ZOOTECHNY AND VETERINARY

Results from Index Evaluation of Kazakh White-Headed and Hereford Cattle for Liveweight

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Abstract—The results from the research study to show the dynamics of liveweight for the Kazakh White-Headed and Hereford cattle youngstock and the index evaluation for liveweight to create the subsequent breeding livestock populations have been reported. The selection index evaluation for liveweight (at birth, weaning, and the age of 12 months) was performed with the best linear unbiased prediction (BLUP) method to form the breeding herds on main farms. The method to estimate the selection index value was developed based on the statistical method for the animal genetic model and the predicted breeding-value indices for three production parameters: liveweight at birth, weaning, and the age of 12 months. Overall, 9503 and 2766 farms for rearing the Kazakh White-Headed and the Hereford cattle livestock, respectively, were analyzed. The accuracy of the breeding value index estimation with the BLUP AM method for the Kazakh White-Headed calf bulls and heifers at birth, weaning, and the age of 12 months comprised 0.509−0.557 and 0.534−0.573, 0.274−0.319 and 0.354−0.368, and 0.336−0.418 and 0.388−0.415, respectively. The accuracy of the breeding value index estimation with the BLUP AM method for the Hereford calf bulls and heifers at birth, weaning, and the age of 12 months comprised 0.531−0.810 and 0.511−0.565, 0.330−0.608 and 0.257−0.366, and 0.386−0.498 and 0.342−0.414, respectively. The BLUP AM method can provide the opportunity to improve the accuracy of evaluation of the Kazakh White-Headed and Hereford cattle livestock through the liveweight measurements at birth, weaning, and the yearling age.

INTRODUCTION

Genetic variations, which may be achieved through selective breeding, are mostly specified by the characteristics of the selected bull sires and their selective parameters for effective selection policy [1, 2]. The livestock breeding value is one of the aspects of the selection breeding program focused on developing the target-inherited traits and selecting the desirable specimens [3−5].

Selective-breeding practices require selecting the bull sires of high production performance combined with the other genetic parameters [6]. Bull selection based on the actual ancestor and progeny performance is a positive factor effect on gradual inherited consolidation of the target trait [7].

In countries with developed livestock farming (the United States, Canada, France, etc.), statistical approaches and methods, including the animal genetic breeding value with the animal mixed biometric models (AM/MM E: Animal Model/Mixed Model Equation) based on the best linear unbiased prediction (BLUP), are used to predict the genetic characteristics of specimens (firstly, the bull sires).

All the factors involved in the model are simultaneously assessed, which can provide the opportunity to compare the values for animals of different generations, despite any genetic trend in a population. The popular value indices, such as the expected progeny difference or deviation (EPD), the estimated breeding value (EBV), etc., are used based on this mathematical method [8, 9].

Increasing the breeding beef-livestock population size requires its genetic improvement and production of big animals capable of maintaining high growth rates for a long time, attaining the heavy carcass conformation with optimal fat deposition, and achieving high reproductive performance and good milkability.

Selection of bull sires with the most valuable beef characteristics, continually passing these specific economically important traits onto their progeny, is the foundation for building highly productive herds. The bull sire breeding value should be estimated based on the two-phase estimation for its own performance and the performance of its progeny. Therefore, improvement and application of the modern methods for bull evaluation relative to increasing the proportion of highly productive beef cattle remain challenges in Kazakhstan.

The objectives of the research study are to analyze the liveweight dynamics in the Kazakh White Headed and Hereford cattle youngstock and to perform the index selection evaluation for their liveweight to determine the reasonableness of this method for creating the breeding livestock population.

EXPERIMENTAL

Index breeding-value assessment of the beef cattle for selection traits was performed with the best linear unbiased prediction method (BLUP). The advantage of this method is to determine the linear predicted biometric animal model (AM) involving multiple permanent, periodic, and occasional factor effects (environments, seasons, keeping and feeding conditions, additive genetic functions, selection breeding groups, and the other randomly registered and unaccounted for factors) on exhibiting the economically important and productive traits [10, 11].

