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Genetic parameters for average daily gain and Kleiber ratio in Limousine breed

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ABSTRACT

The objective of the current paper was to estimate the genetic parameters for average daily gain from 200 days to 365 days and Kleiber ratio in Limousine breed with maternal animal model. The data were represented by performances of 871 Limousine fattening cattle/bulls represented by a mix of bulls and heifers. The pedigree consisted in 1865 cattle: 124 sires, 870 dams and 871 fattening cattle/bulls with performances. The data was provided by the Romanian Breeding Association for Beef Cattle, following results from the performances recordings. The direct breeding value of cattle was from -0.306 to 0. 366 kg for average daily gain between 200 days and 365 days, and maternal breeding value between -0.177 to 0.131. The direct breeding value of cattle for Kleiber ratio was between -0.271 and 0.264, and maternal breeding value were between -0.237 and 0.172. The direct heritability for average daily gain from 200 to 365 days was 0.661, the maternal heritability 0.253 and the total heritability 0.663. The direct heritability for Kleiber ratio was 0.507, the maternal heritability 0.364 and total heritability 0.504.

Keywords: breeding value, cattle, maternal animal model, genetic parameters

INTRODUCTION

Genetics and nutrition had an important role in the development and profitability of animal husbandry (Stoica, 1997). Limousine breed was an important beef breed in Europa. The breed was created in France where was the great effective of Limousine breed 1022000 cattle (Hristov et al., 2023). The breed was imported to numerous countries from Europe: Spain, Italy, Holland, Denmark, United Kingdon, Romania, Bulgaria. The demand for quality meat increased the Limousine breed was spread in other continents.

The advantages of Limousine breed were good conformation, good fertility, high conception rate, easy calving, a high quality of meat (Mirita, 1982). This breed assured productivity with low costs. Limousine breed assured a very good conversion of all feeds. The Limousine cows had a good milk yield. The main direction of breeding in Limousine breed was high quality meat production. In Romania there were favorable natural and socio-economic conditions for the intensification of beef production. The cattle had an important role in the realization of high-quality products for human nutrition from natural resources, natural pasture, a good correlation of vegetal production and animal production. Feed consumption was influenced by age. After weaning a high protein diet were maintained in the nutrition of calves which allowed for normal growth of calves (Stoica, 1997). Fattening cattle was aimed at increasing the quantity and to improve the quality of meat. Rations with higher energy value increased the rate of weight gain, even more so proportion of the concentrates increased in the ratio (Stoica, 1997). In the countries with intensive agriculture the most important system for fattening young cattle was intensive system. The intensive fattening system was characterized by an intense level of nutrition, with balanced and structured rations according to the specific requirements of each age stage (Mirita, 1982). Through intensive system, good quality meat was produced. The amount of dry matter ingested decreased as the growth, fattening stage advanced because it depended on the energy requirements for maintenance, which decreased proportionally with increasing body weight (Simeanu, 2012). The capacity to utilize feed or specific consumption was of particular importance. Specific consumption was interpreted through the prism of age and time dependent elements. It was desirable to valorize the cattle at highest body mass and at lowest possible age. In young cattle the main traits monitored took into account the rate of body mass accumulation and the feed conversion capacity which had implications for the techno-economic efficiency of production (Miriță et al., 1982). The factors which influenced the meat productions in cattle are: breed, individual, the genetic determinism of populations, the age, the sex, precocity, conformation, fattening' state, health' state, behavior, nutrition, maintenance system, the season of calving, climate (Miriță et al., 1982). It was necessary to assure optimal conditions for cattle to obtain high meat production. Beef breeds were characterized by high average daily gains. The farmers were focusing on fattening young bulls until they were 15-18 months old. Nutrition allowed the cattle to achieve their genetic production potential. The Kleiber ratio was a trait from the group of feed efficiency traits. Controlling meat performance involves controlling body weight gain, growth rate and feed consumption. In the breeding program of the Limousine breed followed the improvement of the body weight and growth rate. The objectives of the breeding programs for meat were the improvement of the body weight at different ages, precocity, growth gain, the

commercial quality of cattle, the quality of carcasses. The genetic gain was realized in great proportion by bulls. Since the Limousine breed was an improved breed, the reproduction was organized on the principle of functional stratification of farms, at the top elite farms and the bottom the commercial farms. Genetic progress was created at the level of elite farms, The commercial farms evolved genetically based on the bulls received from elite farms. For improvement the genetic gain used for reproduction bulls with high breeding values. For increase the profit of farms it was necessary to increase the investment in production process and by increase the quality of meat. The inclusion of average daily gain and Kleiber ratio information in selection of cattle would determine the genetic improvement of efficiency and profitability of meat beef production. This study had the aim the estimation of the genetic parameters for average daily gain from 200 days to 365 days and Kleiber ratio in Limousine breed with maternal animal model for selection.

