and genetic parameters of birth weight were estimated using by MTDFREML software (Boldman *et al.,* 1993). Convergence of the REML solutions was considered reached when the variance of function values (-2logL) in the simplex was less than 10^{-6}. To ensure that a global maximum was reached, analyses were restarted for several other rounds of iterations using results from the previous round as starting values. When estimates did not change, convergence was confirmed.

RESULTS

The estimates of (co)variance components and genetic parameters for birth weight are presented in Table 1. Direct heritability (h^2_d), maternal heritability (h^2_m), total heritability (h^2_T) and the fraction of variance due to maternal permanent environmental effects (c^2) were 0.09, 0.04, 0.11 and 0.04, respectively, for calves raised at Malya State Farms and 0.39, 0.015, 0.29 and 0.018, respectively for calves raised at Konuklar State Farms. In both herds, direct heritability was higher than maternal heritability.

Mean calf birth weights were 39.92±0.005 and 42.26±0.09 kg for the calves raised in Malya State Farm and Konuklar State Farm respectively (Table 2). Effects of calving year, parity and calf sex on birth weight were significant both farms (P<0.01). Effect of calving season on birth weight was highly significant (P<0.01) for Malya State Farm, while it was non-significant for Konuklar State Farm.

Table 1: Estimates of (co) variance components for direct and maternal effects on birth weight of Brown Swiss calves.

(Co) Variance Components and Parameters		Malya	Konuklar
Direct additive genetic variance	σ^2_A	0.84	4.32
Maternal genetic variance	σ^2_M	0.40	0.17
Direct-maternal additive genetic covariance	σ_{AM}	0.00	-0.84
Maternal permanent environmental variance	σ^2_{PE}	0.40	0.20
Residual variance	σ^2_E	8.08	7.13
Phenotypic variance	σ^2_P	9.71	10.99
Direct heritability (σ^2_A / σ^2_P)	h^2_d	0.09	0.39
Maternal heritability (σ^2_M / σ^2_P)	h^2_m	0.04	0.015
Maternal permanent environmental variance as a proportion of the Phenotypic variance ($\sigma^2_{PE} / \sigma^2_P$)	c^2	0.04	0.018
Covariance ratio (σ_{AM} / σ^2_P)	C_{AM}	0.00	-0.076
Direct-maternal genetic correlation	R_{AM}	0.00	-0.97
Total heritability [($\sigma^2_A + 0.5\sigma^2_M + 1.5\sigma_{AM}$)/($\sigma^2_P$)]	h^2_T	0.11	0.29
Repeatability	r	0.13	0.41
Records		4894	1830
Sires		167	70
Dams		1432	655
Animals in relationship matrix	ARM	6493	2555
Mixed Model Equations	MME	14453	5794
Means and SD	$\overline{X} \pm S_x$	39.92±3.46	42.26±3.91
Coefficient of Variation	CV	8.66	9.25
-2logL		15963	6117