The research study was conducted based on the data on production and zootechnical events in the herds of pedigree cattle of the Hereford and Kazakh White-Headed breeds on the commercial breeding farms registered in the database of the Information Analytics System of the Republic of Kazakhstan (IAS DB). The beef cattle production parameters required for estimation with the BLUP methods are the liveweight at birth, weaning, and the yearling age. The factor effects taken into consideration included differences in keeping the specimens across the farms, calving years and seasons, sex–age calf groups, maternal age, birth type (twin or single), additive genetic variance components caused by parental inheritance taken through three generations, etc. The general form of equation for the animal linear biometric model is present as follows:

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

where y_{yijklm} denotes production traits (including liveweight at birth, weaning and the age of 12 months in this case), μ is general average value for all the involved animals, a_i is additive genetic variance in a calf evaluated in accordance with pedigree-based data, s_j is animal sex since bull calves and heifers are different in body mass, d_k is year-season of animal birth, h_l is herd or farm, p_m is selective groups with similar keeping and feeding conditions, and e_{ijklm} is model error because of unaccounted factors.

The selection indices in the equation indicate the groups with similar factor effects on production of the evaluated animals. The values for liveweight at birth and weaning were adjusted taking into account the maternal age affecting these values (Table 1). In addition, the liveweight values at weaning were adjusted to consistent 210 days and 365 days of age. The initial weight values were adjusted with formulae:

$$ALWb = LW + FALWb, \qquad (2)$$

where ALWb denotes adjusted liveweight at birth, kg; LWb is liveweight at birth; and FALWb is liveweight at birth, adjusted for maternal age factor, kg;

$$ALWy = \frac{LWy - LWw}{CAy - Caw} \times 155 + ALWw, \qquad (3)$$

Table 1. Adjustments for calf liveweight, made taking into account the maternal age

Mother's age	Adjustment for liveweight at birth, kg	Adjustment for liveweight 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

Table 2. Dynamics of average liveweight in bull calves and heifers across analyzed cattle livestock

Breed, sex-age group	At birth, kg		Liveweight at weaning at 210 days, kg		Liveweight at 365 days, kg	
	n	*M ± m*	*n*	*M ± m*	*n*	*M ± m*
Kazakh White Headed						
Bull calves	158873	27.70 ±0.01	122428	206.30 ± 0.06	86727	315.30 ± 0.08
Heifers	346172	25.80 ± 0.01	300504	192.40 ± 0.03	234087	281.70 ± 0.03
Hereford						
Bull calves	24859	28.90 ± 0.03	17807	215.10 ± 0.24	12792	318.50 ± 0.37
Heifers	59672	28.10 ± 0.02	49806	203.20 ± 0.13	39930	301.30 ± 0.18

where ALWw is adjusted liveweight at weaning, kg; LWw is liveweight at weaning, kg; CAw is calf age at weighing, days; and FALWw is liveweight at weaning, adjusted for maternal age factor, kg; and

$$ALWw = \frac{LWw - LWb}{Caw} \times \\ \times 210 + FALWw + ALWb, \quad (4)$$

where ALWy is adjusted liveweight at the yearling age, kg; LWy is liveweight at the yearling age, kg; and CAy is calf age at weighing at the yearling age, days.

The data to calculate the breeding value index (BVI) were taken from the database of the Information Analytics System of the Republic of Kazakhstan. Thus, this database involves 9503 registered farming companies for rearing and breeding the Kazakh White Headed cattle livestock, including 17 farms, 43 farms, and 242 farm enterprises holding more than 10 000 cattle, 5000−10000 cattle, and 1000−5000 cattle livestock, respectively. In addition, there is information on 2766 farms specialized on the Hereford cattle, including nine farms with 10000 animals, nine farms with 5000−10000 animals, and 62 farm enterprises holding 1000−5000 cattle livestock.

The survey-based index evaluation of the cattle of both breeds for liveweight was performed with 20 specimens (ten bull calves and ten heifers) of 24−28 kg birth liveweight.

RESULTS AND DISCUSSION

Regarding the examined Kazakh White-Headed cattle livestock population, the bull calf liveweight at birth, on 210 day, and at the yearling age made up, on average, 27.7, 206.3, and 315.3 kg, respectively, while the liveweight parameter values for heifers comprised 25.8, 192,4, and 281.7 kg, respectively. With respect to the Hereford cattle livestock, the parameter data for bull calves were recorded as 28.9, 215.1, and 318.5 kg, respectively, while the parameter values for heifers comprised 28.1, 203.2, and 301.3 kg, respectively (Table 2).

