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Mathematical Prediction Of Breeding Value In Sheep,

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ABSTRACT

The most effective assessment of manufacturers is possible using a mixed biometric model, which allows taking into account the influence of the genotype and the environment at the same time. At the same time, this approach makes it possible to identify the environmental effects that have a significant impact on the descendants of the same producer. The traditional method based on the use of a mixed biometric model is widely used in livestock industries associated with cattle breeding. As for sheep breeding, in this branch, this method is represented more modestly. It is possible that this is due to the large population of the studied herds. The study of groups of descendants of several hundred heads imposes serious requirements on the quality of the collection of basic data and leads to a sharp increase in the volume of matrix calculations. At the same time, a wide choice of modern mathematical packages allows the breeder to independently carry out mathematical calculations, without resorting to the help of specialists: mathematicians and programmers. At the same time, independent study of such software products in modern conditions is not difficult. In the present work, the evaluation of the breeding value of producing rams was carried out on the basis of measurement data of economically useful traits of their descendants. Produced ranking of producers for breeding value for each trait. In this case, the ranking was carried out taking into account the effect of the herd effect and without taking this effect into account. It is shown that taking into account the influence of the environment is necessary in the case when the descendants of the same producer are in different herds. It has been established that the use of mathematical packages like MATLAB will allow solving selection problems most efficiently and quickly.
Keywords: animal breeding, genetic groups, estimated effects, system of equations

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INTRODUCTION

The goal of any breeding program is the maximum possible realization of the genetic potential of animals of any population according to its economically useful characteristics. This task can be successfully solved only when using animals with high genetic value in breeding [2, 3, 5, 7, 8, 9, 10]. One of the ways to identify the breeding value of animals is their assessment by the value of economically useful traits (HSP) of their descendants [4, 6].

Modern mathematical methods of breeding evaluation involve the use of a mixed biometric model, which is characterized by operations with large volume matrices. In this case, the dimension of the matrices used is directly proportional to the number of heads in the sample of animals under study. The mixed biometric model involves taking into account the influence of the environment on the values of HPP estimated group of producers. Such methods of breeding evaluation for a long time used in a number of livestock industries. At the same time, in sheep farms, due to the large population of herds, mathematical methods for predicting the breeding value of animals, involving complex calculations, are used poorly or not at all.

MATERIALS AND METHODS

It was necessary to determine the breeding value of a sample of seven producing rams based on the analysis of the values of the HSP of their descendants. Live weight and nesting of wool beetles are taken as HBP. The set of 264 descendants placed in two herds (h_1 and h_2) was analyzed. Manufacturers denote S_1, S_2, S_3, S_4, S_5, S_6 and S_7. All manufacturers are divided into 3 genetic groups by year of birth (g_1, g_2, g_3), i.e. rams born in the same year are combined into one genetic group.

RESULTS AND DISCUSSION

The distribution of descendants by herds and producing rams (fathers) by genetic groups is presented in table 1. From the presented data it can be seen that the number of both herds is the same. The g_1 genetic group includes rams S_1 and S_2, the g_2 group includes rams S_3 and S_4, and the g_3 group includes rams S_5, S_6, and S_7. As noted above, genetic groups were represented by year of birth. The difference between the groups was 1 year. There is no affinity between producers.

Table 1: Distribution of descendants by herds and fathers by genetic groups

№ herd *h*	Genetic group of sheep-rams (fathers)						
	g_1		g_2		g_3		
	Father' number (*S*)						
	S_1	S_2	S_3	S_4	S_5	S_6	S_7
1	8	25	31	0	24	28	16
2	31	17	0	38	14	11	21
In total in 2 herds	39	42	31	38	38	39	37
Total group	81		69		114		

The mathematical model of the breeding assessment of producing sheep is a system of equations, which is written in the matrix form as follows [1]:

$$\begin{bmatrix} X' \cdot X & X' \cdot Z \\ Z' \cdot X & Z' \cdot Z + \lambda A^{-1} \end{bmatrix} \cdot \begin{bmatrix} \hat{\beta} \\ \hat{u} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}, \qquad (1)$$

X and *Z* – matrixes of estimated effects;

y – productivity vector of descendants in HSP terms;

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$\hat{\beta}$ – vector estimates of the herd and genetic groups;

$\hat{u}$ – producer effect ratings vector;

A – producer kinship matrix;

λ– random effects variance.

Matrix *X* has dimension *N* x *L*, where's *N* – total number of descendants, *L*=*m*+*f* (herd number (*m*) + number of genetic groups (*f*)). In each row of the matrix *X*contains only two units (belonging to the herd and to the genetic group), the remaining values – 0.

Matrix *Z* has dimension *N* x *k*, where's *k* – the number of manufacturers of rams. In each row of the matrix*Z*only one unit (belonging to the father), the rest – 0.

Column vector elements *y*, having*N*elements are the deviations of the HSP values of each descendant from the average value of this attribute in the entire sample:

$$t'_i = \left(t_i - \overline{t}\right)\frac{\sigma_b}{\sigma}, \qquad (2)$$

t_i – HSP value of i-th descendant;

$\overline{t}$ – average value of HSP in the sample;

σ_b, σ – RMS of an economically useful feature in the baseline and study period.