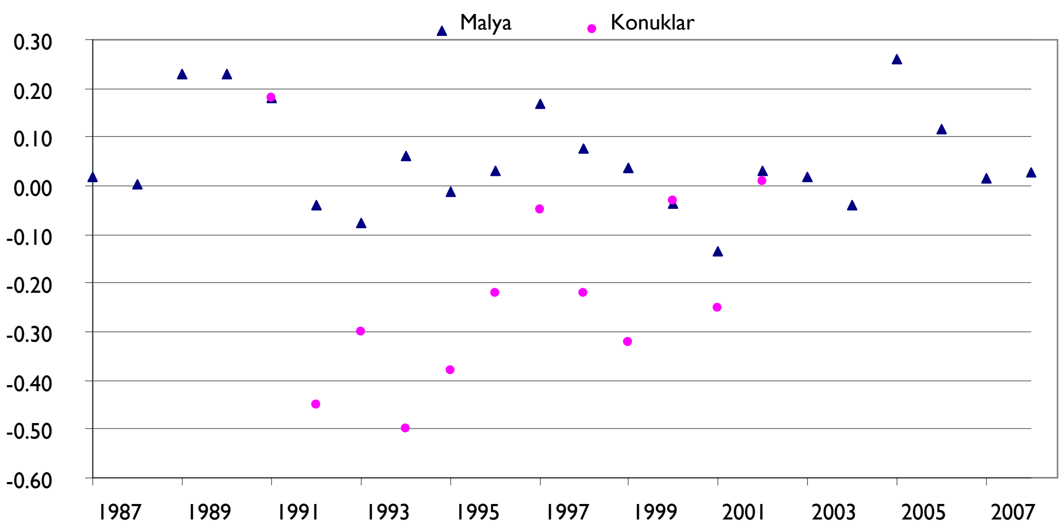

Fig 1: Mean EBVs of birth weight according to years for raised calves at Malya and Konuklar state farms

The expected breeding values (EBV) were estimated and the trends in direct breeding values according to years two farms are presented Fig. 1. No positive or negative trends in direct additive EBVs have been observed among the years.

DISCUSSION

In both herds, direct heritability was higher than maternal heritability. The estimate of this study in Malya herds (0.09) was also compared with the h^2_d Brown Swiss BW. According to this comparison, corresponding values was lower than the values (0.15 to 0.76) reported (Akbulut *et al.*, 2001; Tilki *et al.*, 2008) but in agreement with the values (0.084) reported by Kaygısız (1998). On the other hand, the estimate for direct heritability (h^2_d) of this study in Konuklar herds (0.32) was higher than the estimates, 0.084 and 0.15 reported by Kaygısız (1998) and Tilki *et al.* (2008), but in agreement with the values (0.29 and 0.36) found by Akbulut *et al.* (2001).

The estimates for maternal heritability (h^2_m) of this study (0.04 and 0.015) were also compared with those of (h^2_m) of Brown Swiss BW in other studies. It was indicated that the corresponding values were lower than the values (0.06 to 0.27) (Trus and Wilton, 1988; Gutierrez *et al.*, 1997; Tilki *et al.*, 2008).

The low-modest estimate of heritability for birth weight in this study indicates that the genetic progress for

Table 2: Effects of parity, year, season and calf sex on birth weight (Kg).

Classing	N	Malya $\bar{x} \pm S_x$	N	Konuklar $\bar{x} \pm S_x$
Means	5194	39.92±0.005	1886	42.26±0.09
Calving parity		**		**
1	1434	38.52±0.08d	632	41.67±0.16c
2	1217	39.76±0.09c	489	42.22±0.19bc
3	897	40.58±0.11b	325	42.43±0.22bc
4	616	40.66±0.13b	185	43.49±0.27a
5	430	40.85±0.15ab	122	42.75±0.32ab
6	291	41.19±0.18a	82	42.72±0.38ab
7	309	40.92±0.18ab	51	42.45±0.48bc
Calving Year		**		**
1987	293	40.05±0.18cd		
1988	275	40.25±0.19cd		
1989	285	40.36±0.18bcd		
1990	264	40.21±0.19dc	17	40.47±0.80ef
1991	300	40.57±0.18abc	44	41.70±0.51cd
1992	331	41.06±0.17ab	71	40.25±0.40ef
1993	357	41.20±0.16a	79	41.95±0.38cd
1994	322	41.27±0.17a	119	42.57±0.31bc
1995	169	41.30±0.24a	155	45.68±0.27a
1996	31	36.83±0.57ı	189	45.50±0.24a
1997	104	37.24±0.31ıh	226	43.48±0.23b
1998	153	37.56±0.26gh	261	42.21±0.21cd
1999	162	38.41±0.25f	292	42.10±0.20cd
2000	191	36.69±0.23ı	325	39.76±0.19f
2001	208	38.02±0.22gf	40	41.15±0.51de
2002	224	39.08±0.21e	68	37.53±1.16g
2003	241	40.06±0.20cd		
2004	238	40.57±0.20abc		
2005	252	39.91±0.19dc		
2006	285	39.61±0.18de		
2007	254	39.97±0.19cd		
2008	255	39.81±0.19cd		
Calving Season		**		n.s
Spring	1411	39.68±0.09c	515	42.05±0.20a
Summer	1642	39.85±0.08bc	608	42.26±0.20a
Autumn	1016	40.00±0.10ab	378	42.42±0.22a
Winter	1125	40.19±0.10a	385	42.38±0.22a
Calf Sex		**		**
Male	2725	40.54±0.07a	944	42.84±0.18a
Female	2469	39.21±0.07b	942	41.67±0.18b

n.s; non-significant, **P<0.01; a, b, c, d,e,f,g: Means with different superscripts within a column indicate significance (P<0.05).

