

Original Research Paper

Estimated Breeding Value of Kazakh White-Headed Cattle Breed

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Abstract: The purpose of the study is to establish the estimated breeding value index of Kazakh white-headed cattle by productive indicators. The Estimated Breeding Value (EBV) of the productive indicators of animals of the Kazakh white-headed breed was determined for 2018-2021. The index values were further interpreted as an assessment of the own genetic productivity of each evaluated animal relative to the corresponding average values. For the Kazakh white-headed breed, the estimated breeding values in terms of live weight at birth in 2018 ranged from -8.00 to +12.91, in 2019 from -8.02 to +19.42, in 2020 from -9.96 to -0.96, in 2021 -9.87 to +19.91. The values by the indicator of live weight at weaning in 2018 ranged from -8.63 to +57.39, in 2019 from -23.27 to +57.31, in 2020 from 23.97 to - +57.29, in 2021 -24.37 to +57.26. The estimated breeding value in terms of live weight at one year of age in 2018 varied in the range from -51.37 to +58.26, in 2019 -58.53 to +72.10, in 2020 -57.77 to +71.43, in 2021 -52.73 to +72.00. The breeding value in terms of live weight for adult animals in 2018 ranged from -50.60 to +43.19, in 2019 -135.95 to +118.86, in 2020 from -138.04 to +121.82, in 2021 from -140.56 to +112.43. The breeding value by the milking capacity of mothers of the Kazakh white-headed breed in 2018 ranged from -35.55 to +33.79, in 2019 -8.85 to +46.67, in 2020 from -27.41 to +46.68, in 2021 from -30.26 to +46.65. The accuracy for the EBV of productive indicators of Kazakh white-headed breed animals was 0.004-0.999 by live weight at birth, 0.001-0.998 at weaning, 0.002-0.998 at 12 months, and 0.001-0.965 for adult animals. The estimated breeding value of dairy cows is 0.018-0.990. The features of the distribution of the indices of breeding value of the average daily increase of animals of the Kazakh white-headed breed in 2021 have been clarified. For the Kazakh white-headed cattle breed, the estimated breeding values in terms of the average daily gain from birth to 12 months of age are in the range from -183.56 to +813.34.

Keywords: Beef Cattle, Live Weight, Estimated Breeding Value

Introduction

The Kazakh white-headed breed of cattle is common in many livestock farms in Kazakhstan. Therefore, the study of the productive indicators of this breed is of particular scientific interest. In cattle breeding of meat productivity, the BLUP method is widely used (Forni *et al.*, 2011; VanRaden and Sullivan, 2010).

When evaluating servicing bulls, statistical approaches and methods are mainly used: Assessment of the genetic breeding value of an animal according to

a mixed biometric model Animal Model/Mixed Model Equation (AM/MME) using the classical method of the Best Linear Unbiased Prediction (BLUP). The advantage of this method is the determination of a linear predictive animal biometric model (animal model), in which it is possible to take into account and evaluate the degree of influence of many constant, periodic, and random factors and effects on the estimated useful, productive traits, namely: Environmental effects; seasonal effects; conditions of keeping and feeding; additive genetic effects; the

effects of the influence of selection groups; other random recorded effects; random unaccounted effects.

All factors included in the model are evaluated simultaneously. This approach makes it possible to compare the scores of animals from different generations, even if there was a genetic trend in the population. Based on this mathematical method, many popular index estimates are implemented, such as EPD, EBV, etc., (Strandén and Mäntysaari, 2010).

Live weight is a hereditary trait in the selection of each type of farm animal and one of the main indicators in the selection and technology of the productive traits of farm animals (Bozymov *et al.*, 2019).

The experience of both domestic and foreign cattle breeding convinces us that the effective development of beef cattle breeding is determined by a set of measures to organize a sustainable forage base, the introduction of innovative technologies, and selection work. Continuous, purposeful work to improve breeds, breed groups, types, lines, and individual herds of meat animals through the use of the most valuable animals to improve large arrays of livestock is the main area of activity of breeding work on farms (Khakimov *et al.*, 2021).

The age dynamics of live weight are interconnected with changes in the exterior (Nikonova *et al.*, 2021; Kayumov *et al.*, 2021).

The use of different methods for determining the live weight of farm animals by measurements is based on a high correlation between measurements and live weight: Height at the withers (0.51); chest depth (0.11); width in the head of the femur (0.80); oblique body length (0.56); chest girth (0.89); straight body length (0.76); girth of the belly (0.88).

Therefore, the assessment of bulls by their own productivity in the conditions of the assessment station will contribute to the selection of the most valuable genotypes for use in reproduction.

