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Kazakhstan Beef Cattle Indices

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ABSTRACT: The paper presents the results of the industrial calculation of breeding value indices for the Auliekol breed. The methodology for index evaluation calculation with the use of the BLUP AM statistical method with the construction of the animal genetic model was exercised. The predicted breeding value indices were calculated using three productive traits: live weight at birth, at weaning, and at 12 months of age. A brief outline of the creation of the Auliekol breed was given and advantages of the original breeds participating in the crossing were emphasized. The article presents equations of a linear biometric model of the animal, which considers the influence of a variety of factors and effects on the evaluated trait of productivity. The effect of all factors included in the model was considered simultaneously in the calculation process. As a result of solving the linear equations of biometric models of animals using the BLUP method, genetic estimates of their productivity were obtained according to economically useful characteristics. Estimates of factors and effects of influence on productive traits were obtained as well.

Keywords: index evaluation, live weight, BLUP, bull-calves, heifers, Auliekol breed, breeding value index, equation of a linear biometric model of the animal.

I. INTRODUCTION

In the modern world, food security is the most important problem. The Government of Kazakhstan has developed a strategic plan for the development of the republic until 2020 and a program for the development of the agro-industrial complex for 2013-2020 “Agribusiness 2020”. Thereby, in recent years, the volume of investments in the agricultural sector has increased significantly. The following task was set by the head of the state: to become one of the 30 most economically developed countries of the world and increase the country's food security. This is impossible without the use of accumulated knowledge and its continuous improvement, as well as the development of new innovative solutions and their introduction into production. Animal husbandry plays a decisive role in the solution of the food security problem, as it ensures the growth of the country's food resources.

Description of the Republic of Kazakhstan. The Republic of Kazakhstan is a state in the center of Eurasia, largely located in Asia; most western parts are in Europe. The population is 18,448,600 people (according to a 2019 estimate).

Kazakhstan is the ninth largest country in the world and the second largest country in the CIS (after Russia), with an area of 2,724,902 km^2.

The capital of Kazakhstan is Nur-Sultan. The largest city is Almaty with a population of more than 1.7 million people. The official language is Kazakh.

Kazakhstan shares borders with Russia (in the north and west – border length is 7,548.1 km), China (in the east – 1,782.8 km), Kyrgyzstan (in the south – 1,241.6 km), Uzbekistan (2,351.4 km) and Turkmenistan (426 km).

Administratively, Kazakhstan is divided into 14 regions and three cities of republican significance: Astana, Almaty, and Shymkent.

The climate in the republic is mostly sharp continental, with distinct seasons. The average January temperature is from −19°C in the north and northeast to +1°C in the south, the average July temperature is from +17°C to +31°C, respectively. Summer is hot and arid in all regions of Kazakhstan. The temperature can reach +50°C (the city of Turkestan, South Kazakhstan region). Winter is dry and cold, the temperature can reach −58°C (the city of Atbasar, Akmola region and the city of Pavlodar, Pavlodar region).

The stable development of animal husbandry depends on a large number of factors: feed and feeding, care and maintenance, selection and breeding, etc. According to the state policy and development programs in the field of livestock breeding, more than 72 thousand breeding animals of foreign selection were imported to Kazakhstan between 2011 and 2016.

One of the most important stages of breeding work in purebred breeding is a reasonable choice of animals intended to improve the breed. Most existing assessment methods consider, as a rule, a small number of interrelated features. However, the breeding value and productivity of animals is determined by the whole genotype. Examples of the negative effects of one-sided breeding are well known in livestock farming. An example of such an approach is the determination of the complex class of an animal during valuation, which gives only a partial assessment of the animal.

The accuracy of the assessment according to the genotype depends on many factors: the number of offspring used in the test, the genetic background on which it is carried out, the conditions of feeding and keeping, the season, and many others. As a result, quite often bulls rated in some conditions as improvers turn out to be neutral or even worse.

