Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 14, Issue 3, 2014
PRINT ISSN 2284-7995, E-ISSN 2285-3952

RESEARCH ON THE BREEDING VALUE ESTIMATION FOR BEEF TRAITS BY A SIMPLIFIED MIXED MODEL

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Abstract

The paper purpose was to apply a simplified mixed model BLUP for estimating bulls' breeding value for meat production in terms of weight daily gain and establish their hierarchy, Also, it aimed to compare the bulls' ranging obtained by a simplified BLUP mixed model with their hierarchy set up by contemporary comparison. A sample of 1,705 half sibs steers, offspring of 106 Friesian bulls were used as biological material. Bulls' breeding value varied between + 244.5 g for the best bull and -204.7 g for the bull with the weakest records. A number of 57 bulls (53.77%) registered positive breeding values. The accuracy of the breeding value estimation varied between 80, the highest precision, in case of the bull number 21 and 53, the lowest precision, in case of the bull number 38. A number of 7 bulls of the total of 57 with a positive breeding value were situated aproximately on the same positions at a difference of 0 to 1 points on the both lists established by BLUP and contemporary comparison. As a conclusion, BLUP could be largely and easily applied in bull evaluation for meat production traits in term of weight daily gain, considered the key parameter during the fattening period and its precision is very high, a guarantee that the bulls' hierarchy is a correct one. If a farmer would chose a high breeding value bull from a catalogue, he could be sure of the improvement of beef production by genetic gain.

Key words**:** *breeding value estimation, bulls ranging, meet production traits, simplified mixed model*

INTRODUCTION

Selection of the best animals, needed to induce genetic gain, requires to estimate their breeding value, which allows to establish their ranging according to their genetic superiority.
The accuracy of the breeding value estimation is the key aspect to which many researchers paid attention. The precision depends on the number of measurements, number of offspring and heritability of the traits. The higher the number of measurements, the number of descendants and heritability, the higher the accuracy of the breeding value [22].
The best modern method considered to assure a correct estimation of the breeding value with the highest precision is BLUP Animal Model and its present variants. The mixed model BLUP was established by [20,21] and later it was improved by other researchers. It is a linear unbiased mathematical model destined to minimize the error of breeding value estimate.
Its advantages consists of: (a) the reduction of time and cost of the data processing, (b) the reduction of the error of breeding value estimate, (c) the increased accuracy of the breeding value estimate, (d) the facilitation of the assessment of breeding value of sires and dams based on the records used for family selection, (e) the facilitation of an increased selection precision due to the use of multi trait genetic and environment correlations between various characters [9,31,32,41,56].
BLUP is widely used to estimate breeding value in various animals species and breeds: in dairy cattle [1,4,6,14,26,33,34,37,45,46,50], in beef cattle [3,7,12,13,16,35,37,39,42,43], in swine [5,25,38], in poultry [27,54], in horses [2,48,57], in sheep and goats [3,10,18,53], in fishes [29,47], in honey bee [8], in dogs [23]. Also, this subject was theoretically approached by many other authors [28,40,44,51]. Due to its advantages, BLUP was also used in the prediction of breeding value and estimation of single nucleotide

polymorphism (SNPs) [1,17, 30], in cross under dominance [24], in small populations with long-term objectives where selection procedures put less emphasis on family information [52], in the field of ecology to estimate the genetic component of phenotypic variation as a tool for ecologists [55].

The use of BLUP was also successfully extended to plant breeding and variety testing [36].

During the last half of century, animal and plant production carried out remarkable records by means of the genetic improvement [15,16,49].

The evolution mathematical models used in breeding value estimation was marked by the substantial contribution given by two researchers: Charles Henderson, who established BLUP mixed models and Robin Thompson, who sustained the Residual Maximum Likelihood (The REML), a method for variance component estimation [15,19,49].

The BLUP implementation was facing difficulties due to the limitations of the computers performance in the period 1972-1995. Later, it has been easily applied due to the performance registered in the field of computing techniques and equipment.

In the field of cattle breeding, BLUP was successfully used for the evaluation of many breeds such as Angus, Hereford, Polled Herford, Shorthorn, Limousin, Red Angus in the USA based on various sire models (1971-1984). After 1984, the BLUP model included the additive maternal effect [7,16]. Later, the RAM models (reduced animal models) were largely used based on birth weight and weaning weight as well as weaning weight and post weaning weight [49].

In this context, the paper approached the topic of breeding value estimation for beef production traits of Friesian bulls using a simplified mathematical model of BLUP in Romania, where contemporary comparison was applied for a long period.