The variance of random effects is determined by the expression:

$$\lambda = 4/h^2 - 1, \qquad (3)$$

h^2 – the coefficient of heritability of HSP. In the framework of this work, the coefficient of heritability in terms of live weight was taken to be 0.35, and that of hair was 0.20.

The result of the solving system (1) is a column vector of *Q* estimates, containing estimates of the herd effect, estimates of the effect of genetic groups, and estimates of each producer ram.:

$$Q = \begin{bmatrix} \hat{\beta} \\ \hat{u} \end{bmatrix} = \begin{bmatrix} \hat{h}_1 & \hat{h}_2 & \hat{g}_1 & \hat{g}_2 & \hat{g}_3 & \hat{S}_1 & \hat{S}_2 & \hat{S}_3 & \hat{S}_4 & \hat{S}_5 & \hat{S}_6 & \hat{S}_7 \end{bmatrix}^T \qquad (4)$$

The tribal value of the manufacturer BV_k without taking into account the influence of the environment (herd effect) is defined [1] as twice the sum of the estimate of the effect of the genetic group and the rating of the producer belonging to this group:

$$BV_k = 2\left(\hat{g}_f + \hat{S}_{fk}\right) \qquad (5)$$

Differences between the estimates of the two manufacturers R_{kk} or the superiority of one manufacturer over the other are determined by the expression:

$$R_{kk'} = \left(\hat{g}_f + \hat{S}_{fk} \right) - \left(\hat{g}_{f'} + \hat{S}_{f'k'} \right) \quad (6)$$

Evaluation (5) does not take into account the effect of the herd. At the same time, a situation may arise where the conditions of detention and the environment will have a significant impact on the evaluation of the breeding value of the animal. It should be borne in mind that different herds contain a different number of descendants of the same ram-producer. In this case, it is necessary to take into account this number. Then the expression (5) to assess the breeding value, taking into account the influence of the herd, will take the form:

$$BV_k^C = 2\left(\hat{g}_f + \hat{S}_{fk} + \sum_{i=1}^{w} u_i^k \cdot \hat{h}_i \right), \quad (7)$$

u_i^k –the proportion of descendants of the *k*-th father in the *i*-th herd, defined as

$$u_i^k = K_i^k / K_k, \quad (8)$$

K_i^k – the number of descendants of the *k*-th father in the *i*-th herd;

K_k – The total number of descendants of the *k*-th father.

Differences between the estimates of the two manufacturers, taking into account the impact of the herd $\Delta R_{kk'}^C$, taking into account (8) are determined by the expression:

$$\Delta R_{kk'}^C = \left(\hat{g}_f + \hat{S}_{fk} + \sum_{i=1}^{w} u_i^k \cdot \hat{h}_i \right) - \left(\hat{g}_{f'} + \hat{S}_{f'k'} + \sum_{i'=1}^{w'} u_{i'}^{k'} \cdot \hat{h}_{i'} \right). \quad (9)$$

To compile and solve the system of equations (3), the integrated mathematics package MATLAB was used. To solve the system, the QR decomposition method was used. The results of solving the system (3) are presented in tables 2 and 3.

As can be seen from the data in Tables 2 and 3, the environment (the herd effect shows just that) has a rather significant effect on the producers' assessment.

Table 2: Breeding assessment of producers and their ranking in live weight of descendants

Breeding assessment without the effect of the herd							
Rammaker	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Evaluation	17,160	16,443	26,941	37,014	14,035	15,253	18,085
Rating	4	5	2	1	7	6	3
Breeding assessment with the effect of the herd							
Evaluation	-7,591	-2,619	13,784	9,271	-4,497	-2,018	-3,351
Rating	7	4	1	2	6	3	5

Table 3: Breeding assessment of manufacturers and their ranking by cutting descendants of wool

Breeding assessment without the effect of the herd							
Rammaker	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Evaluation	-0,361	-0,388	-0,381	0,078	-0,159	-0,207	-0,360
Rating	5	7	6	1	2	3	4
Breeding assessment with the effect of the herd							
Evaluation	-0,282	-0,079	0,167	0,035	0,171	0,174	-0.148
Rating	7	5	3	4	2	1	6

If all the descendants of the estimated group of producing sheep are in the same herd, the rating, taking into account the effect of the herd and without taking into account the effect of the herd, remains unchanged. The data of tables 2 and 3 show that taking into account the effect of the herd (environmental effect) is necessary for accurate prediction of the breeding value of animals in cases where the conditions of the offspring of these animals will differ.

CONCLUSION

Based on the study, it can be concluded that the application of the mathematical prediction method of breeding value based on a mixed biometric model will more accurately determine the rank of each producer in the general list, as well as identify the influence of the environment on the value of the economically useful characteristics of the descendants of the group of producers under study. It should be noted that the quality of the forecast will most depend on the completeness and accuracy of the collection of baseline data, as well as on the weighted approach and the rigorous justification of the distribution of producers to genetic groups.

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