Currently, in many farms involved in beef cattle breeding, mass breeding data are used to assess breeding value; animals are selected based on origin and phenotype while the latter is not always implemented in the offspring. At the present stage, in the practice of breeding work with beef cattle, the method of two-stage evaluation of bulls based on the quality of offspring and testing of their sons based on their own productivity is most often used. At the same time, the accepted genotypic assessment of bulls provides for the identification of the maximum potential productivity of offspring in conditions of intensive cultivation, which is very difficult to create at farms.

The existing assessment of the breeding value of animals in beef cattle breeding, considering their class and complex breeding index, does not fully reflect the real value of the animal, since it is obtained without taking into account many interrelated environmental factors and the interaction of the environment and genotype.

The methods used to assess and determine the breeding value of beef cattle in Kazakhstan are inferior to modern ones used in countries with developed cattle breeding. It is necessary to introduce the most promising selection methods for the comprehensive evaluation of the animal, for example, the use of index evaluation to determine the breeding value and obtain the projected productivity of cattle.

First of all, it is necessary to decide on the assessment technique for the breeding value of animals, as its further improvement requires the use of advanced genotype evaluation methods and modern selection methods with the use of computer and information technologies. Selection and breeding must be carried out on the basis of uniform breeding value indices (BVI). Based on the index, it is possible to evaluate the parameters of the offspring, which provides their predicted characteristics [1, 2].

Calculation of the breeding value of an animal, reduction of the time and costs associated with the maintenance of young breeders, and selection of only the best animals for the herd and reproduction are possible only with the use of selection. The genetic changes that can be achieved by selection almost always are determined by the selected servicing bulls, as well as the possibilities for their intensive selection [3].

The purpose of stock breeding is to change the gene pool of animals and improve their traits. A means of changing the gene pool is selection, which uses productivity as the main indicator for changing of a certain trait at the genetic level. Assessment of the breeding value of livestock is one of the stages of the implementation of a breeding program in herds or populations, the aim of which is directional formation of the intended hereditary traits in animals and selection of desirable individuals during the determination of the breeding value of bulls [4].

In selection and breeding, it is necessary to select servicing bulls that combine high productivity [5-8].

The selection for the productivity of the ancestors and offspring of bulls plays a positive role in the gradual hereditary reinforcement, i.e. the consolidation of a certain trait [9].

The BLUP (Best Linear Unbiased Prediction) method is of great importance in the comprehensive assessment of the breeding value of beef cattle [10-12].

In countries with developed livestock breeding (USA, Canada, Germany, France, etc.), statistical approaches and methods are used to predict the genetic characteristics of individuals (primarily servicing bulls): estimation of the animal's genetic breeding value using a mixed biometric model (AM/MME – Animal Model/Mixed Model Equation) with the use of the BLUP method.

The index assessment of the genetic breeding value of beef cattle using selection traits was carried out with the use of the BLUP method. The advantage of this method is the ability to determine a linear predictive biometric model of the animal (AM), which can take into account and assess the degree of influence of a large number of constant, periodic, and random factors and effects on the estimated useful or productive trait:

– environmental effects
– seasonal effects
– conditions of livestock management and feeding
– additive genetic effects;
– effects of the influence of selection groups
– other random traceable effects
– random unaccounted effects.

All factors included in the model are evaluated simultaneously. This approach allows comparing estimates for animals of different generations, even if a genetic trend was observed in the population. A large number of popular index estimates, such as EPD, EBV, and others, are based on this mathematical method [13-19].

One of the pressing challenges of the present day is the assessment of the breeding value and predicted productivity using the modern methods and their improvement for more efficient selection of beef cattle with the use of computer technology and software.

Beef cattle breeding stock herd expansion requires its genetic improvement and the creation of large animals that can maintain high growth rates for a long time, produce heavy carcasses with optimal fat deposition, and have good reproductive qualities and high milking capacity.

