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RESEARCH ON MEAT PRODUCTION PARAMETERS IN STEER FATTENING AND THEIR IMPORTANCE FOR SIRES BREEDING VALUE ESTIMATION IN ROMANIA

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Abstract

The paper presents the genetic and phenotypic parameters for meat production characters using the results in progeny testing based on 1,705 half brothers offspring of 105 Friesian bulls from Romania. The live traits taken into account were weight at the age of 180 and 365 days, and weight daily gain during the period of fattening starting at the age of 2.5 months and ending at the age of 12-15 months of the steers. Taking into account that the fattening was made in 28 herds and the peculiarities of half sibs families, it was used a linear mathematical model for nested (hierarchical) classification. Weight at the age of 180 days registered 138.85±6.04 kg, weight at the age of 365 days was 293.41±1.04 kg in average and daily gain 881.977 ± 4.24 g/head/day. Heritability was h^2= 0.524 for weight at the age of 180 days, h^2= 0.642 for weight at the age of 365 days and h^2= 0.372 for daily gain. The correlations between weight at the age of 180 days and weight at the age of 365 days was r_G = - 0.287 and r_P = - 0.189, between weight at the age of 180 days and weight daily gain r_G = - 0.307 and r_F = -0.726, and between weight at the age of 365 days and weight daily gain r_G = 0.850 şi r_F =0.771. The meat production traits are closely related one to each other. Weight daily gain is substantially influenced by environmental factors. In practice, farmers should pay attention to live weight at various fattening stages and improve all the environment conditions in order to reach the weight daily gain as planned. In the breeding programmes, live characters are the most important ones and the steers month of birth needs to be corrected in order to precisely detemine sire position in the breeding pyramid.

Key words: *Friesian breed, meat production characters, Romania, steer fattening*

INTRODUCTION

The development of meat production in commercial fattening farms has to be based on breeding programmes which have to take into consideration the estimates of genetic and phenotypic parameters for the economic traits [1,4,6, 8,12,13,14].

The most important selection criteria commonly used in most breeding programmes for beef production are live weight at different ages (birth, weaning, post-weaning, various stages of fattening), weight daily gain [3,16,17,18,19,20,21, 22, 24, 26, 27, 28, 30, 35,36, 37, 38, 39].

Other selection criteria are carcass weight and its composition characters: meat share in carcass weight, muscle-bone ration, eye muscle surface, rib eye area, marbling score, dressing percentage, fat thickness [5,7,25,31].

Close relationships exist between live weight at different ages, daily gain and carcass components which is an opportunity to simplify the number of traits taken into consideration in breeding improvement [11].

This brings to the conclusion that it is not compulsory to apply multiple traits selection based on live and carcass characters and it is enough to be focused on live characters of beef animals.

The evaluation of meat production characters for beef bulls is achieved in the most of countries in test stations where standard growth conditions are assured in order to allow the comparison among various live records obtained by tested bulls and finally to identify the best ones [15, 29]

The last decades were marked by an increased attention paid to precision of statistical methods applied in breeding value estimation:

BLUP, mixed model, animal model [32,33,36].

In this context, the objective of this paper was to present the genotypic and phenotypic parameters of meat production traits for Friesian breed raised in Romania based on progeny testing for live weight at the age of 180 and 365 days and weight daily gain. Heritability, variances, co-variances among relatives, as well as correlations among the studied traits have been determined and differences were pointed out using Snedecor-Fisher and Bartlett Tests.

MATERIALS AND METHODS

A number of 1,705 half brothers descendants from 105 Friesian bulls in Romania were fattened in 28 specialized fattening units, existing in 18 counties of the country.

The young steers were born in an interval of maximum 60 days and fattening started at their age of 2.5-3 months and ended at the age of 12-15 monts.

During the testing period, the performance for the following meat production characters was registered: live weight at the age of 180 days and 365 days, as well as weight daily gain.

The calculated genetic parameters were heritability and correlations among various studied characters.

Their determination imposed the calculation of variances and co-variances.