MATERIALS AND METHODS

The data were represented by records of 871 fattening cattle/bulls. The pedigree consisted in 1865 cattle: 871 fattening cattle/bulls which had performances, the parents consisted of 870 cows and 124 bulls from Limousine breed. From 871 fattening cattle/bulls, the number of females was 624 and the number of males was 247. The data came from Romanian Breeding Association for beef cattle, from performances recording. The year when data were collected was 2022. The number of farms was 113. Average farm size was 7.707. The greatest farm had 86 cattle.

The estimation of variance components and genetic parameters was performed based on script (Grosu and Oltenacu, 2005) using maternal animal model with the software R 3.5.1.

The maternal animal model was (Mrode and Thompson, 2005):

y = Xb+Za+Wm+Spe+e

y = the vector of performances

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 residual effects.

X, Z, W and S were the incidence matrices that associate phenotypes to each type of effect considered.

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

A was the kinship matrix between animals;

I was the identity matrix;

σ^2_a=the additive genetic variance

σ^2_m, the variance of maternal genetic effects,

σ_{am}, the additive genetic covariance between the direct and maternal effects,

σ^2_{pe}= the variance of the permanent environmental effects,

σ^2_e= the variance of the residual error.

c^2= the ratio between σ^2_{pe} and σ_p^2

- the direct heritability $h_a^2 = \sigma^2_a / \sigma_p^2$,

σ_p^2 = phenotypic variance

- the maternal heritability $h_m^2 = \sigma^2_m / \sigma_p^2$
- 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)

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

The relative breeding value was:

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

BV% = relative breeding value

BV_{abs}= absolute breeding value

σ_{BVabs}= standard deviation of absolute breeding values

The traits studied were: average daily gain (ADG) between 200 and 365 days and Kleiber ratio (KR). The cattle were weighed 200 days and 365 days. The performance testing was done in accordance with ICAR regulations.

The Kleiber ratio at 365 days was estimated with formula:

$KR_i = ADG/BW^{0.75}*100$

ADG= average daily gain between 200 and 365 days

BW= the body weight at 365 days

After weaning, the calves were introduced to fattening. The fattening was realized in 4 phases in intensive system: suckling- weaning phase, growth phase, growth-fattening phase and fattening-finishing phase. In semi-intensive system the fattening was realized in three phases: quarantine and conditioning phase, growth fattening phase, finished phase. In extensive

system the fattening was from 10-12 months to 18-20 months. The level of nutrition of calves was established according to the planned growth rate using appropriate norms. In the winter season, the important feeds in this period were: good quality hays, pickled fodder and concentrates feeds. In the summer season in the nutrition of young cattle was green fodder, the maintenance on the pasture of cattle with concentrates supplements.

RESULTS AND DISCUSSION

The descriptive statistics for the analysed traits in Limousine breed are shown in the Table 1. The means of weight at 200 days, 220.090±1.19 and weight at 365 days, 374.599±1.720 from present study were lower than the values for body weight at 210 days and 365 days reported by Rezende et al. (2022) 247.73 respectively, 411.98. The Kleiber ratio at 365 days in present study 1.093±0.0068 was lower than the mean 1.14, the average daily gain between 200 days and 365 days 0.936±0.007 was also lower in our study than the mean 1.060 reported by Rezende et al. (2022) in Limousine breed. The metabolic live weight at 365 days in our study 85.003±0.292 was also lower than the value 91.91 kg obtained by Rezende et al. (2022) in Limousine breed. The values for means for body weight at 365 days, average daily gain and Kleiber ratio for Limousine breed in our study were higher than the values reported by Matos et al. (2018), the weight at 365 days 273.79 kg in Brahman cattle breed and the average weight gain from 205 days to 365 days 0.42 kg and Kleiber ratio at 365 days 0.61. In the analyzed population from present study there were individuals plus variants which have the average daily gain over 1.5 kg/day the maximum limit was 1.72 kg. The majority of plus variants were males but there were females which had the average daily gain over 1.5 kg. in the population was high variability for average daily gain.

Table 1. The means and standard error of mean (SEM), the standard deviation and coefficient of variability of traits

Trait	Mean ±SEM	Standard deviation	Coefficient of variability (%)
Weight at 200 days (kg)	220.090±1.19	15.974	35.159
Weight at 365 days (kg)	374.599±1.720	50.779	13.555
Average daily gain (kg/day)	0.936±0.007	0.232	24.809
Kleiber ratio (kg/kg$^{0.75}$)	1.093±0.0068	0.201	18.450
Metabolic live weight at 365 days	85.003±0.292	8.627	10.149

The higher average daily gain during the fattening period determined the shorter fattening period and this means a reduction in specific consumption, as a result reducing maintenance costs (Stoica, 1997). The feed was reached in protein because the appetite was influenced by the presence of protein. Fattening could be indirectly influenced by the preparation methods of the fibrous feeds used. Grinding and granulating fibrous feeds increased daily intake.

In the Table 2 are shown the statistics for studied traits for females and males. Using Student test showed that was very significant difference between means for males and females for growth rate between 200 days and 365 days, t calc>$t_{\infty;0.001,}$ 10.319>3.290. The sex of animal influenced the both traits. The very significant difference between means for females and males for Kleiber ratio was observed t calc>$t_{\infty;0.001,}$ 7.422>3.290.