The basis for the creation of highly productive herds should be the use of servicing bulls with the most pronounced meat traits that steadily propagate these valuable qualities to offspring. The assessment of the breeding value of a servicing bull should have two stages: evaluation of its intrinsic productivity and evaluation of the quality of its offspring. Therefore, given the increase in the proportion of highly productive beef cattle in Kazakhstan, the improvement and application of modern methods for bull evaluation is a pressing challenge for science and practical activities.

Relevance: The scientists of Kazakhstan were tasked with preserving and improving the productive traits and breeding ability of Kazakhstan livestock by applying modern methods of breeding value assessment.

Scientific novelty. We developed mathematical AM to assess the genetic breeding value of selection-significant productive traits of beef breeding cattle that are being selected in the natural and climatic conditions of Kazakhstan. We used the BLUP AM statistical method with regard to various factors and their effects on the manifestation of phenotypic traits and, accordingly, on the productivity of animals. They were subsequently ranked in the index scale for the assessment and selection of the best individuals for breeding.

Scientific and practical significance: The results of the research on index evaluation will be the basis for improvement of the selection methods and techniques with the use of the best gene pool, which will allow for the most complete realization of the animal genetic capabilities and increase the productivity potential of the breeds.

The aim of the research. Improvement of economic traits using the method of index evaluation of the Auliekol breed with the use of computer software.

Achievement of this goal will facilitate the solution of the challenges of the cattle breeding value assessment, early prediction of animal productivity, and improvement of the breeding process quality in beef cattle breeding.

Research objectives: Calculation of BVI using at least three indicators (live weight at birth, live weight at weaning, live weight at 12 months of age) for animals of the Auliekol breed.

The research work was carried out as part of the scientific and technical program "Improvement of the selection methods efficiency in livestock breeding" for 2018-2020 in the framework of the budget program 267 "Improvement of the availability of knowledge and research", subprogram 101 "Program-targeted funding of scientific research and events".

II. METHODS

The animals of the Auliekol breed were used as the object of the research. The Auliekol breed was bred in Northern Kazakhstan using composite crossbreeding of the animals of the Kazakh white-headed breed with Aberdeen-Angus and Charollais bulls.

The Auliekol breed was approved as an independent breed in 1992. This specialized meat breed is characterized by good maturing rate, high yield and quality of meat, and high growth energy and is adapted to local conditions.

The breed combines the positive qualities of the original breeds: large size, intensive and continuous growth rate, and good beefiness of the Charollais breed; early maturity of meat, fecundity, and polledness of the Aberdeen-Angus breed; adaptation to breeding conditions, fecundity, and taste qualities of meat of the Kazakh white-headed breed.

The most important economic traits of the Auliekol breed have the following values: growth rate of bull-calves from 8 to 15 months of age – 1,100 g; live weight at the age of 15-18 months – 450-540 kg; the mass of bull-calves' carcasses when slaughtered at 18 months of age –300-310 kg; slaughter carcass yield – 60-63%; live weight of bulls – 950-1,050 kg, cows – 540-560 kg, calves at the age of 8 months – 230-240 kg; withers height of adult cows – 130 cm.

The color of the animals is light gray, 70% of the livestock are hornless. Animals have a sound constitution and are able to tolerate periods when the quantity and quality of the feed decreases. During the winter, they grow a dense hair coat and are well adapted to harsh climatic conditions [15, 16].

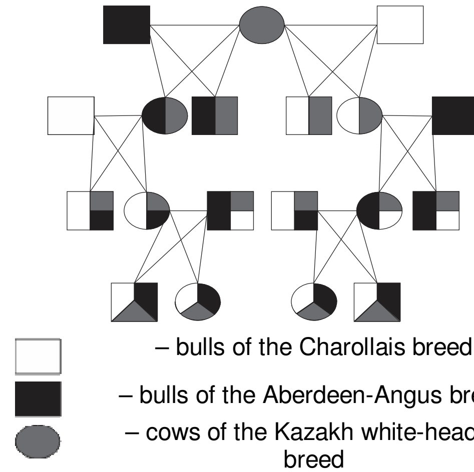


Fig. 1. Crossbreeding scheme for the breeding of the Auliekol breed.

