Applying Methods of Mathematical Modeling in Cattle Breeding

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Abstract: In this manuscript has presented the results of applying modern methods of mathematical modeling in animal husbandry. To conduct the research has used the method of least squares, which has reflected in the work by approximation probabilistic non-linear relations, making it possible to establish the relationship between different measurements the body parts of animal and meat productivity, and linear measurements of the udder.

Keywords: mathematical modeling, hyperbolic model, multiple regressions, measurements the body parts.

I. INTRODUCTION

Expediency of wide application of mathematical modeling at studying of interrelations between investigated signs is obvious. The analytical form of the representation of the revealed regularities in biological processes has a number of important advantages in comparison with the tabular. A mathematical model constructed in the form of a formula that establishes a quantitative relationship of independent arguments with the function, allows more accurately describe the processes under investigation, make this description more visible and convenient for later analysis. In some cases, the form of the expression of dependence makes it possible to significantly reduce the volume of field experiments, reduce their labor intensity [4, 5, 7]. For example, having constructed the function of connection of complex parts for the natural measurement of parts of an animal's body, it becomes possible in specific economic cases to refuse measurements of this parameter [8, 9, 11].

II. MATERIALS AND METHODS

The most convenient for practical use and, at the same time, universal mathematical method of a given empirical series is the method of least squares. It provides the formation of functions, squares of deviation from the empirical values give the smallest sum. The algorithm for applying this method depends on the complexity of the structure of the function, that is, on the number of parameters sought and the number of independent arguments.

The above method was decided to be tested on several zootechnical indicators of various types of farm animals. The object of the studies described in this article were measurements of the udder in a cow and the meat qualities of bull calves.

III. RESULTS AND DISCUSSIONS

Simulation of linear characteristics of udders in cows. The udder circumference is statistically reliably associated with the dairy productivity of cows. According to several authors [1, 2, 3, 6], the correlation coefficient for individual cattle populations ranges from 0.4 to 0.7. The results of the regression analysis show that an increase in the udder's circumference by 10 cm allows one to receive an increase in milk yield from lactation from 100 to 500 kg of milk [10]. However, this measurement is associated for the researcher with a certain risk caused by work in the vicinity of the animal, significant labor and time costs, and also large errors in the measurement. In order to minimize the number of measurements, were analysis was made of the relationship between individual easily identifiable udder measurements-length (x) and width (y) with its girth (Z). The regression equations have the following form:

\[ Z = 1.96x + 40.6 \]  
\[ Z = 3.15y + 19 \]

where 1.96; 40.6; 3.15 and 19 are weights (in cm).

Below is an example of the application of the calculated parameters of regressive connection for a selected cow of the Holstein breed. The parameters of girth, udder length and width measurements, measured on the 800th day after calving, were 97, 29 and 26 cm, respectively.

The introduction of the length value in the regression equation leads to the next estimated udder circumference (\(Z = 1.96 \times 29 + 40.6 = 97.4\) cm).

Similarly, the udder width measurement (\(Z = 3.15 \times 26 + 19 = 100.9\) cm).

The calculated udder circumference, as the arithmetic mean of the two calculated values, was 99 cm, in this case the discrepancy does not exceed 2%.
Along with the traditional approach that establishes a linear regressive relationship between the two features being investigated, were attempt made to apply the apparatus of the method of least squares for the case of a multiparameter dependence. This is another confirmation of the validity of the use of least-squares methods in modeling udder measurements.

In particular, for the discussed attribute of udder circumference (Z), were create analytical relationship, which establishes a functional connection between the desired measurement and the main linear measurements - the length (x) and the width (y):

\[ Z = -0.019x^2 + 0.224x + 0.22y^2 - 0.22y - 2.7 \]  

(3)

For the purpose of a comparative analysis of the proposed options for an analytical assessment of udder circumference, value of this indicator was calculated using the two-parameter dependence for the same measurements (\( Z = -0.019x^2 + 0.224x + 0.22y^2 - 0.22y - 2.7 = 95.7 \) cm).

The difference between this calculated value and the experimental value in the considered case did not exceed 1.3%. Thus, the accuracy of determining the udder's circumference using the above analytical techniques is quite high: the discrepancy does not exceed 1-2%. At the same time, in real-time measurements, the error often exceeds 5%.

Consequently, the use of the described methods in practical work will greatly facilitate the manual work of zootechnical personnel and will improve the accuracy of the measurements.

Forecasting of meat qualities of experimental bull-calves. An increase in the meat productivity of cattle can be ensured only with purposeful selection work. The effectiveness of such work will be higher if the main indicator of the meat productivity of livestock - the mass of the carcass - is taken as one of the main selectable features. The methodological complexity of this approach is connected with the possibility of statistically reliable prediction of this index during the life of the animal. Justified from a biological point of view, the mass of the carcass by the totality of the exterior signs (measurements).

The obtained results showed that of all the variants with an incomplete set of characteristics of the model based on three measurements (the girth of the chest behind the shoulder blades, semi-grip of the backside and the oblique length of the trunk) the accuracy of the prediction is fairly close to the full model. The simplest structure is characterized by linear (4) and hyperbolic models (5):

\[ Y = -386.4 + 0.825x_1 + 4.79x_2 + 1.449x_3 \]  

(4)

\[ Y = 1/2.29 \times 10^{-2} - 2.006 \times 10^{-3}x_1 - 1.644 \times 10^{-5}x_2 - 4.351 \times 10^{-7}x_3 \]  

(5)

where y is the mass of the carcass, kg; \( x_1 \) - chest girth behind the shoulder blades, cm; \( x_2 \) - semi-grip of the backside, cm; \( x_3 \) - is the oblique length of the trunk, the numbers at the values of the measurements are weight coefficients.

Formed simplified dependencies, not inferior to the full model, advantageously differ from it in that they allow you to exclude manual calculations and determine the mass of the carcass by three-parameter calculation tables (scales), constructed with the help of the corresponding formulas.
IV. CONCLUSIONS

Thus, as a result of extensive numerical experiments using modern methods of multivariate analysis and computer technology were identified 3 measurements of animals that significantly affect the carcass weight. Based on these measurements, a complete hyperbolic model is constructed to predict the carcass weight estimate with an average error of 3.5% and a simplified linear model with an error of 5%. These studies allow accurately determine meat quality of the animal through the main index - the weight of the carcass. And, importantly, an indication of the meat content, it is possible to determine during the life of the animal, without control of slaughter. This fact largely gives you the opportunity to obtain interesting information about the individual animals, valuable in the breeding relation. Results of the application of modern methods of mathematical simulation clearly show the wide possibilities of their use in animal husbandry.

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REFERENCES


