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:

$$Z = 1{,}96x + 40{,}6 \quad (1)$$

and

$$Z = 3{,}15y + 19 \quad (2)$$

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 × 29 + 40,6 = 97,4 cm).

Similarly, the udder width measurement (Z=3,15×26+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%.

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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):

$$Z = -0,019x^2 + 0,224x + 0,22y^2 - 0,22y - 2,7 \qquad (3)$$

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 ($Z = -0,019\times29^2+0,224\times29+0,22\times26^2-0,22\times26-2,7=95,7$ 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 solution of a problem can be the method of estimating the carcass by the totality of the exterior signs (measurements). To date, there are no mathematical models that characterize this functional relationship.

Despite the fact that there are no general formal methods for optimizing the mathematical model, which would best reflect the original multidimensional dependence, selection of the approximating function was carried out on a limited number of analytical forms. As such forms, effective for comparative analysis, 3 nonlinear (multiplicative, hyperbolic, exponential) and one linear model were used.

To solve the problems, we have already applied the algorithm and program described above, with the help of which the apparatus of stepwise regression analysis was realized in nonlinear and linear formulations.

The quality of the approximation provided by each of the matched regression models was estimated by three main statistical indicators: the multiple correlation index, the Fisher criterion (F), and the mean relative error.

The accuracy of predicting the mass of the carcass should increase with the increase in the number of measurements used in the mathematical model. To explore this pattern in the framework of the linear form was carried out step-by-step multivariate regression analysis with the variables of characteristics. The essence of it is that for the initial version of the regression model, including all 11 measurements, the ranking of the criteria was carried out by the Student's reliability test (t).

When the next model was moved, the criterion with the maximum criterion value was excluded. The calculated process was repeated until there was only one measurement.

Experiments have shown that the number of measurements carried contradictory effect on carcass weight.

Reducing their number from 11 to 5 leads first to a sharp, and then to a gradual increase in the accuracy of approximation. Further exclusion of measurements from the model reduces the accuracy of approximation.

Thus, as a result of the described first stage of the study, a complete set consisting of five measurements, which statistically significantly affect the mass of the carcass and the exclusion of each of which worsens the quality of its prediction. These measurements include: chest width, chest grasp behind the shoulder blades, a semi-grip of the backside, an oblique length of the trunk, an oblique length of the backside.

The revealed effective model with a full set of statistically significant measurements is rather complicated for practical use, therefore, other variants of models with all possible combinations of five measurements were studied.

To the comparative analysis, 30 different variants were used for each of the four analytic forms under consideration.

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):

$$Y = -386,4 + 0,825x_1 + 4,79x_2 + 1,449x_3 \qquad (4)$$

$$Y = 1/2,29\times10^{-2} - 2,006\times10^{-5}x_1 - 1,644\times10^{-4}x_2 - 4,351\times10^{-5}x_3 \qquad (5)$$

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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