The evaluation of genetic qualities (index evaluation of genetic breeding value) of beef cattle was performed using the BLUP method.

For this purpose, mixed linear biometric animal models (AM/MME) were constructed for each evaluated productive trait: live weight at birth, live weight at weaning, live weight at one year of age. The contributions of the influence of a large number of factors and effects on the evaluated productive trait were factored into these models: fixed and genetic effects, environmental factors, seasonal factors, random and unaccounted effects. During the calculation, the influence of all of the factors included in the model was taken into account simultaneously.

The calculations using the BLUP method were performed on the basis of data on productivity and zootechnical events with breeding stock of the Auliekol breed at the farms registered in the "Republican livestock breeding information and analytical system" database (hereinafter – IAS database). Values of live weight at birth, at weaning, and at one year of age were used as baseline beef cattle productivity data for BLUP evaluation. The following fixed effects were included in the analysis: differences in the management of individuals in enterprises and farms; calving years and seasons; age and sex group of calves; age of mother; type of birth (single, twins). Data on the following additive genetic effects connected with parental qualities for three previous generations was used in the biometric model of the animal: the sex of the animal, the effects of the herd, and the effects of the year and season of birth.

The general form of the equation of the linear biometric model of the animal (AM) (formula 1) is shown below:

$$y_{ijklm} = \mu + a_i + s_j + d_k + h_l + p_m + e_{ijklm} \quad (1)$$

where

y_{ijklm} – productive traits, in our case: live weight at birth, live weight at weaning, live weight at 12 months of age.

μ – total average for all animals.

a_i – additive genetic effect on the evaluated calf, in accordance with the breeding record.

s_j – sex of the animal, as the bulls and heifers differ in weight.

d_k – year and season of the animal birth.

h_l – herd or farm.

p_m – breeding groups with the same conditions of management and feeding.

e_{ijklm} – model error caused by the effect of unaccounted factors.
The indices in the equation define groups with the same effects on the productivity of the evaluated animals.
The Eqn. (1) in vector form (formula 2) is presented below:

$$y = X \times b + Z \times a + W \times p + e \quad (2)$$

where
y – vector of productive traits;
X – matrix of the influence of paratypical and permanent effects.
b – vector of estimated paratypical indicators.
Z – unity matrix of the correlation of additive genetic effects.
a – vector of estimated additive genetic effects.
W – matrix of the influence correlation of random effects.
p – vector of random effects.
e – vector of unaccounted effects.
In accordance with the linear model (formula 1), the following paratypic and permanent effects were accounted for in the practical calculations of breeding value based on individual productivity: sex of the animal, as the bulls and heifers differ in weight; year and season of the animal birth; farm designated as the "herd" parameter.
The values of the initial live weight at birth and at weaning were adjusted in accordance with the age of the mother, which affects these indicators. Table 1 shows the adjustment values for live weights at birth and at weaning. Additionally, the live weight at weaning was adjusted for the age of 210 days and the live weight at the age of one year was adjusted for the age of 365 days. Adjustments to the raw data were performed according to the formulas (3-5), presented below.

$$CW_b = W_b + AW_b \quad (3)$$

$$AWb = \frac{Ww-Wb}{Aw} \times 210 + AWw + CWb \quad (4)$$

$$CWo = \frac{Wo-Ww}{Ao-Aw} \times 155 + AWb \quad (5)$$

where
CW_b – corrected live weight at birth, kg.
W_b – live weight at birth, kg.
AW_b – adjusted live weight at birth with regard to the age of the mother, kg.
CW_w – corrected live weight at weaning, kg.
W_w – live weight at weaning, kg.
A_w – the age of the animal when weighing at the time of weaning, days.
AW_w – adjustment factor for live weight at weaning with regard to the age of the mother, kg.
CW_o – corrected live weight at the age of one year, kg.
W_o – live weight at the age of one year, kg.
A_o – the age of the animal when weighing at the age of one year, days.