these traits is possible by selection. Maternal effects on birth weight of calves were significant. In this reason, both direct additive effects and maternal effects need to be considered for improving this trait by selection.

Mean calf birth weights were 39.92±0.005 and 42.26±0.09kg for the herds raised in Malya State Farm and Konuklar State Farm, respectively. Several research findings such as 39.50kg reported by Kaygısız (1998) were comparable with these. But, the means (33.6 to 37.63kg) reported by Uğur *et al.* (1999), Akbulut *et al.* (2001) and Tilki *et al.* (2008) were lower than those recorded here.

The effect of calving year on birth weight was highly significant (P<0.01). The significant effect of year on birth weight was also reported by various researchers (Kaygısız 1998; Akbulut *et al.,* 2001; Tilki *et al.,* 2008).

In Malya farm, the highest birth weight (41.30±0.24kg) was obtained in the year 1995, while lowest birth weight (36.69±0.23kg) was observed in the year 2000. Difference between the means for maximum and minimum years is 4.61kg. In Konuklar farm, the highest birth weight (45.68±0.27kg) was obtained in the year 1995 and lowest birth weight (37.53±1.16kg) was observed in 2002. Difference between the means for maximum and minimum years is 8.15 Kg. Because of changes which occur in climate and pasture conditions from year to year, differences in calf birth weights among years are expected. This result may be explained by the differences in feeding and other administrative conditions over the years.

The effect of parity on birth weight was found to be highly significant (P<0.01) for both farm. The lowest birth weights 38.52±0.08kg (Malya) and 41.67±0.16kg (Konuklar) were recorded in 1st parturition in both farms and highest birth weight 41.19±0.18kg (Malya) and 43.49±0.27kg (Konuklar) were obtained in 6st or 4st parturitions. Calves born in early parities were lighter in weight than those born to late-parity dams. However, the mean birth weights appeared to be similar between 2th and 7th parturitions (Table 2). Akbulut *et al.* (2001) and Tilki *et al.* (2008) also reported that the effect of parity on birth weight of calves was highly significant. One explanation of these results is that earlier-parity cows continue to grow until reaching adult size and may compete with the fetus for available nutrients during pregnancy.

Effect of calving season on birth weight was highly significant P<0.01) for Malya State Farm, while it was nonsignificant for Konuklar State Farm. As has already been reported (Kaygısız, 1998; Tilki *et al.,* 2008), the effect of season on birth weight was significant at Malta Farm in the present study. At this farm, the highest (41.19±0.10kg) and the lowest (39.68±0.09kg) birth weight was recorded in Winter and Spring season, respectively. This may result from low temperature to winter calves during the last trimester.

The effect of calf sex on birth weight was highly significant (P<0.01). Male calves were 1.33 and 1.17kg heavier at birth than females for Malya and Konuklar farms, respectively. These results were similar to the findings of Akbulut *et al.* (2001) and Tilki *et al.* (2008) reported that birth weights of male calves were 5-8% heavier than female calves. This was attributed to longer gestation period of males (Spencer, 1982), or high androgen concentrations in male fetuses (Kim *et al.,* 1972).

Since birth weight is related to growth, development and various yield traits during the early ages this trait can be used as an indirect selection criterion in farm animals. Average birth weight determined in the present study was similar to findings in literature. This indicated that cows in the farms were treated well during gestation when intrauterine growth of the fetus was rapid. Effects of environmental factors such as year, farm, birth parity and season on birth weight have been found to be statistically significant. Therefore, the effects of environmental factors should be eliminated in the selection which will be mediatele based on birth weight.

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