The mathematical model used in this research is ***based on the nested (hierarchical)classification,*** because the estimation of the breeding value for sires is based on their offspring testing in the same herd, and has the following formula:

$$Y_{ijk} = \mu + a_i + b_{ij} + c_{ijk} \qquad (1)$$

where: k=1,2...., n_{ij}; j=1,2...., B_i; i=1,2,....,A.

$$\sum_j n_{ij} = n_i \quad \sum_{ij} n_{ij} = \sum_i n_i \approx n \sum B_i = B$$

This involves the existence of A groups of a_i. The unit a_i contains B_i units of b_{ij} (or the unit a_i contains n_i units of c_{ijk}) depending on the model as presented in Table 1.

Table 1. Block model for nested (hierarchical) classification

a_1	a_2	a_A
$b_{11}b_{12}....b_1B_1$	$b_{21}b_{22}....b_2B_2$	b_{A1} b_{A2}.......B_A B_A
$c_{111}c_{121}$....		
$c_{112}c_{122}$....		
$c_{113}c_{123}$....		
$c_{11n}c_{12n}$....		

The model used for the analysis of variance is given in Table 2.

Table 2.Analysis of variance for nested (hierarchichal) classification model

Variation source	DL	SS	SA	S^2
Total	N	$\sum_{ijk} Y_{ijk}^2$	-	-
Average	1	$\frac{Y^2...}{n}$		
a classes	A-1	$\sum_{ijk} (y_i. - y^2,,,)$	Ams	$S_c^2 + q_1 S_b^2 + q_2 S_a^2$
b classe	B-A	$\sum_{ijk} (Y_{ij}. - y_i...)^2$	Bms	$S_c^2 + q_o S_b^2$
c classes	n-B	$\sum_{ijk} (Y_{ijk}. - y_{ij}...)^2$	C_{ms}	S_c^2

$$q_0 = \frac{n - \sum_i \sum_{j...} \frac{n_{ij}^2}{n_i}}{B - A} = \sum_{ij} n_{ij}^2 f_{ij} \qquad (2)$$

$$q_1 = \frac{\sum_{ij} \left(\frac{n_{ij}^2}{n_i} - \frac{n_{ij}^2}{n}\right)}{A - 1} = \sum_{ij} n_{ij}^2 f_i \qquad (3)$$

$$q_2 = \frac{n - \frac{\sum_i n_i^2}{n}}{A-1} = \sum_i n_i^2 f_i \qquad (4)$$

where:

$$f_i = \frac{\frac{1}{n_i} - \frac{1}{n}}{A-1} \qquad (5)$$

$$f_{ij} = \frac{\frac{1}{n_{ij}} - \frac{1}{n_i}}{B-A} \qquad (6)$$

The data for the column S^2 and the coefficients q_0, q_1 şi q_2, will be obtained as presented below.
For the beginning to consider:

$$E(B_{ms}) = \frac{1}{B-A} E\left[\sum_{ijk}(y\cdot_{j.} - y_{i..})^2\right] = \frac{1}{B-A} E(\sum_{ij}\frac{Y_{ij.}^2}{n_{ij}} - \sum_i \frac{Y_{i...}^2}{n_i} =$$

$$= \frac{1}{B-A} E\left[Ei_j \frac{(n_{ij}\mu)^2 + n_{ij}a_i + n_{ij}b_{ij} + \sum_k {}_{cijk})^2}{n_{ij}} - \sum_i \frac{(n_i\mu + n_i a_i + \sum_t n_{it}b_{it} + \sum_{ts} c_{its})^2}{n_i}\right] \qquad (7)$$

Taking into account that $E_{(ai)} + E_{(bj)} + E_{(cijk)} = 0$ and that all the random variables are uncorrelated we will obtain:

$$E(Bms) = \frac{1}{B-A}(\sum_{ij}\frac{n_{ij}^2\mu^2 + n_{ij}^2 S_a^2 + n_{ij}^2 S_b^2 + n_{ij}S_c^2}{n_{ij}} - \sum_i \frac{n_i^2\mu^2 + n_i^2 S_a^2 + \sum_t n_{it}^2 S_b^2 + n_i S_c^2}{n_{ij}} =$$

$$= \frac{1}{B-A}(\ n\mu^2 + nS_a^2 + nS_b^2 + BS_c^2 - n\mu^2 + nS_a^2 - \sum_{it}\frac{n_{it}^2}{n_i} S_b^2 - AS_c^2) =$$

$$= S_c^2 + \frac{n - \sum_{it}\frac{n_{it}^2}{n_i}}{B-A} S_b^2 \quad (8) \quad q_o = \frac{n - \sum_{it}\frac{n_{it}^2}{n_i}}{B-A} = \sum_{ij}\frac{1}{B-A}(\frac{1}{n_{ij}} - \frac{1}{n_i})n_{ij}^2 \qquad (8)$$