Further work should be directed to the creation of animals more adapted to the conditions of modern technology, namely, to obtaining livestock that combines high productivity, as well as good reproductive properties and health.

The recommendations of the international non-governmental non-profit organization FAO regarding the assessment of the breeding value of livestock have been studied (Henderson, 1975).

The Aim of the Research

To set the estimated breeding value of the Kazakh white-headed cattle breed by productive indicators.

Materials and Methods

The material of the study the genealogical structure of animals of the Kazakh white-headed breed is represented by intrabreed types, factory lines, and related groups, common in many herds of our country and CIS countries.

The intrabreed Ankata enlarged type is represented by the factory lines of Landysh 9879, Cactus 7969, Salem 12747, Mailan 13851, related groups of Churchill C-60, Martian C-12; intrabreed Shagatai polled type Baikal 442, Veteran 7880, Vyun 712, Vostok 7632, Copperton 150 K, related group Comerton 63118, intrabreed Zavolzhsy type factory line of the King 13682.

As a result of solving linear equations of animal biometric models (AM/MME) using the BLUP method on the data of zootechnical registration of events in the IAS for the Kazakh white-headed cattle breed, genetic estimates of their productivity were obtained according to economical traits: Live weight at birth; live weight at weaning; milking capacity of cows; body weight at one year of age. Also, as trial calculations, genetic assessments were carried out on average daily gains in live weight: In the period from birth to weaning (SP 0-205); in the period from weaning to a year (SP 205-12); in the period from birth to one year (SP 0-12).

The BLUP method was carried out based on data on productivity and zootechnical events of breeding cattle of beef breeds from farms registered in the Database of the Information Analytical System (DB-IAS). Initial indicators of the productivity of cattle of the studied breed for evaluation by the BLUP method: Live weight at birth, live weight at weaning, and live weight at one year of age. Fixed effects of influence took into account: Differences in the content of individuals on farms; years and seasons of calving; sex and age group of calves; mother's age; type of birth (single, twin). The biometric model of the animal took into account additive genetic effects due to parental qualities in generations taken up to three ancestors, the sex of the animal, the effects of the herd, and the effects of the year and season of birth.

The Estimated Breeding Value (EBV) of the productive indicators of animals of the Kazakh white-headed breed was determined for 2018-2022. The index values were further interpreted as an assessment of the own genetic productivity of each evaluated animal relative to the corresponding average values.

Assessment of genetic qualities an index assessment of the genetic breeding value of cattle of the Kazakh white-headed breed was carried out by the method of the best linear unbiased prediction BLUP.

For this, Mixed Model Equations (AM/MME) were built for each estimated productive trait: Live weight at birth, live weight at weaning, the milking capacity of cows at weaning of the calf, and live weight at one year of age. These models took into account the contributions of many factors and effects to the estimated productive trait: Fixed and genetic effects, environmental factors, seasonal factors, and random and unaccounted effects.

The influence of all factors included in the model was taken into account simultaneously in the calculation process (Bozymov *et al.*, 2019). The initial indicators of the live weight of young animals at birth, and at weaning

were adjusted in accordance with the age of the mothers, which affect the studied indicators.

Similarly, live weight at weaning was adjusted to 210 days of age and body weight per year by 365 days of age. Initial data adjustments were made according to formulas (1, 2, 3):

$$CM_p = M_p + \Phi M_p \quad (1)$$

$$CM_o = \frac{M_o - M_p}{B_M} \times 210 + \Phi M_o + CM_p \quad (2)$$

$$CM_r = \frac{M_r - M_o}{B_r - B_M} \times 155 + CM_o \quad (3)$$

where:

CM_p = Adjusted live weight at birth, kg

M_p = Live weight at birth, kg

ΦM_p = Adjusted live weight at birth, taking into account the age of the mother, kg

CM_o = Adjusted live weight at weaning, kg

M_o = Live weight at weaning, kg

B_M = Animal age when weighed at the time of weaning, days

ΦM_o = Correction factor of live weight at weaning by mother's age, kg

CM_r = Adjusted live weight at one year of age, kg

M_r = Live weight at one year of age, kg

B_r = Animal age when weighed at one-year-old, days

In 2018, 10,584 business entities were engaged in breeding Kazakh white-headed cattle, in 2019-8,739, in 2020-8,848, and in 2021-9,012.

The number of animals whose productive and hereditary data, with a depth of at least three generations,

were downloaded from the IAS database for the subsequent calculation of the Estimated Breeding Value (EBV). To calculate the breeding values, data were taken on live and archival animals of the Kazakh white-headed breed for 2018-2022. There were 1,018,163 cattle of the Kazakh white-headed breed in 2018, of which the EBV was calculated for 258,403 animals; in 2019 of 1176070-358325 animals, 2020 of 1241069-386368 animals, in 2021 of 1317755-355084 animals.

