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Original Paper

Genetic parameters for growth traits of Charolais and Limousine cattle breeds

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The aim of this study was to estimate the genetic parameters for the birth weight and weaning weight in Charolais and Limousine cattle breeds. In this study was used the records from 2018 calves from Charolais breed and 2,099 calves from Limousine breed for the birth weight while for weaning weight the records were from 1,125 calves Charolais and 1,092 calves Limousine. The genetic parameters were estimated with maternal animal model. The data were from Romanian Breeding Association for beef cattle. The direct heritability of birth weight and weaning weight were 0.67 and 0.35 for Charolais breed while for Limousine breed were 0.70 and 0.69. The maternal heritability of birth weight and weaning weight were 0.26 and 0.12 for Charolais and 0.245, 0.249 respectively for Limousine breed. The total heritability for birth weight and weaning weight was high in Charolais and Limousine breeds. Direct-maternal correlations were negative for birth weight (-0.340) for Charolais and (-0.311) for Limousine and for weaning weight (-0.306) for Charolais and (-0.290) for Limousine.

Keywords: birth weight, weaning weight, genetic parameters, meat breeds

1 Introduction

Charolaise and Limousine are two breeds from France. Charolaise and Limousine breeds produce beef of good quality, these breeds can be used to improve other breeds. Charolaise and Limousine breeds are easily adaptable to environmental changes. The cows have easy calving and good maternal instinct. The average daily gain is good for these breeds, the meat is aromatic, tasty and tender. Limousine and Charolais breeds are also raised in Romania. Beef is important meat produced in Europe. In European Union, beef production represents 13% of total world production of beef (Valee-Desoneville, 2017). Meat production is necessary to assure the food for consumers. The Limousine and Charolais breeds are specialized breeds for meat production and the main objective is the production of high-quality meat. Other aims of breeding program for these breeds are to improve the reproductive and functional traits of two breeds to ensure the achievement of the highest possible meat production, with the lowest possible costs. In beef cows, the phenotype of the offspring is influenced by the ability of mother to provide a favorable nutritional environment for offspring (Grosu and Oltenacu, 2005). Crews and Wang (2007) showed that the maternal animal model was used for genetic evaluation of beef cattle in Canada. Michenet et al. (2016) reported that in beef cattle, maternal care is critical for calf survival and growth and 12 candidate genes have role in the genetic variation of suckling performance. Many farmers are in Romanian Breeding Association for beef cattle. The growth traits are important for profitability of farms, these traits are in the objective of breeding program of Charolaise and Limousine breeds of Romanian Breeding Association for beef cattle. The aim of this study was to estimate the genetic parameters for the birth weight and weaning weight in Charolais and Limousine cattle breeds with maternal animal model.

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2 Materials and methods

The data used in this study provide from Romanian Breeding Association for beef cattle.

The pedigree contents 4,213 animals: 2,018 calves, 194 sire and 2,001 dams for Charolais breed and 4,354 animals: 2,099 calves, 2,095 dams and 160 sire for Limousine breed for the birth weight. The pedigree contents 2,413 animals: 1,125 calves, 1,123 dams, 165 sire for Charolais and 2,305 animals: 1,092 calves, 1,091 dams, 122 sire for Limousine breed for weaning weight. The age of calves at weaning was 200 days. Database contents calves born in 2021. For analyze the data was used the R software, the script built by Grosu (Grosu and Oltenacu, 2005).