Then, let's consider:

$$E(Ams) = \frac{1}{A-1)} E\left[(\sum_{ijk}(y_i ... - y...)^2\right] = \frac{1}{A-1} E\left[(\sum_i \frac{Y_{i...}^2}{n_i} - \frac{Y^2...}{n)}\right] =$$

$$= \frac{1}{A-1}(\sum_i \frac{n_i^2\mu^2 + n_i^2 S_a^2 + \sum_t n_{it}^2 S_b^2 + n_i S_c^2}{n_i} - \frac{n^2\mu^2 + \sum_i n_i^2 S_a^2 + \sum_{ij} n_{ij}^2 S_b^2 + nS_c^2}{n} =$$

$$= \frac{1}{A-1}\left[\sum_i n_i^2(\frac{1}{n_i} - \frac{1}{n})S_a^2 + \sum_{ij} n_{ij}^2(\frac{1}{n_i} - \frac{1}{n})S_b^2 + (A-1)S_c^2\right] \qquad (9)$$

The coefficients of S_a^2 and S_b^2 correspond to q_1 and q_2. if the average of the expected sqaures is equal to the square average and if the equations resulted are solved for S_a^2 , S_b^2 and S_c^2, these variances are the estimates of the analysis of variance and are unbiased.

For the other items taken into consideration in this study, the mathematical formulas are given below.

Heritability, $h^2 = \frac{V_A}{V_F}$ (10)

Heritability standard deviation, $S_{h2} = (h^2 + \frac{4}{n_i})\sqrt{\frac{2}{S}}$ (11)

Phenotypic correlation, $r_F = \frac{\text{cov}\, F_{XY}}{\sqrt{S^2_{FX_x} . S^2_{FY}}}$ (12)

Genotypic correlation, $r_G = \frac{\text{cov}_{G\,XY}}{\sqrt{S^2_{G_X} S^2_{GY}}}$. (13)

The homogenousness of the variances was checked using Snedecor-Fisher Test [9,10].

RESULTS AND DISCUSSIONS

Weight daily gain for the fattening period was in average 881.977 ± 4.24 g/head/day, ranging between the minimum value of 543.3 g/head/day and the maximum value of 1,128.5 g/head/day. This aspect proves thatthe Friesian young steers have a good growth and fattening capacity. The variation coefficient for this trait was low, accounting for 3.14 % (Tabel 3).

Table 3. Average and variability parameters for meat production traits registered by the fattened steers (N=1,705)

Meat production trait	$\overline{X} \pm s\overline{X}$	GSD	PSD	V (%)
Weight at the age of 180 days (kg)	138.050±6.04	219.519	249.386	19.31
Weight at the age of 365 days (kg)	293.410±1.04	34.364	42.863	4.33
Weight daily gain (g/head/day)	881.977±4.24	168.524	176.102	3.14

Source: Own calculations

Average and variability indicators for meat production traits

Weight at the age of 180 days registered 138.85±6.04 kg in average, ranging between 191.7 kg, the minimum value and 191.7 kg, the maximum value.The variation coefficient was 19.31 % (Tabel 3).

Weight at the age of 365 days was 293.41±1.04 kg in average, varying between 199.3 kg, the minimum value and 369.1 kg, the maximum value. The variation coefficient was very small, just 4.33 %, compared to the one registered by the steers weight at the age of 180 days. This reflects that at the age of 180 days the variabilitty of performances among individuals was higher, while at the age of 365 years, the steers live weight was more homogenous (Tabel 3).

Components of genotypic and phenotypic variance for meat production traits

Weight at the age of 180 days registered a share of the genotypic variance in the phenotypic variance of 52 %, reflecting that this character is genetaically determined in high measure.