Table 1: Adjustment values for live weight parameters of calves with regard to the age of the mother.

Age of the mother	Adjustment for the live weight at birth, kg	Adjustment for the live weight at weaning, kg	
		Bull-calf	Heifer
2 years	+ 3.1	+ 33	+ 27
3 years	+ 1.3	+ 17	+ 14
4 years	+ 0.4	+ 7	+ 4.5
5 to 10 years	0	0	0
11 years and older	+ 0.9	+ 12	+ 11

The BLUP AM method requires the construction of a system of linear equations of a mixed model (formula 6) – MME:

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + \alpha A^{-1} \end{bmatrix} \begin{bmatrix} b \\ a \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix} \quad (6)$$

where
α – coefficient calculated using the formula: $\alpha = \frac{\sigma_e^2}{\sigma_a^2} = \frac{1-h^2}{h^2}$
σ_a^2– variance for to genetic factors.
σ_e^2 – residual variance.
h^2 – heritability estimate of the trait.
A^{-1} – the inverse matrix of kinship.
The solution of the system of MME linear equations provided an evaluation of the productive traits of animals – the index of breeding value of the animal.
Depending on the changing conditions, factors and effects on the selection trait could be added to the BLUP AM base model.
Accuracy, or, in other words, reliability, of the breeding value assessment in the solution of the biometric model Eqn. (7) was calculated using the diagonal elements of the inverse matrix Z'Z, which is a part of the main matrix of equation (6). For this, the following formula was used (formula 7):

$$r_a = \sqrt{1 - c * \alpha} \quad (7)$$

where:
r_a – accuracy of the breeding value assessment;
c – diagonal elements of the inverse matrix Z'Z;
α – the same coefficient of dispersion ratio that is used in formula (6).
Accuracy values (r_a) are in the range from zero to one: the closer the value of r_a to one, the higher the accuracy and reliability of the obtained breeding value.
The heritability estimate values used in the calculation of BVI for 2018, were calculated in the period of 2015-2016 for selection traits for different breeds. They were provided to the Center by the Australian Agricultural Business Research Institute (ABRI). They are listed in Table 2.

Table 2: Heritability estimates for selection traits.

No.	Breed	Live weight at birth, kg	Live weight at weaning, kg	Live weight at the age of one year, kg
1	Auliekol	0.30	0.14	0.22

III. RESULTS

The linear equations for animal biometric models (AM/MME) were solved using the BLUP method with the use of zootechnical events recordings for animal groups of the Auliekolsky breed obtained from the IAS database.

As a result, genetic estimates of their productivity were obtained for the following economic traits: live weight at birth; live weight at weaning; live weight at the age of one year. Additionally, estimates of factors and effects on productive traits were obtained: sexually mature group; year – season – herd/farm (HYS).

The number of animals whose productive and hereditary data (for at least three generations) was obtained from the IAS database for the subsequent calculation of the BVI, is shown in Table 3.

Table 4 contains data that was used for the BVI calculation. Table 5 shows the average values for animal productivity parameters.

Before calculation, the initial values of animal live weight were adjusted in accordance with formulas (3-5) and Table 1.

Distributions of live weight values at birth, at weaning, and at the age of one year for animals of the Auliekol breed before and after adjustment are presented in the form of histograms in Fig. 2-4.

Table 3: Statistics for animals, data for which was used to calculate the BVI.