The model was (Mrode and Thompson, 2005):

$$y = Xb + Za + Wm + Spe + e$$

where: y – the vector of observations; b – the vector of the fixed effects; a – the vector of the random animal effects; m – the vector of the random maternal genetic effects; pe – the vector of the permanent environmental effects; e – the vector of the random residual effects; X, Z, W and S – the incidence matrices referring to animal performance, to the fixed effects, to the direct effects, to the maternal effects and to the permanent environmental effects

It is assumed that:

$$\mathrm{var}\begin{bmatrix} a \\ m \\ pe \\ e \end{bmatrix} = \begin{bmatrix} \sigma_a^2 A & \sigma_{am} A & 0 & 0 \\ \sigma_{am} A & \sigma_m^2 A & 0 & 0 \\ 0 & 0 & I\sigma_{pe}^2 & 0 \\ 0 & 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

where: A – the kinship matrix between animals; I – the identity matrix; σ_a^2 – the additive genetic variance for the direct effects; σ_m^2 – the additive genetic variance for the maternal effects; σ_{am} – the additive genetic covariance between the direct and maternal effects; σ_{pe}^2 – the variance due the permanent environmental effects; σ_e^2 – the variance of the residual error

According to the objective of this paper the following genetic parameters were estimated:

- the direct heritability $ha^2 = \sigma_a^2/\sigma_p^2$, where σ_p^2 is the phenotypic variance;
- the maternal heritability $h_m^2 = \sigma_m^2/\sigma_p^2$;
- the covariance between direct and maternal effects as proportion of the phenotypic variance (σ_{am}/σ_p^2);
- the total heritability (Wilham et al., 1972).

$$h_T^2 = \frac{\sigma_a^2 + 0.5\sigma_m^2 + 1.5\sigma_{am}}{\sigma_p^2}$$

where: h_T^2 is the total heritability, and σ_p^2 is the phenotypic variance:

- the ratio of the maternal permanent environment to phenotypic variance (c^2);
- ram the genetic correlation between the direct and maternal effects.

$$r_{am} = \frac{\sigma_{am}}{\sqrt{\sigma_a^2 \cdot \sigma_m^2}}$$

In the present study, the fixed part of the model included the sex of calves with two levels, male and female. The random effects were the direct genetic effects, the maternal genetic effects and the permanent environmental effects.

3 Results and discussions

The average performances for growth traits for Charolaise and Limousine cattle are presented in table 1.

The results obtained in our study were similarly with the results from literature. Shi et al. (1993) reported the mean for birth weight was 38 kg and 210 days weight 251.1 kg for French Limousine. The birth weight for Charolais calves in the study herein was lower than the weight at birth of calves of Charolais breed from Slovenia, at male was 48 kg and female was 46.3 kg (Čepon et al., 2009).

The weaning weight for calves from Charolais and Limousine in our study was lower than the value obtained by Rezende et al. (2022) for weaning weight at 210 days 242.77 kg for Charolais and 247.73 kg for Limousine and higher than the weaning weight 223.5 obtained by Szabó et al. (2021) at age of weaning 219 days for Limousine.

Table 1 The average performances for growth traits

Breeds	Traits	Mean (kg)	Standard deviation	Variation coefficient (%)
Charolaise	birth weight	39.94 ±0.13	5.91	14.80
	weaning weight (200 days)	222.58 ±0.97	32.55	14.62
Limousine	birth weight	38.93 ±0.13	6.18	15.88
	weaning weight (200 days)	240.14 ±1.15	38.12	15.87

Vostry et al. (2014) reported that the birth weight in Czech Charolais was 40.81.Pabiou et al. (2014) reported that the average weaning weight ranged from 214 kg to 275 kg from Limousine and 273 kg to 300 kg for Charolais across eight member countries of Interbeef (France, the United Kingdom, Denmark, Spain, Ireland, Sweden, Finland, Czech Republic). Phocas et al. (2004) reported the mean for birth weight for Charolais 47.1 kg and for Limousine 39.5 kg and for weaning weight for Charolais 279.8 kg and Limousine 258.3 kg. Lukaszewicz et al. (2015) reported the mean for birth weight for Limousine 39 kg and for weaning weight 265 kg.

In Romania, Pârvu et al. (2015) studied the growth rate of Limousine calves maintained on pasture and free stabulation and Maciuc et al. (2012) studied Charolaise cattle breed reared in N-E Area of Romania.