The estimated values for index evaluation indicate that the Kazakh White-Headed bull calf liveweight at birth, at weaning, adjusted to 210 days, at 12 months of age, and adjusted to 365 days should comprise 24−28, 185−249, 161.1−219,4, 296−350, and 292.8−351.5 kg, respectively. With respect to heifers, the estimated parameter values should comprise 24−28, 177−206, 157.8−228.9, 275−300, and 282.8−299.3 kg, respectively.

The accuracy of the index breeding-value assessment of the Kazakh White-Headed bull calves and heifers at birth, weaning, and 12 months of age comprised 0.509−0.557 and 0.534−0.573, 0.274−0.319 and 0.354−0.368, and 0.336−0.418 and 0.388−0.415, respectively (Table 3). The accuracy of the index breeding-value assessment of the Hereford bull calves and heifers at birth, weaning, and 12 months of age comprised 0.531−0.810 and 0.511−0.565, 0.330−0.608 and 0.257−0.366, and 0.386−0.498 and 0.342−0.414, respectively (Table 4).

The cattle livestock achieving 5 years of age and older, which was evaluated for liveweight at birth, weaning, 210 days of age, and 12 months of age with the BLUP method, exceeded the breed standards for liveweight. Thus, the average liveweight of the mature (5-year-old) Hereford and Kazakh White-Headed

Table 3. Results in survey-based index estimation of liveweight in Kazakh White Headed Cattle

Identification number of an animal	Year of birth	Liveweight, kg					Estimate,					
		at birth	at weaning	adjusted to 210 days	per year	adjusted to 365 days	at birth		at weaning		at the age of 12 months	
							BVI	accuracy	BVI	accuracy	BVI	accuracy
Bull calves												
4538109	2019	25	195	211.9	350	356.2	1.19	0.516	2.48	0.286	4.72	0.352
6788776	2019	25	195	200.1	350	356.3	2.16	0.513	1.89	0.277	6.68	0.343
8096780	2019	27	255	217.6	300	302.5	−0.09	0.577	5.63	0.379	2.12	0.418
8096783	2019	25	241	213.9	310	309.0	−0.39	0.537	9.04	0.343	2.53	0.396
8096835	2019	26	249	219.4	304	302.8	−0.70	0.543	6.17	0.358	−0.86	0.406
9308340	2020	24	210	175.6	303	299.6	0.24	0.524	1.14	0.313	0.16	0.372
9308571	2020	25	185	202.1	302	300.3	−3.66	0.532	−1.16	0.319	−6.29	0.377
9310548	2020	25	189	161.1	296	292.8	0.97	0.524	2.24	0.316	1.44	0.375
9310553	2020	24	211	180.5	303	300.1	−0.07	0.526	1.28	0.317	−3.48	0.375
9311541	2020	28	192	177.3	350	351.5	−0.18	0.509	0.04	0.274	11.01	0.336
Heifers												
7898642	2019	25	189	186.9	285	299.3	−4.68	0.546	−6.13	0.368	−9.31	0.415
7898755	2019	24	192	187.5	275	288.8	−4.97	0.542	−6.26	0.356	−10.80	0.404
7899177	2019	25	192	188.1	275	288.8	−4.58	0.545	−5.88	0.363	−11.06	0.412
7899238	2019	26	192	196.1	284	298.2	−4.40	0.540	−5.23	0.354	−11.62	0.403
8084362	2019	28	206	228.9	291	294.6	0.03	0.573	4.68	0.339	−3.30	0.388
8817224	2020	26	177	182.3	300	297.4	−0.72	0.534	−4.70	0.362	−1.41	0.407
8817230	2020	25	177	159.8	289	285.8	0.28	0.540	−0.86	0.364	0.64	0.412
8817254	2020	28	177	157.8	286	282.8	1.69	0.541	1.34	0.365	5.22	0.412
8817372	2020	25	177	175.1	300	296.6	−0.22	0.540	0.11	0.366	0.24	0.413
8817423	2020	26	177	175.2	288	284.7	−0.10	0.537	0.37	0.353	−2.27	0.403

Table 4. Results in survey-based index estimation of liveweight in Hereford Cattle