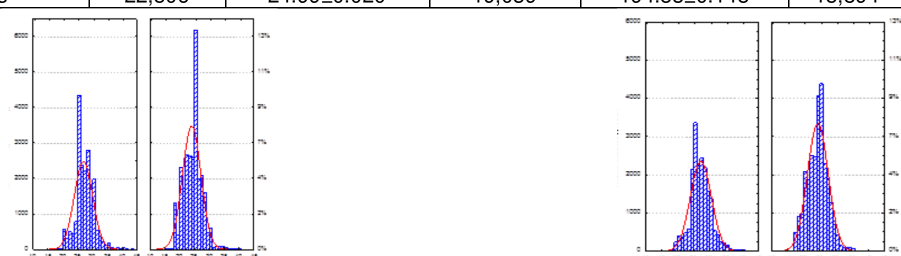
No.	Breed	Total number, for which the hereditary data were obtained	Including animals, for which the BVI were calculated
1	Auliekol	162,492	42,560
	Total	162,492	42,560

Table 4: The number of animals registered in the IAS database, by farms.

No.	Number of animals at the farm	Number of farms with animals of the Auliekol breed
1	more than 10,000	0
2	5,000-10,000	6
3	1,000-5,000	35
4	500-1,000	18
5	200-500	46
6	100-20	37
7	less than 100	1,585
Total number of farms		1,727

Table 5: Average values for animal productivity parameters.

Breed, age-sex group	Live weight at birth, kg		Live weight at weaning (210 days of age), kg		Live weight at 365 days of age, kg	
	n	M±m	n	M±m	n	M±m
Auliekol						
Bull-calves	13,679	28.07±0.024	8,964	208.46±0.211	7,245	323.95±0.262
Heifers	22,506	24.99±0.020	19,039	194.83±0.148	15,894	280.69±0.197



Bulls/Bull-calves Heifers/Cows
Live weight at birth, kg.

Bulls/Bull-calves Heifers/Cows
Adjusted live weight at birth, kg.

Fig. 2. Distributions of live weight values at birth for animals of the Auliekol breed before and after adjustment to account for maternal age.

Bulls/Bull-calves Heifers/Cows
Live weight at weaning, kg.

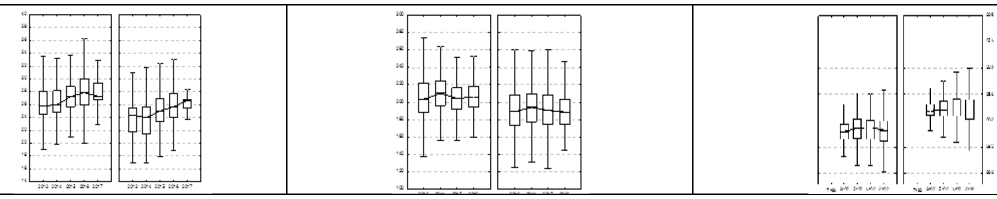
Bulls/Bull-calves Heifers/Cows
Adjusted live weight at weaning, kg.

Fig. 3. Distributions of live weight values at weaning for animals of the Auliekol breed before and after adjustment to account for the age of weaning.

Bulls/Bull-calves Heifers/Cows
Live weight at the age of one year, kg.

Bulls/Bull-calves Heifers/Cows
Adjusted live weight at the age of one year, kg.

Fig. 4. Distributions of live weight values at the age of one year for animals of the Auliekol breed before and after adjustment to account for age.



Years of birth

Bulls/ Bull-calves | Heifers | Bulls/ Bull-calves | Heifers | Bulls/ Bull-calves | Heifers

Fig. 5. Diagrams of the ranges of medians for the live weights of animals of the Auliekol breed at birth, at weaning, and at the age of one year.

Table 6: Percentile distribution of the calculated BVI values of productive traits of animals of the Auliekol breed.