Results and Discussion

It has been established that the largest (best) and smallest (worst) estimated breeding values for cattle of the Kazakh white-headed breed are in 10% marginal intervals relative to the entire set of calculated estimates.

For the Kazakh white-headed breed, the values of the estimated breeding value indices in terms of live weight at birth in 2018 varied in the range from -8.00 to +12.91, in 2019 -8.02 to +19.42, in 2020. -9.96 to -0.96, in 2021 -9.87 to +19.91, and in 2022 -9.57 to +19.59 (Table 1).

The estimated breeding values in terms of live weight at weaning in 2018 varied in the range from -8.63 to +57.39, in 2019 -23.27 to +57.31, in 2020 -23.97 to +57.29, in 2021 -24.37 to +57.26, in 2022 r. -25.66 to +57.34 (Table 2).

The estimated breeding values in terms of live weight at one year of age in 2018 varied in the range from -51.37 to +58.26, in 2019 -58.53 to +72.10, in 2020 -57.77 to +71.43, in 2021 -52.73 to +72.00, in 2022 r. -50.16 to +64.68 (Table 3).

The estimated breeding values in terms of live weight for adult animals in 2018 varied in the range from -50.60 to +43.19, in 2019 -135.95 to +118.86, in 2020 -138.04 to +121.82, in 2021 -140.56 to +112.43, in 2022 r. -191.49 to +176.07 (Table 4).

Table 1: Percentile distribution of calculated EBV values of live weight of Kazakh white-headed breed animals at birth

Percentile (%)	Year of observation				
	2018	2019	2020	2021	2022
0	-8.00	-8.02	-9.96	-9.87	-9.57
5	-0.95	-0.92	-0.96	-0.90	-0.93
10	-0.64	-0.59	-0.62	-0.58	-0.59
20	-0.31	-0.25	-0.27	-0.24	-0.25
25	-0.21	-0.15	-0.09	-	-0.07
30	-0.14	-0.08	-0.00	0.07	0.00
40	-0.04	+0.00	0.00	0.00	0.00
50	+0.00	+0.00	+0.01	0.00	+0.08
60	+0.07	+0.01	+0.13	+0.03	+0.25
70	+0.21	+0.12	+0.35	+0.16	+0.51
75	+0.31	+0.21	+0.76	-	+0.90
80	+0.44	+0.34	+1.17	+0.40	+1.27
90	+0.87	+0.75	+19.44	+0.80	+19.59
95	+1.28	+1.16	-9.96	+1.18	-9.57
100	+12.91	+19.42	+19.44	+19.91	+19.59
Minimum	-8.00	-8.02	-9.96	-9.87	-9.57
Maximum	+12.91	+19.42	-0.96	+19.91	-0.93

Table 2: Percentile distribution of calculated EBV values of live weight of Kazakh white-headed breed animals at weaning

Percentile (%)	Year of observation				
	2018	2019	2020	2021	2022
0	+57.39	+57.31	+57.2900	+57.26	+57.34
5	+4.62	+3.94	+3.9900	+3.79	+4.25
10	+3.19	+2.62	+2.6600	+2.55	+3.09
20	+1.68	+1.18	+1.2100	+1.23	+1.80
25	+1.16	+0.71	+0.4100	-	+0.89
30	+0.74	+0.38	+0.0700	+0.44	+0.27
40	+0.23	+0.06	+0.0001	+0.07	0.00
50	+0.03	+0.00	0.0000	0.00	0.00
60	-0.04	+0.00	-0.1100	0.00	-0.07
70	-0.22	-0.11	-0.5000	-0.13	-0.45
75	-0.39	-0.24	-1.5200	-	-1.46
80	-0.66	-0.47	-2.5900	-0.54	-2.53
90	-1.66	-1.46	-23.9700	-1.56	-25.66
95	-2.68	-2.53	-23.9700	-2.61	-25.66
100	-28.63	-23.27	+57.2900	-24.37	+57.34
Minimum	-28.63	-23.27	-23.9700	-24.37	+57.34
Maximum	+57.39	+57.31	+57.2900	+57.26	+4.25

Table 3: Percentile distribution of calculated EBV values of live weight of animals of the Kazakh white-headed breed at one year of age