MATERIALS AND METHODS

In order to set up this research work, a sample of 1,705 half sibs steers, offspring of 106 Friesian bulls were used as biological material. The bulls were randomly selected and it was considered that there is no relationship between them.

The sire breeding value estimation was based on the records of their offspring during the fattening period, in term of weight daily gain, considered one of the main selection characters.

The breeding value was assessed using a simplified BLUP mixed model, a linear mathematical model having the form:

$Y_{ij} = \mu + s_i + e_{ij},$ (1)

where Y_{ij} = the record of the j offspring of the bull i, μ is a fixed unknown parameter, $s_i = ½ g_i$, where: g_i – the „i" bull's breeding value (j=1, ..., n_{ij}), e_{ij} = the residual effect, s and e are non correlated variables among them with the averages equal to zero and variances $\sum_s^2$ and $\sum_e^2$.

Considering $\sum(e_{ij}) = 0, \text{cov}(e_{ij}, e_i, j,) = o$, if i ≠ i', or at least j ≠ j' and $\sum_{ij}^2 = \sum_e^2$. The linear model does not suppose that bulls are relatives among them, $\text{cov}(s_i, s_i) = 0, \sum_{si}^2 = \sum_s^2 = 1/4 \sum_A^2$.

Considering that n_i represents the number of decendants of the "i" bull, then the equations of the mixed model are:

$$\begin{bmatrix} n & n_1 & n_2 & \cdots \\ n_1 n_1 + \sum_e^2 / \sum_s^2 & & 0 & \cdots \\ n_2 & 0 & n_2 + \sum_e^2 / \sum_s^2 & \cdots \\ \cdots\cdots & \cdots & \cdots & \cdots \end{bmatrix} \begin{bmatrix} \mu \\ s_1 \\ s_2 \\ \cdots \end{bmatrix} = \begin{bmatrix} y.. \\ y_1 \\ y_2 \\ \cdots \end{bmatrix}$$

(2)

The breeding value of the "i" bull, s_i, will be:

$s_i = 2(n_i/n_{i.} + a)(y_{i.} - \mu)$ (3)

where: s = $\sum_e^2 / \sum_s^2$. If we consider $n_i/(n_i.+a) = w_i$, then $\bar{\mu} = \sum w_i \bar{y}_{i.} / \sum w_i$.

The precision of the estimated breeding value, R^2, was calculated using the formula:

$$R^2 = w_i - \frac{w_i}{\sum w_i} \quad (4)$$

When n_i has a high value, then $R^2 = w_i(1 - \frac{1}{\sum w_i})$, unde $\sum w_i$ goes to infinity and $1/\sum w_i$ goes to zero.

This simplified mixed model was utilized for estimating the bulls breeding value and its precision for daily gain.

The estimated breeding value allowed to establish the bulls hierarchy. The results were compared to the bulls' classification based on the contemporary comparison.

The rank correlation between the two classifications of the bulls was calculated according to the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)} \quad (5)$$

The correlation significance was tested for the probabilities P = 0.05 and P = 0.01, using Fisher Test.

RESULTS AND DISCUSSIONS

Bulls' breeding value varied between + 244.5 g for the best bull and -204.7 g for the bull with the weakest records.

Of the total of 106 bulls evaluated in this experiment, 57 bulls (53.77%) registered positive breeding values, being situated over the average of the sample. The best bull for improving meat production in terms of weight daily gain recorded + 244,5 g and the bull situated on the last position as improver + 2.2.g (Table 1).

The accuracy of the breeding value estimation varied between 80, the highest precision, in case of the bull number 21 and 53, the lowest precision, in case of the bull number 38. It deserves to mention that the breeding value of the bull with the number 21 was estimated based on its 30 offspring, while the breeding value estimated in case of the bull number 38 was calculated only based of the records coming from 8 descendants.

The precision values could be explained by the fact that they depended on the offspring group size per bull, which varied between the optimum limitations, minimum 8-10 descendants per bull.