Percentile	BVI for live weight, kg		
	at birth	at weaning	at the age of 12 months
0%	-3.47	+53.63	+71.86
5%	-0.70	+6.56	+15.27
10%	-0.45	+5.19	+12.82
20%	-0.18	+3.74	+10.01
25%	-0.10	+3.23	+8.98
30%	-0.04	+2.80	+8.06
40%	+0.02	+2.02	+6.50
50%	+0.14	+1.34	+5.07
60%	+0.27	+0.68	+3.62
70%	+0.43	+0.10	+1.96
75%	+0.53	+0.00	+1.05
80%	+0.64	-0.11	+0.23
90%	+0.98	-0.91	-0.40
95%	+1.29	-1.79	-1.71
100%	+9.03	-19.76	-39.37
Minimum	-3.47	-19.76	-39.37
Maximum	-3.47	+53.63	+71.86

A visual evaluation of the distributions in these figures showed that the adjustments to the recorded live weight values to account for maternal age and the age of the animals themselves at the time of weighing brought the initial distribution of the data closer to normal distribution. Accordingly, this reduced the overall error of the model and improved the quality of BVI calculation. Fig. 5 presents diagrams of the ranges of medians for the adjusted live weights of animals of the Auliekol breed.

After the BVI for animals of the Auliekol breed were calculated using the BLUP method in accordance with the biometric model (3), the frequency distribution tables of the obtained BVI values were compiled in the form of centile charts, which are presented in Table 6.

The percentiles presented in Table 6 describe 5% and 10% fractional distributions of index values. For the Auliekol breed, the calculated BVI values for live weight in 90% of cases were as follows: at birth – in the range from -3.47 to +0.98; at weaning – in the range from -0.91 to +53.63; at the age of one year – in the range from -0.40 to +71.86. Tables 5 and 6 show that the largest (best) and smallest (worst) values of the indices of the entire set of calculated estimates were in the 10% extreme intervals.

In the process of BVI calculation, accuracy values were obtained for them, shown in Table 7.

There are no zero values of the fractional distribution of accuracy for the estimated BVI for 2018 for the productive parameters of animals of the Auliekol breed, presented in Table 7. The general increase in the proportion of non-zero accuracy values for the BVI indicates that entries of live weight productive parameters for these breeds to the IAS database are more complete and of higher quality in the recent years.

As an example, Table 8 presents the BVI values for three parameters (live weight at birth, at weaning, and at 12 months of age) for ten animals of the studied Auliekol breed.

The values of the indices shown in Table 8 should be interpreted as an evaluation of the intrinsic genetic productivity of each evaluated animal relative to the corresponding average values that were given in Table 5.

Therefore, we can conclude that the methodology for the index evaluation calculation using BLUP AM method with the construction of the genetic model of an animal was tested and the predicted BVI were calculated using three productive indicators: live weight at birth, at weaning, and at 12 months of age.

Table 7: Percentile distribution of the calculated accuracy values for the BVI of productive traits of animals of the Auliekol breed.

Percentile	Accuracy of BVI for live weight, kg		
	at birth	at weaning	at the age of 12 months
0%	0	0	0
5%	0.001	0.001	0.001
10%	0.014	0.008	0.010
20%	0.156	0.119	0.137
25%	0.210	0.168	0.183
30%	0.245	0.203	0.215
40%	0.325	0.266	0.257
50%	0.428	0.310	0.295
60%	0.452	0.332	0.348
70%	0.465	0.348	0.392
75%	0.471	0.356	0.402
80%	0.478	0.365	0.411
90%	0.520	0.388	0.434
95%	0.558	0.416	0.465
100%	0.982	0.970	0.978

Table 8: Results of the index evaluation of the live weights of the animals of the Auliekol breed.