Weight at the age of 365 days recorded a share of 63 % of genotypic variance in the total variance, also showing how important is the aditive effect of genes on this trait.

Weight daily gain recorded only a share of 37 % for the genotypic variance in the total variance, which means that this character is deeply influenced by environmental factors than by the genetic differences.

Heritability of meat production traits

Weight at the age of 180 days registered a heritability of h^2= 0.524$^{\pm}$0.072, reflecting the strong aditive action of genes in the determination of this trait.

Weight at the age of 365 days recorded a heritability of h^2= 0.642$^{\pm}$0.088, a high value, but smaller than in case of the weight atthe age of 180 days.

The values of the heritability at the age of 365 days are similar with the ones found by Cundiff (h^2=0.56), but different from the ones found by Negrutiu et al. in 1975 (h^2=0.37), Muresan in 1983 (h^2=0.21) for Friesian breed [11, 22, 23].

Also, some smaller values for the heritability ofthis character were found by Baldi et al.,, 2012 (h^2=0.18-0.30), Schenkel et al.,, 2002, (h^2=0.32-0.40), Nephawe et al., 2006 (h^2=0.22-0.31), Vostry et al., 2009 (h^2=0.15-0.57). [3, 24, 29, 35]

Weight daily gain had the lowest heritability compared to the live weights, only h^2= 0.372$^{\pm}$0.051 reflecting that this character is mainly determined by the action of the environment conditions (Table 5).

Table 4. Phenotypic and genotypic variances for meat production characters

Trait/ Variance	Weight at the age of 180 days	Weight at the age of 365 days	Weight daily gain
Among sires (S_T^2)	$\frac{11060,751}{13,118}$	$\frac{295,229}{16,068}$	$\frac{8829,496}{9,302}$
Among herds-years (S_F^2)	$\frac{12047,200}{14,288}$	$\frac{929,319}{50,580}$	$\frac{71000,168}{74,806}$
Among half brothers (S_D^2)	$\frac{61207,200}{72,594}$	$\frac{612,747}{33,352}$	$\frac{15082,554}{15,892}$
Phenotypic variance (S_F^2)	$\frac{84315,151}{100,000}$	$\frac{1837,295}{100,000}$	$\frac{94912,218}{100,000}$
Genotypic variance (S_G^2)	44243,004	1180,916	35317,985

Source: Own calculations

Table 5.Heritability and its error for meat production characters

Meat production character	$h^2 \pm S_h^2$	
Weight at the age of 180 days	0.524	0.072
Weight at the age of 365 days	0.642	0.088
Weight daily gain	0.372	0.051

Source: Own calculations

The values of heritability estimated for weight daily gain are smaller compared to the ones calculated by Averdunk, 1968 (h^2=0.5), Calo et al., 1973 (h^2=0.44), Negrutiu (h^2=0.44), Vesela (h^2=0.5). [2, 6, 23, 34]

Phenotypic and genotypic correlations between meat production traits

The correlations were calculated based on the variances and co-variances between various pairs of traits. In this respect, firstly, it was needed to calculated the components by source of variation (Table 6).

Genotypic and phenotypic correlations reflect the links between various pairs of traits and this important for the selection practice. The changes of a character or another attract substantial changes upon the other considered traits.

In order to present the sense and intensity of the links between various pairs of meat production characters, it was needed to also determine the coefficients of genotypic and phenotypic correlation. ***Correlation between weight at the age of 180 days and weight at the age of 365 days*** was (r_G = - 0.287 and r_P = - 0.189), a weak and negative value reflecting that the change of this character has a low impact on the change of the other trait.

Between ***weight at the age of 180 days and weight daily gain,*** the correlation was also a negative one, but its value was higher than in first case. Thus, r_G = - 0.307 indicated a weak intensity and of a different sense between the two traits, while the phenotypic correlation r_F = -0.726, showed that between these two characters there is a strong relationship to the environment conditions.

Both genotypic and phenotypic correlations between weight at the age of 365 days and weight daily gain recorder high values, r_G = 0.850 şi r_F =0.771, reflecting a substantial positive influence between these two characters. For this reason, from a practical point of view, selection should be focused just on only one of these characters in order to improve the other one. (Table 7).

