

# Estimation the genetic parameters for age at first calving in Charolais and Limousine breeds

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## ABSTRACT

The objective of this study was to estimate the genetic parameters for age at first calving in Charolais and Limousine cattle breeds using animal model. The reproduction traits are influenced by genetic factors and environmental factors. The genetic factors are breed, individual and environmental factors are: climate condition and nutrition. The data consisted on 239 records for Charolais breed and 309 records for age at the first calving for Limousine breed. The data were from Romanian Breeding Association for Beef cattle. The age at the first calving was  $792.92 \pm 6.77$  days for Charolais breed and  $813.83 \pm 6.09$  days for Limousine breed. The heritability value for age at the first calving was 0.273 for Charolais and for Limousine breed was 0.275. The breeding values of cows with records for age at first calving were between -30.697 and 40.929 for Limousine breed were between -46.64 and 42.65. For improvement the reproduction traits it is necessary to improve the environmental conditions and supervision of reproduction activity in the farms and the selection of the best cows. The selection based on the breeding values of the cows determined the improvement of age at first calving. Improvement the reproduction traits increase the profitability of farms.

**Keywords:** age at the first calving, cows, animal model, genetic parameters

## INTRODUCTION

Charolais and Limousine are beef cattle with a high - quality meat. Charolais breed has the following advantages: high growth rate, very heavy carcasses, low fat percentage, high utilization of fibers, high intake, docile breed, maternal instinct and longevity.

Limousine breed presented the qualities: high feed conversion rate, high yield at slaughter, ease of calving, fertility and productive longevity.

The Limousine breed is raised in eighty countries in the world. This breed has a good ability to adapt to different environments.

The breeding programs of Charolais and Limousine cattle breeds have the objective to increase the meat production. The reproduction trait as calving ease is included in the objectives of the breeding program. The age of the first calving of dam influenced the calving ease. The calving difficulty were presented in the first calving of cows because the cows are smaller at first parturition.

In Romania, Tăpăloagă et al. (2016) studied the reproduction traits in Charolais herd.

The goals of breeding programs of Charolais and Limousine breeds included production traits and reproduction traits. The age at first calving it is important economically for beef cows breeds. The age at first calving is determined by genetics factors and the management of farms. Twomey et al. (2023) observed that reducing age at first calving to 24 months is efficient for beef cattle breeds.

Brzakova et al. (2020) reported that to improve the production of beef cattle is necessary to reduce unproductive periods of females by reducing age at first calving.

Van Eetvelde et al. (2020) reported that decreasing age at first calving reduces rearing costs in farms.

Medina et al. (2020) considered that earlier age at first calving has a favorable effect of the cows, on productive life and increase in longevity.

Kalinska et al. (2019) constated that the dairy cows with age at first calving 791-850 days had the highest lifetime milk.

Orsoletta et al. (2021) constate that lower replacement rate and two years old at first calving reduce CH<sub>4</sub> emissions.

Abreu et al. (2022) observed that the reduction the age at first calving at 24 months in beef cows determined the reduction on CO<sub>2</sub> emissions.

Reducing age at first calving in beef herds decreases the cost with feed and increased the productive longevity (Day and Nogueira, 2013, Lopez-Paredes et al. 2018).

In beef cattle, selection for age at first calving has a main role for reproduction and meat yield. The age at the first calving influences meat production and the profitability of farms. Age at first calving influenced the body weight and the number of calves of cows (Lopez-Paredes et al., 2018). Early age at the first calving determines lighter calves (Lopez-Paredes et al., 2018). Age at first calving influence the birth rates, ability to conceive (Bormann and Wilson, 2010). The cows with precocity had more calves in their life and shortening the generation interval and intensify the selection.

The factors that influenced the age at first calving are: the age at first service, the number of services per conception, the service interval and the conception rate (Watanabe et al., 2017). The age at first calving is influenced by de breed, being different in different beef cattle, herd, season at birth (Dakay et al., 2006). Taussat et al. (2022) reported that improving sexual precocity can increase the farm profitability. The heritability for sexual precocity was 0.20. The precocity of the cows determines the reduce of the age at first calving and the increase of the productivity in the farms (Martin et al., 1992, Perry 2016). The precocity gives to the breeds economic advantage. Fertility is one of the important traits for beef cattle breeds, having an important effect on the natality (Jimenez et al., 2023).