The estimates of (co) variance components, direct heritability, maternal heritability, direct-maternal genetic correlation and fraction of total variance due to maternal permanent environmental effects for growth traits are shown in Table 2.

The direct and total heritability was higher for both traits for Limousine breed, birth weight and weaning weight than Charolais breed. The maternal heritability was higher for birth weight for Charolais breed and lower for weaning weight than for Limousine breed. Direct additive genetic variance for birth weight for Charolais breed was 67% from phenotypic variance, the maternal genetic variance was 26% and the maternal permanent environmental variance represents 5.3%. The direct additive genetic variance for weaning weight was 35.1% from the phenotypic variance while the maternal genetic variance and maternal permanent environmental variance are 12.3%, 2.3% respectively. The direct additive genetic variance for birth weight for Limousine breed represents 70.2% from the phenotypic variance while the maternal genetic variance and the maternal permanent variance are 24.5% and 4.6% respectively. The direct additive genetic variance for weaning weight for Limousine breed represents 69% from the phenotypic variance. The maternal genetic variance and the maternal permanent environmental variance are 24.9% and 4.7%, respectively. The covariance between the direct and the maternal genetic effects for two traits was negative in our study. The direct heritability for two traits was greater than the maternal heritability. Direct-maternal additive genetic correlation was negative for birth weaning and weaning weight in our study. In our study c^2 was low suggest that maternal effects were due to maternal additive genetic effects. The ability of cows to be good for offspring is expressed by the value of the maternal genetic effects, this trait is specific for each individual (Grosu and Oltenacu, 2005).

Others authors, Čepon et al. (2009) reported negative covariance between direct and maternal effects for birth weight for Charolais breed and Szabo et al. (2021) reported negative direct-maternal covariance for weaning weight in Limousine breed. Maciuc et al. (2012)

Table 2 Estimates of (co)variance components and genetic parameters for birth weight, weaning weight for Charolais and Limousine cattle breeds

Item	Birth weight Charolais	Weaning weight Charolais	Birth weight Limousine	Weaning weight Limousine
σ^2_a	15.250	343.340	11.137	474.185
σ^2_m	6.050	120.662	3.889	170.889
σ_{am}	-3.660	-62.437	-2.048	-84.739
σ^2_{pe}	1.208	23.105	0.744	32.743
σ^2_e	3.660	552.690	2.123	92.551
σ^2_p	22.510	977.360	15.845	685.629
c^2	0.053	0.023	0.046	0.047
σ_{am}/σ^2_p	-0.162	-0.063	-0.129	-0.123
h^2_a	0.670	0.351	0.702	0.690
h^2_m	0.260	0.123	0.245	0.249
r_{am}	-0.340	-0.306	-0.311	-0.290
h^2_T	0.560	0.508	0.636	0.630

σ^2_a – direct additive genetic variance; σ^2_m – maternal genetic variance; σ_{am} – direct – maternal additive genetic covariance; σ^2_{pe} – maternal permanent environmental variance; σ^2_e – residual variance; h^2_a – direct heritability; h^2_m – maternal heritability; $c^2 = \sigma^2_{pe}/\sigma^2_p$ – ratio of maternal permanent environmental variance to phenotypic variance; σ_{am}/σ^2_p – covariance between direct and maternal effects as proportion to phenotypic variance; r_{am} – genetic correlation between direct and maternal effects; h^2_T – total heritability reported the heritability for birth weight was 0.35 and for weight at 210 days 0.37 for Charolaise cattle breeds.

Szabo et al. (2021) reported direct-maternal negative correlation for weaning weight at Limousine. Crews et al. (2004) reported negative correlation between direct and maternal effects for birth weight (-0.49) and for weaning weight at 205 days (-0.35).