These values for the genptypic correlations are in accordance with the ones found by Schenkel et al.,, 2002 r_G =0.86-0.99 and Baldi et al., 2012 r_G =0.78-0.98 [3, 29].

Table 6. Components of variance by various pairs of meat production traits

Co-variance/ Pairs of traits	Between sires Cov_T	Between herds $Cov_{F.}$	Between half brothers Cov_D	Phenotypic co-variance Cov_F	Genotypic co-variance Cov_G
Weight at the age of 180 days x Weight at the age of 365 days	969.804	-941.250	-631.069	2,542.123	3,879.216
Weight at the age of 180 days x Weight daily gain	3,000.826	-2,845.446	-3,341.778	9,188.050	12,003.304
Weight at the age of 365 days x Weight daily gain	2,323.398	1,260.794	2,236.466	5,820.658	9,293.592

Source: Own calculations

Table 7.Genotypic and phenotypic correlations between various pairs of meat production traits

Genotypic correlations		Traits	Phenotypic correlations	
0.850	-	Live weight at the age of 365 days	-	0.771
-0.307	-0.287	Live weight at the age of 180 days	-0.189	-0.726
Daily Gain	Live weight at the age of 180 days	-	Live weight at the age of 180 days	Daily Gain

Source:Own calculations

Analysis of variance using Snedecor-Fisher Test

Making the comparison between the F statistics obtained for each character with the F value from tables for different probabilities P=0.05, P = 0.01 and P=0.001, one can notice that the variances are not homogenous, therefore the nule hypothesis H_0 can not be accepted, on the contrary, we have to accept the true hypothesis H_1. As a result, the two factors taken into account have a substantial influence on the slection characters for meat production.

The results of the Bartlett Test applied on the variances from a month to another, caused by the systematic factors taken into account, are given in Table 9.

Table 8.Analysis of variance for Snedecor-Fisher Test for meat production characters

Source of variation	DL	SS	SA	F
Weight at the age of 180 days				
Global variance among groups	11	176,895.808	16,081.437	-
Error	1,693	930,328.734	549.514	-
Total	1,705	1,107,224.543	-	29.264
Weight at the age of 365 days				
Global variance among groups	11	330,116.834	30,010.621	-
Error	1,693	2,756,033.555	1,627.899	-
Total	1,705	3,086,150.390	-	18.435
Weight daily gain				
Global variance among groups	11	4,164,207.530	378,564.320	-
Error	1,693	48,049,421.629	28,381.229	-
Total	1,705	52,213,629.159	-	13.338

Source: Own calculations

Comparing the calculated B statistic with the tabled one, we may see non significant differences.

The conclusion is that the characters are deeply influenced by the steers month of birth. Correction factors for the steers month of birth are needed to increase the accuracy of the data which are later used in the sires breeding value estimation based on their half brothers performances in meat production.

Table 9. Calculated B value compared to the critical interval for various probabilities

Selection character	Calculated B	Critical interval for:		
		P=0.05	P=0.01	P=0.001
		18.30-21.02	23.20-26.21	29.58-32.90
Weight at the age of 180 days	77,716	No	No	No
Weight at the age of 365 days	48,215	No	No	No
Weight daily gain	160,940	No	No	No

Source: Own calculations

CONCLUSIONS

Meat production characters studied within this research work: weight at the age of 180 days and 365 days and weight daily gain as well are closely related one to each other and are very important for the practice of selection.

The heritability recorded higher value compared to other authors and reflect the aditive influence of genes, that is, they could be successfully used in selection. The values of the genotypic parameters determined in this study are close to the one found by other foreign and Romanian authors. Weight daily gain is substantially influenced by environmental factors, so that it is wiser to include in the breeding programmes mainly characters linked to live weights at different ages which have a better response to selection. Also, from a practical point of view, this is a reason reason to recommend farmers to pay attention to live weight at various fattening stages and improve all the environment conditions in order to reach the weight daily gain as planned.

In the breeding programmes, it is enough to make selection based on live characters of meat production because their improvement with have a benefic effect on the other meat production traits. Also, the steers month of birth is very important to be taken into consideration because it could lead to error in sires breeding value estimation. For this reason, correction factors for the steers month of birth are imposed to be used in order to increase precision in breeding value evaluation and assure a correct sire hierachization.

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