Different authors (Day and Anderson, 1998, Day and Nogueira, 2013) have shown that is important economic for beef breeds that the first calving to be between 22 and 24 months. Zavadilova et al. (2013) observed that age at first calving influenced functional longevity of cows.

The aim of this study was to determine the genetic parameters of age at first calving in Charolais and Limousine cattle breeds using animal model.

#### MATERIALS AND METHODS

The data consisted on 239 records for Charolais breed and 309 records for age at the first calving in Limousine breed. The data were from Romanian Breeding Association for Beef cattle. The fixed effect is the herd. The levels of herd fixed effect are 57 for Charolais breed and 66 for Limousine breed. The pedigree consisted of 553 cattle, 239 dams, 75 sire and 239 cows with records for Charolais breed and 709 cattle, 309 dams, 91 sire and 309 cows with performances for Limousine breed.

#### *Statistical analysis*

The data were analysed with animal model with R software (Grosu et al. 2013, Grosu et al. 2019):

The model is:

$$y = Xb + Za + e$$

X= the incidence matrices for fixed effects

Z= the incidence matrices for additive genetic effects

y= the vector of observations, age at first calving

b= the vector of the fixed effects, the fixed effect of herd-year of calving

a= the vector of the additive genetic effects of cows

e= the vector of error

The mixed model-like equations were:

$$\begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1} * k \end{pmatrix} \begin{pmatrix} \tilde{b} \\ \hat{a} \end{pmatrix} = \begin{pmatrix} X'Y \\ Z'Y \end{pmatrix}$$

$$k = \frac{1 - h^2}{h^2}$$

The variance components were estimated:

$$\sigma_e^2 = \frac{P'P - \tilde{b}' * X' * P - \hat{a}' * ZP}{n - r(X)}$$

$\sigma_e^2$ = residual variance

where  $r(X)$ = rank of matrix X

$$\sigma_a^2 = \frac{\hat{a}' * A^{-1} * \hat{a} + \sigma_e^2 * tr(A^{-1} * C_{22})}{q}$$

$\sigma_a^2$ = the additive genetic variance

where  $C_{22}$ =the sub-matrix corresponding to random effects in the system of equations which was obtained after reversed throughout the system of equations:

$$C = \begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1} * k \end{bmatrix}^{-1} = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix}$$

The heritability for reproduction traits was:

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

Where  $\sigma_a^2$ = the additive genetic variance

$\sigma_e^2$ = residual variance

The relative breeding value is:

$$BV\% = 100 + 12 * \left( \frac{BV_{abs} - \text{Average } BV_{abs}}{\sigma_{BV_{abs}}} \right)$$

BV% = relative breeding value of cow for age at first calving

$BV_{abs}$ = absolute breeding value of cow for age at first calving

$\sigma_{BV_{abs}}$ = standard deviation of absolute breeding values

## RESULTS AND DISCUSSION

The age at the first calving was shown in table 1.

**Table 1.** Statistics coefficients in Charolais and Limousine breeds

| Breeds    | Mean<br>±mean error (kg) | Standard<br>deviation | Coefficient<br>of<br>variability | Number<br>of cows |
|-----------|--------------------------|-----------------------|----------------------------------|-------------------|
| Charolais | 792.92±6.77              | 104.68                | 13.20                            | 239               |
| Limousine | 813.83±6.09              | 107.15                | 13.17                            | 309               |

The mean age at first calving in our study was lower than mean the age at first calving found by Goncalves de Rezende et al., (2020)  $1191.19 \pm 307.10$  days in the Charolais breed and  $1099.26 \pm 232.15$  days in Limousine breed. The cows from our study have a good precocity, that increase the productive life and the profit of farms.

Dakay et al. (2006 a, b) reported the age at first calving 2.82 and 3.02 years in Limousine and Charolais breeds in Hungary. Bene et al. (2021) obtained the mean for age at the first calving was  $34.7 \pm 0.4$  month in Limousine breed. Zsuppan et al. (2010) reported the mean for age at first calving in Charolais breed was  $2.80 \pm 0.07$  years. Gutierrez et al. (2002) reported the mean for age at first calving in Asturiana de los Valles beef breed was 1063.48 days. The age at first calving is influenced by the age at puberty. The mean age at puberty was 342 days for Charolais breed and 349 days for Limousine breed (Swiestra et al., 1977). In others meat breeds, the age at puberty was 464.6 in Angus, 478.6 in Hereford and 493.3 in Creole breed (Pardo et al, 2018).