The body weight is one of the major selection traits in meat cattle population. The heritability estimates obtained in the present study are in agreement with those reported for various populations. Čepon et al. (2008) obtained heritability for birth weight in Charolais calves was 0.62.Direct heritability for birth weight for Charolais breed in our study (0.69) was lower than the direct heritability 0.74 obtained in Charolais breed from Slovenia while the maternal heritability was higher in our study (0.26) than the maternal heritability 0.04 obtained by Čepon et al. (2009). The correlation between direct and maternal effects in our study for Charolais breed was negative -0.34 as in the study of Čepon et al. (2009) -0.35.

Crews et al. (2004) reported direct heritability estimates were 0.53 and 0.22 for birth weight and weaning weight at 205 days while the maternal heritability were 0.16 and 0.10 for birth weight and weaning weight.

The value of the additive genetic heritability for weaning weight of the cattle from our study 0.35 for Charolais was lower than the additive genetic heritability estimated 0.39 obtained by Rezende et al. (2022). The maternal heritability for weaning weight for Charolais in our study 0.12 was higher than the value 0.11 obtained by Rezende et al. (2022). For weaning weight of the calf is important the maternal ability. The direct and maternal heritability for Charolais population from our study were lower (0.35, respectively 0.12) than the direct heritability 0. 57 and maternal heritability 0.32 obtained by Szabó et al. (2007) for weaning weight.

Pabiou et al. (2014) showed that the heritability for Limousine weaning weight was between 0.20 and 0.36 and the maternal heritability was between 0.07 and 0.25, for Charolais direct heritability ranged between 0.20 and 0.35 and maternal heritability was between 0.07 and 0.15 across eight member countries of Interbeef.

Phocas et al. (2004) reported direct heritability for birth weight was 0.33 for Charolais and 0.38 for Limousine, the maternal heritability was 0.11 for both breeds for birth weight while for weaning weight, direct heritability was 0.13 for Charolais and 0.29 for Limousine and maternal heritability was 0.09 for Charolais and 0.12 for Limousine.

Vostry et al. (2014) obtained direct heritability for birth weight was from 0.21 to 0.22 and maternal heritability was from 0.074 to 0.075 in Czech Charolais using different models.

Shi et al. (1993) obtained direct heritability of birth weight for Limousine breed that was 0.31, and for weaning weight (201 days) was 0.26. The maternal heritability was 0.08 for birth weight and 0.13 for weaning weight for Limousine breed.

Rios-Utrera et al. (2011) obtained direct heritability 0.13, maternal heritability 0.15 for birth weight while for weaning weight adjusted to 205 days direct heritability was 0.21 and maternal heritability was 0.32 in Mexican Limousine cattle.

Van Niekerk et al. (2006) reported lower values for direct heritability for birth weight 0.09 and 0.19 for weaning weight at 200 days and for maternal heritability were 0.05 and 0.12 for South African Limousine cattle. The correlation between direct and maternal effects were -0.64 and -0.70.

The direct heritability for weaning weight from our study was higher than the direct heritability 0.63 obtained by Szabó et al. (2021) for Limousine breed from Hungary while the maternal heritability from our study was lower than the maternal heritability 0.29 obtained by the same authors.

Lukaszewicz et al. (2015) obtained the heritability for birth weight 0.41 and for weaning weight 0.24 for Limousine breed.Heydarpour et al. (2008) showed that direct and maternal additive genetic effects should be considered in selection for the traits influenced by maternal effects.

The results from our study revealed that direct heritability estimates were high for birth weight for both breeds, while for weaning weight for Charolaise the heritability was moderate, but for Limousine were high. In conclusion the genetic parameters are very important in selection program on these breeds.

4 Conclusions

Birth weight and weaning weight were highly influenced by direct genetic effects. Maternal effects influenced lower than direct genetic effects the both traits. The heritability for growth traits were similar to those reported in literature. Total heritability for birth weight and for weaning weight were high, these traits can be used for genetic improvement of Charolaise and Limousine breeds.

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