Table 1.Bulls' breeding value and its precision for meat production trait-weight daily gain- Simplified mixed model BLUP

Bull number	Number of offspring	Breeding Value +BV	Accuracy R^2
1	22	244.5	75
2	28	181.2	79
3x	17	174.5	70
4x	18	168.2	71
5x	13	162.6	64
6x	18	156.3	71
7x	12	150.1	62
8	23	149.3	76
9	14	113.4	66
10	22	112.2	75
11	12	109.5	62
12	11	108.1	60
13	15	98.6	67
14x	20	98.2	73
15	15	93.5	67
16	22	84.0	75
17	13	82.5	64
18	14	81.6	66
19x	15	75.9	67
20	9	74.0	55
21	30	72.9	80
22	16	72	69
23x	12	64.9	62
24	13	64	64
25	12	63.8	62
26	32	61.4	81
27	16	60.6	69
28	17	58.8	70
29	14	54.0	68
30	25	50.2	77
31	21	50	74
32	24	44.6	76
33	23	43	76
34	10	42.2	58
35	16	41.6	69
36	20	40.6	73
37x	16	39.4	69
38	8	37.6	53
39	24	30.5	76
40	17	23.7	70
41	15	21.5	67
42	13	21.4	64
43x	11	21.1	60
44	15	16.3	67
45	11	15.8	60
46	17	14.2	70
47	12	13.0	52
48	21	12.8	74
49	23	11.4	76
50x	12	10.4	62
51	15	8.8	67
52	14	7.1	66
53	16	6.5	69
54	13	4.9	64
55	13	4.0	64
56	15	2.3	67
57	13	2.2	64

Source: Own calculations

Bulls' classification based on the simplified mixed model BLUP and contemporary comparison

Table 2. Comparison between bulls' hierarchy according to their breeding value calculated by the simplified mixed BLUP model and their classification established by contemporary comparison

Bull number	Position occupied according to the method used for breeding value estimation	
	Simplified BLUP mixed model	Contemporary comparison
1	1	19
2	2	20
3xx	3	3
4x	4	5
5	5	2
6	6	10
7x	7	6
8	8	37
9	9	14
10	10	18
11	11	27
12	12	1
13	13	38
14	14	11
15	15	31
16	16	21
17	17	28
18	18	30
19x	19	17
20	20	12
21	21	34
22	22	16
23x	23	22
24	24	15
25	25	53
26	26	44
27	27	35
28	28	32
29	29	4
30	30	46
31	31	9
32	32	47
33	33	50
34	34	24
35	35	43
36	36	51
37x	37	39
38	38	33
39	39	57
40	40	54
41	41	55
42	42	48
43	43	45
44	44	23
45	45	36
46	46	26
47	47	40
48	48	8
49	49	56
50x	50	48
51	51	7
52	52	13
53	53	41
54	54	25
55	55	29
56	56	42
57	57	52

Source: Own calculations

Based on the breeding value estimated by the simplified mixed model BLUP, the bulls were classified in the decreasing order.

Also, their breeding value was calculated by means of the contemporary comparison and again the bulls were classified according to the results obtained by the application of this method.

The comparison between the bulls' classification based on the breeding value calculated by means of the mixed model BLUP and the bulls' hierarchy established based on the contemporary comparison showed that the bulls occupied different positions on the two classification lists because we used two different methods to determine their breeding value.

But, if we look at the first 10 bulls situated on the list established based on the breeding value calculated by the simplified mixed model BLUP, we can select 5 bulls which have almost similar positions on the other list, where their breeding value was calculated by contemporary comparison.

If we take into consideration all the 57 bulls able to improve weigh daly gain, we may notice that 7 bulls are situated aproximately on the same positions on the both classifications at a difference of 0 to 1 positions. It is about the bulls with the number: 3,4,7,19,23,37 and 50. (Table 2).

The rank correlation between the positions occupied by bulls on the two classifications based on the breeding value, calculated by means of two methods: simplified mixed model BLUP and contemporary comparison, was r = 0.569, substantially significant for P=0.05 and P=0.01, meaning that the use of BLUP modifies in a small measure the positions occupied by bulls in the hierarchy established by means of contemporary comparison.

Crettenand (1975) found closer correlations between these positions, but he considered that BLUP has a higher precision which reflects its superiority compared to contemporary comparison [11].

CONCLUSIONS

BLUP could be largely and easily applied in bull evaluation for meat production traits in term of weight daily gain, considered the key parameter during the fattening period.

The method assured a high precision ranging between 53 and 80, depending on the number of offspring per bull.

However, it would be better to proceed to the bull selection based on a multiple trait model where many other characters to be taken into consideration such as: body weight at the age of 180 days, body weight at the age of 365 days, and carcass characters as well. Only in this way, breeding value estimation could be more precisely determined. The more characters considered, the higher accuracy in breeding value estimation.

ACKNOWLEDGMENTS

The author thanks the farmers where the bulls' descendants were tested for weight daily gain and for their kindness to deliver the data needed to estimate the breeding value of the sires.

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