Table 2. The average performances of females and males cattle

Trait	Mean ±SEM	Standard deviation	Coefficient of variability (%)
Females			
Weight at 200 days (kg)	216.42±1.373	34.312	15.854
Weight at 365 days (kg)	362.399±1.809	45.196	12.471
Average daily gain (kg/day)	0.884±0.008	0.204	23.109
Kleiber ratio (kg/kg$^{0.75}$)	1.061±0.007	0.189	17.861
Metabolic live weight at 365 days	82.940±0.309	7.738	9.330
Males			
Weight at 200 days (kg)	229.368±2.267	35.630	15.534
Weight at 365 days (kg)	405.421±3.253	51.135	12.612
Average daily gain (kg/day)	1.066±0.015	0.247	23.168
Kleiber ratio (kg/kg$^{0.75}$)	1.174±0.013	0.208	17.789
Metabolic live weight at 365 days	90.214±0.545	8.572	9.502

The highest breeding values of cattle are shown in the Table 3. The highest direct breeding value of the cattle had values between 0.340 and 0.366 for average daily gain and maternal breeding value varied between 0.121 and 0.131. For Kleiber ratio the highest direct breeding value of cattle ranged between 0.252 and 0.264 and the maternal breeding values were from 0.154 to 0.172.

Table 3. The highest absolute breeding value of the cattle

No	Direct breeding value of cattle for ADG	Maternal breeding value of cattle for ADG	Direct breeding value of cattle for KR	Maternal breeding value for KR
1	0.366	0.131	0.2642	0.172
2	0.357	0.131	0.2624	0.167
3	0.354	0.130	0.2617	0.166
4	0.351	0.128	0.2593	0.164
5	0.349	0.127	0.2591	0.162
6	0.345	0.125	0.2572	0.159
7	0.342	0.124	0.2557	0.159
8	0.341	0.122	0.2553	0.157
9	0.341	0.122	0.2547	0.156
10	0.340	0.121	0.2523	0.154

The relative highest breeding values for cattle for the traits are shown in the Table 4.

Table 4. The highest relative breeding value of the cattle for ADG and KR.

No	Relative Direct breeding value of cattle for ADG	Relative Maternal breeding value of cattle for ADG	Relative Direct breeding value of cattle for KR	Relative Maternal breeding value for KR
1	134.998	134.062	134.644	134.323
2	134.097	133.960	134.399	133.302
3	133.849	133.782	134.304	133.145
4	133.552	133.194	133.979	132.732
5	133.334	133.067	133.952	132.398
6	132.889	132.428	133.694	131.888
7	132.601	132.198	133.490	131.888
8	132.572	131.815	133.436	131.279
9	132.522	131.815	133.355	131.161
10	132.453	131.432	133.029	130.886

In the Table 5 are shown the components of variance and the genetic parameters for both traits in Limousine breed. The direct heritability and maternal heritability for Kleiber ratio from present study had higher values than the direct heritability reported by Rezende et al. (2022) 0.41, respectively 0.13. The value of heritability obtained in present study was

higher than the value reported by Koster et al. (1994) for Kleiber ratio for growth from 205 days to 365 days, 0.225 in Hereford cattle and the heritability value for Kleiber ratio at 365 days reported by Khobondo et al., 0.26. The direct heritability for average daily gain from our study was higher than the heritability obtained by Khobondo et al. (2022) for ADG 205-365 days 0.12.

Table 5. The genetic parameters for ADG and KR

Item	Average daily gain	Kleiber ratio
σ^2_a	0.023	0.015
σ^2_m	0.0088	0.011
σ_{am}	-0.0028	-0.0037
σ^2_{pe}	0.00005	0.000087
σ_e^2	0.000069	0.000081
σ_p^2	0.035	0.030
c^2	0.0014	0.0029
$\sigma_{am/}\ \sigma_p^2$	-0.08	-0.123
h_a^2	0.661	0.507
h_m^2	0.253	0.364
r_{am}	-0.202	-0.286
h_T^2	0.663	0.504

In the Table 6 are shown the genetic correlation between the direct breeding values for the traits analysed and the genetic correlation between maternal breeding values for two traits.
Both correlations were very high. The genetic correlation from present study was higher than the genetic correlation between average daily gain and Kleiber ratio reported by Mehrban et al. (2021)

Table 6. The genetic correlations between the direct breeding values for ADG and KR and between maternal breeding values for two traits

Item	The genetic correlation between direct breeding values for ADG and KR	The genetic correlation between maternal breeding values for ADG and KR
	0.995	0.998

CONCLUSION

In the Limousine breed the direct heritability for average daily gain from 200 to 365 days and Kleiber ratio was high and the maternal heritability for both traits was medium. The total heritability for both traits was high. The genetic correlation between direct breeding values of cattle and maternal breeding values for average daily gain and Kleiber ratio was very high. For improvement the meat production and feed efficiency the selection of the cattle with highest breeding values for average daily gain and Kleiber ratio was necessary in Limousine breed.

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