Identification number of an animal	Year of birth	Liveweight, kg					Liveweight estimate					
		at birth	at weaning	adjusted to 210 days	per year	adjusted to 365 days	at birth		at weaning		at the age of 12 months	
							BVI	accuracy	BVI	accuracy	BVI	accuracy
Bull calves												
8092287	2019	26	235	228.8	330	326.3	−2.43	0.536	4.89	0.343	0.10	0.396
8092293	2019	28	200	194.7	320	316.4	−0.85	0.540	4.12	0.352	4.73	0.402
8092294	2019	30	224	231.6	330	334.6	0.49	0.810	7.42	0.608	7.99	0.498
8092298	2019	28	230	207.9	330	330.2	−0.02	0.536	6.95	0.347	12.80	0.395
8092302	2019	25	236	236.7	330	330.1	−2.46	0.533	8.23	0.345	7.58	0.394
9322710	2020	30	226	231.6	381	372.1	−1.80	0.539	−4.82	0.355	0.85	0.404
9333725	2020	25	185	172.3	297	285.0	−2.78	0.531	−2.86	0.331	−12.83	0.387
9333727	2020	31	191	178.0	281	289.0	−0.51	0.531	−0.97	0.331	−5.69	0.387
9333728	2020	29	200	186.3	306	294.3	−1.90	0.531	−2.99	0.330	−9.60	0.386
9333729	2020	30	242	224.3	330	338.5	−2.44	0.531	0.01	0.331	−4.62	0.387
Heifers												
8092322	2019	28	210	206.9	285	282.9	−1.10	0.564	3.56	0.354	1.17	0.398
8092325	2019	26	214	210.6	315	312.6	−0.95	0.565	4.36	0.354	8.43	0.398
8095207	2019	30	237	233.1	373	381.8	1.66	0.541	4.91	0.363	5.94	0.409
8095221	2019	30	179	178.7	300	307.4	1.62	0.544	−3.14	0.366	−8.32	0.414
8095346	2019	31	231	219.8	359	369.2	−0.08	0.539	−3.67	0.354	−15.41	0.404
9312517	2020	28	206	209.8	382	367.7	−1.69	0.542	−5.23	0.361	5.02	0.410
9318090	2020	29	195	207.0	378	371.3	−1.19	0.540	−8.92	0.358	4.50	0.406
9318094	2020	28	218	193.8	343	337.3	−1.73	0.540	−8.72	0.357	−0.55	0.406
9323942	2020	25	228	196.7	274	282.3	−2.43	0.514	−2.05	0.282	2.74	0.348
9323947	2020	25	226	195.6	274	282.2	−1.93	0.511	−1.02	0.275	6.94	0.342

Table 5. Average values for liveweight of mature (5-year-old) Kazakh White-Headed and Hereford cattle livestock

Breed	Bulls		Cows	
	number, n	$M \pm m$	number, n	$M \pm m$
Kazakh White Headed	111	801.4 ± 13.8	4308	536.8 ± 0.6
Hereford	14	834.1 ± 14.5	423	508.5 ± 3.3
Total	125		4731	−

bulls comprised 834.1 and 801.4 kg, respectively, and the parameter values for cows comprised 508.5 and 536.8 kg, respectively (Table 5). The produced data can demonstrate the efficiency of this method for index evaluation of cattle for liveweight.

CONCLUSIONS

The BLUP AM method can provide the opportunity to improve the accuracy of evaluation of the Kazakh White-Headed and Hereford cattle for liveweight at birth, weaning, and the yearling age.

The accuracy of the breeding value index estimation of the Kazakh White-Headed calf bulls and heifers at birth, weaning, and the age of 12 months comprised 0.509−0.557 and 0.534−0.573, 0.274−0.319 and 0.354−0.368, and 0.336−0.418 and 0.388−0.415, respectively. With respect to the Hereford cattle, the parameter values comprised 0.531−0.810 and 0.511−0.565, 0.330−0.608 and 0.257−0.366, and 0.386−0.498 and 0.342−0.414, respectively.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The animal-related experiments were conducted in accordance with Directive 2010/63/EU of the European Parliament and the Council on the protection of animals used for scientific surveys. The sample collection and survey objective protocols were approved by the Institutional Animal Care and Use Committee, All-Russia Research Institute of Sheep and Goat Breeding, Stavropol, Russian Federation (decision no. 2023−0045, April 14, 2023).

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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