In beef cattle the age at first calving differs from a breed to other. Shin et al. (2021) reported that heifer can calve when are not older than 24 months and have adequate body size. The first calving is affected by factors related to the management of farms and the genetics of the female, as well as physiology.

For the beef cows the age for the mating was 15-17 months, the bulls can be used for mating at 12-15 months.

In the table 2 are presented the variances for age at first calving.

**Table 2.** The variances for age at first calving in Charolais and Limousine breeds

| Breeds    | Additive variance | Residual variance | Phenotypic variance |
|-----------|-------------------|-------------------|---------------------|
| Charolais | 168.310           | 447.422           | 615.732             |
| Limousine | 215.738           | 568.031           | 783.769             |

The genetic variance, the residual variance and the phenotypic variance were higher for Limousine breed than for Charolaise breed.

Management practice of farms and environmental factors have important role for improving the age at first calving.

In table 3 gives the heritability for age at the first calving. In our study heritability was 0.273 for Charolais breed and 0.275 for Limousine breed. The traits for reproduction have low heritability due the environmental effects.

**Table 3.** Heritability for age at first calving in Charolais and Limousine breed

| Breeds    | Heritability |
|-----------|--------------|
| Charolais | 0.273        |
| Limousine | 0.275        |

Bene et al. (2021) reported the heritability for age at the first calving for Limousine breed was 0.08 lower than the value from our study. Bene et al. (2021) observed that the effect of the sire, the herd and the birth year of cow on the age at first calving was significant. Brzakova et al. (2020) obtained the heritability lower than our study for age at first calving in Charolais breed 0.234 and in Aberdeen Angus breed 0.175. The heritability for age at first calving in Brahman cattle breed was 0.10.

In the table 4 are shown the absolute breeding values for the best ten cows for age at first calving in Charolais breed.

**Table 4.** The breeding values of the best Charolais cows for age at the first calving

| No. | Breeding value |
|-----|----------------|
| 1   | -30.697        |
| 2   | -22.809        |
| 3   | -22.809        |
| 4   | -22.685        |
| 5   | -22.605        |
| 6   | -22.409        |
| 7   | -16.299        |
| 8   | -16.299        |
| 9   | -16.082        |
| 10  | -14.049        |

The absolute breeding values ranged between -14.049 and -30.697 for the best cows.

The relative breeding values for the best Charolais cows for age at first calving are presented in table 5.

**Table 5.** The relative breeding values of the best Charolais cows for age at the first calving

| No. | Relative Breeding value |
|-----|-------------------------|
| 1   | 144.295                 |
| 2   | 132.861                 |
| 3   | 132.861                 |
| 4   | 132.682                 |
| 5   | 132.572                 |
| 6   | 132.282                 |
| 7   | 123.426                 |
| 8   | 123.426                 |
| 9   | 123.111                 |
| 10  | 120.164                 |

The cows with high breeding values for age at first calving are selected for reproduction for obtained the best descendants. The relative breeding

values for age at first calving for the best Charolais cows were between 120.164 and 144.295.

The absolute breeding values for the best Charolais sire for age at first calving are presented in table 6.

**Table 6.** The breeding values of the best Charolais sire for age at the first calving

| No. | Breeding value |
|-----|----------------|
| 1   | -17.709        |
| 2   | -14.885        |
| 3   | -11.175        |
| 4   | -9.121         |
| 5   | -8.281         |
| 6   | -7.497         |
| 7   | -7.42          |
| 8   | -6.466         |
| 9   | -5.622         |
| 10  | -3.223         |

The absolute breeding values for the best Charolais sire ranged from -3.22 and -17.709.

The relative breeding values for the best Charolais sire for age at first calving are shown in table 7.

**Table 7.** The relative breeding values of the best Charolais sire for age at the first calving

| No. | Relative breeding value |
|-----|-------------------------|
| 1   | 138.708                 |
| 2   | 132.535                 |
| 3   | 124.426                 |
| 4   | 119.936                 |
| 5   | 118.100                 |
| 6   | 116.386                 |
| 7   | 116.218                 |
| 8   | 114.131                 |
| 9   | 112.288                 |
| 10  | 107.044                 |

The relative breeding value of the best Charolais sire ranged between 107.044 and 138.708.

The breeding values for the best Limousine cows for age at the first calving are shown in table 8.