No.	ID number of the animal	Year of birth	Live weight, kg			
			at birth	at weaning	corrected for 210 days of age	at the age of one year
1	2	3	4	5	6	7
Bull-calves						
1	2615457	2015	26.0	225.0	192.1	410.0
2	4307875	2015	25.0	190.0	188.3	370.0
3	4157446	2015	28.0	225.0	193.3	410.0
4	4308630	2015	25.0	190.0	216.3	370.0
5	4345085	2015	25.0	215.0	166.6	351.0
6	4307935	2015	25.0	180.0	192.4	331.0
7	5016796	2016	28.0	240.0	223.6	329.0
8	5506508	2016	25.0	192.0	180.6	315.0
9	5506352	2016	26.0	195.0	186.3	310.0
10	5481589	2016	29.0	183.0	181.3	286.0
Heifers						
1	4323543	2015	25.0	160.0	185.2	340.0
2	4324051	2015	25.0	165.0	187.5	348.0
3	4323574	2015	25.0	150.0	170.2	342.0
4	4507969	2016	22.0	185.0	163.2	325.0
5	4323550	2015	25.0	175.0	202.6	339.0
6	3836396	2015	23.0	225.0	202.3	311.0
7	4234280	2015	26.0	226.0	193.2	336.0
8	4508006	2016	23.0	180.0	161.4	325.0
9	5541169	2016	28.0	205.0	218.2	300.0
10	5016688	2016	25.0	210.0	187.9	300.0

Table 9.

No.	Live weight, kg corrected for 365 days of age	Live weight evaluation at birth		Live weight evaluation at weaning		Live weight evaluation at the age of 12 months	
		BVI	accuracy	BVI	accuracy	BVI	accuracy
1	8	9	10	11	12	13	14
Bull-calves							
1	441.9	0.90	0.44	6.69	0.31	39.64	0.37
2	369.8	-0.22	0.48	8.21	0.38	33.24	0.42
3	500.4	1.72	0.45	5.86	0.35	31.97	0.40
4	370.3	-0.29	0.48	9.10	0.37	28.45	0.42
5	346.3	-0.62	0.47	12.61	0.35	24.74	0.41
6	334.8	-0.04	0.48	6.76	0.37	24.51	0.42
7	333.5	0.49	0.46	6.64	0.35	22.86	0.40
8	370.5	-0.49	0.46	2.36	0.34	21.33	0.39
9	355.6	-0.37	0.46	3.16	0.34	18.72	0.39
10	286.0	-0.02	0.47	8.66	0.36	17.98	0.41
Heifers							
1	344.4	0.74	0.47	4.48	0.36	34.87	0.40
2	348.2	0.37	0.48	9.22	0.38	33.76	0.42
3	342.2	0.46	0.48	6.83	0.37	30.06	0.42
4	320.9	0.56	0.45	4.00	0.32	29.62	0.38
5	343.9	0.75	0.47	6.72	0.35	29.26	0.39
6	312.1	1.26	0.46	7.28	0.33	29.11	0.39
7	341.7	1.07	0.47	5.37	0.35	26.79	0.40
8	325.8	0.92	0.46	4.17	0.33	24.37	0.39
9	310.3	2.39	0.45	7.48	0.33	23.00	0.38
10	298.0	-0.76	0.45	4.83	0.32	19.09	0.38

IV. CONCLUSIONS

– We performed the calculation of the BVI for intrinsic productivity for three productive traits: live weight at birth; live weight at weaning; live weight at the age of one year. We used the raw zootechnical event data for animals of the Auliekol breed that was added to the IAS database by farms.

– An industrial BVI calculation was performed for 42,560 animals of the Auliekol breed using three parameters simultaneously.

– The statistical distribution of the results of the BVI calculations was analyzed and the diagrams of the ranges of medians were constructed.

– Statistical distribution and percentile distribution of the BVI were analyzed.

– Statistical distribution and percentile distribution of the accuracy of the BVI was analyzed.

– We see the prospects for further research in the study of new methods for assessing the breeding value of cattle. The simultaneous use of several methods will increase the level of prediction of animal productivity and improve the quality of beef cattle breeding.

Conflict of Interests. The authors declare that there is no conflict of interest to disclose.

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