**Table 8.** The breeding values of the best Limousine cows for age at the first calving

| No. | Breeding value |
|-----|----------------|
| 1   | -46.64         |
| 2   | -30.32         |
| 3   | -22.55         |
| 4   | -21.95         |
| 5   | -21.75         |
| 6   | -21.75         |
| 7   | -21.75         |
| 8   | -21.43         |
| 9   | -20.66         |
| 10  | -20.66         |

The absolute breeding values for the best Limousine cows ranged between -20.66 and -46.64.

The cows are ranking according to breeding values as breeding candidates.

The relative breeding values for the best cows in Limousine breed are presented in table 9.

**Table 9.** The relative breeding values of the best Limousine cows for age at the first calving

| No. | Relative Breeding value |
|-----|-------------------------|
| 1   | 153.962                 |
| 2   | 135.035                 |
| 3   | 126.025                 |
| 4   | 125.332                 |
| 5   | 125.100                 |
| 6   | 125.100                 |
| 7   | 125.100                 |
| 8   | 124.732                 |
| 9   | 123.844                 |
| 10  | 123.842                 |

The relative breeding values for Limousine cows ranged from 123.842 and 153.962.

BLUP (Best Linear Unbiased Prediction) corrects the phenotypes for systematic effects and it estimates breeding values while making use of the additive genetic relationship between animals (Oldenbroek K. and Van der Waaij, 2014). The accuracy of estimation of the breeding values increases when is available the more information related to the genetics of cattle (Oldenbroek K. and Van der Waaij, 2014)

The breeding values of the best Limousine sire for age at first calving are presented in table 10.



**Table 10.** The breeding values of the best Limousine sire for age at the first calving

| No. | Breeding value |
|-----|----------------|
| 1   | -23.319        |
| 2   | -22.965        |
| 3   | -17.816        |
| 4   | -13.016        |
| 5   | -12.018        |
| 6   | -10.768        |
| 7   | -10.631        |
| 8   | -10.332        |
| 9   | -10.193        |
| 10  | -9.55          |

Bene et al. (2021) estimates the breeding values for age at first calving in Limousine breed. The breeding value ranged between -0.3 and 0.3 months for sires of cows. The breeding value for the best sire from Limousine breed in our study ranged between -9.55 and -23.319 days.

The relative breeding values for the best sire in Limousine breed are shown in table 11.

**Table 11.** The relative breeding value of the best Limousine sire for age at the first calving

| No. | Relative Breeding value |
|-----|-------------------------|
| 1   | 126.398                 |
| 2   | 125.998                 |
| 3   | 120.169                 |
| 4   | 114.735                 |
| 5   | 113.605                 |
| 6   | 112.190                 |
| 7   | 112.035                 |
| 8   | 111.696                 |
| 9   | 111.539                 |
| 10  | 110.811                 |

The relative breeding values for the best Limousine sire ranged between 110.811 and 126.398. The bulls are selected in order to obtain products with a high growth rate and good precocity. In present the insemination artificial was used and the new technologies like genomics increase the progress. The sires were selected from the best families. The mating plan accounts for inbreeding in bull selection and in individual cow matching. The selection determines the improving the productive and reproductive performances of the cows.

Many countries used animal model for genetic evaluation of cattle for the estimation of breeding values for reproduction traits.

The relative breeding values for the best cows and best sires were greater for Charolais breed than Limousine breed. A tool for improving the selection for age at first calving was genomic testing (Hutchinson et al. 2017). The selection for improve age at first calving improve the profitability. Earlier age at first calving was correlated with production and fertility traits (Hutchison et al. 2017).

Lopez-Parades et al. (2018) observed that the genetic correlation between the age at first calving and direct calving ease was positive and the correlation between age at first calving and calving interval was positive in Blonde d' Aquitaine beef population.

Bourdon et al. (2014) reported that the breeding values are the values of the relative genetic potential of a cow for a trait. The breeding values are estimated knowing records of the cows. Half of the cow's breeding value and half of sire breeding value are passed on the progeny (Bourdon et al., 2014).

#### CONCLUSIONS

The cows from our study have a good precocity. The mean age at the first calving was  $792.92 \pm 6.77$  days for Charolais breed and  $813.83 \pm 6.09$  days for Limousine breed. The heritability value for age at the first calving was 0.273 for Charolais and for Limousine breed was 0.275.

The cows with higher reproductive efficiency determine the high meat production and the profitability of farms.

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