Percentile (%)	Year of observation				
	2018	2019	2020	2021	2022
0	+58.26	+72.10	+71.430	+72.00	+64.68
5	+6.61	+5.81	+5.830	+5.58	+6.24
10	+4.40	+3.66	+3.720	+3.67	+4.35
20	+2.19	+1.53	+1.620	+1.70	+2.27
25	+1.49	+0.91	+0.550	-	+0.97
30	+0.96	+0.49	+0.060	+0.60	+0.23
40	+0.32	+0.04	+0.001	+0.07	0.00
50	+0.00	+0.00	0.000	0.00	0.00
60	-0.15	+0.00	-0.360	0.00	-0.39
70	-0.61	-0.35	-1.250	-0.37	-1.38
75	-1.02	-0.69	-3.260	-	-3.38
80	-1.59	-1.23	-5.320	-1.30	-5.35
90	-3.49	-3.26	-57.770	-3.29	-50.16
95	-5.41	-5.37	-57.770	-5.26	-50.16
100	-51.53	-58.53	+71.430	-52.73	+64.68
Minimum	-51.53	-58.53	-57.770	-52.73	+64.68
Maximum	+58.26	+72.10	+71.430	+72.00	+6.24

Table 4: Percentile distribution of calculated EBV values of live weight of Kazakh white-headed breed animals aged 5 years and older

Percentile (%)	Year of observation				
	2018	2019	2020	2021	2022
0	+43.19	+118.86	+121.8200	+112.43	+176.07
5	+9.28	+8.26	+8.5600	+8.29	+9.10
10	+5.78	+5.10	+5.3100	+5.30	+6.02
20	+2.89	+1.99	+2.1100	+2.25	+3.04
25	+2.21	+1.14	+0.6600	-	+1.25
30	+1.62	+0.59	+0.0800	+0.75	+0.28
40	+0.71	+0.06	+0.0001	+0.10	0.00
50	+0.00	+0.00	0.0000	0.00	0.00
60	-0.48	+0.00	-0.3700	0.00	-0.42
70	-1.56	-0.35	-1.4600	-0.37	-1.66
75	-2.20	-0.74	-4.0600	-	-4.36
80	-2.98	-1.39	-7.0000	-1.44	-7.36
90	-5.63	-3.95	-138.0400	-3.90	-191.49
95	-9.08	-6.95	-138.0400	-6.58	-191.49
100	-50.60	-135.95	+121.8200	-140.56	+176.07
Minimum	-50.60	-135.95	-138.0400	-140.56	+176.07
Maximum	+43.19	+118.86	+121.8200	+112.43	+9.10

The index of breeding value in terms of the milking capacity of mothers of the Kazakh white-headed breed in 2018 varied in the range from -35.55 to +33.79, in 2019 -8.85 to +46.67, in 2020 -27.41 to +46.68, in 2021 -30.26 to +46.65, in 2022 г. -35.84 to +46.73 (Table 5).

In the process of calculating the breeding values of animals of the Kazakh white-headed breed in 2021, their accuracies were obtained (Table 6).

The accuracy for the EBV of the productive indicators of animals of the Kazakh white-headed breed was 0.004-0.999 for live weight at birth, 0.001-0.998 at weaning, 0.002-0.998 at 12 months of age and 0.001-0.965 for an adult animal. The estimated breeding value of the milking capacity of cows is 0.018-0.990.

The features of the EBV distribution of the average daily gain in animals of the Kazakh white-headed breed in 2021 were clarified (Table 7).

For the Kazakh white-headed cattle breed, the EBV in terms of average daily gain from birth to 12 months of age range from -183.56 to +813.34.

The general increase in the proportion of non-zero EBV accuracy values indicates a more complete and high-quality content in recent years of the database on live weight for the Kazakh white-headed cattle breed.

A methodology for calculating predicted EbV using the BLUP AM statistical method with the construction of an animal genetic model was developed and predicted EBV was calculated for 6 productive indicators: Live weight at birth, at weaning, at 12

months of age, an adult animal (5 years old), the milking capacity of cows, average daily gain (Table 8).

For the Kazakh white-headed cattle breed, the values of the calculated EBVs in terms of average daily gain from birth to 12 months of age lie in the range for the minimum indicator from 0.211-0.424, for the maximum indicator from 0.996-0.999 (Table 8).

It was established that the average live weight of bulls and heifers of the Kazakh white-headed breed corresponded to the elite class (Table 9).

It was found that the live weight at 5 years of age in bulls of the Kazakh white-headed breed corresponded to the elite class, cows to class 1 (Table 10).

The breeding value of Kazakh white-headed cattle is determined by certain quantitative indicators, the variability of which depends on genetic and paratypical factors (Abilov *et al.*, 2014; Nasambaev *et al.*, 2020; 2021). The conducted studies are devoted to the evaluation of productivity by the BLUP method. The genealogical structure of Kazakh white-headed cattle has been clarified for the first time in Kazakhstan. The results of the research work carried out confirm the effectiveness of productivity assessment and selection by the BLUP method. The accuracy for the EBV of the productive indicators of animals of the Kazakh white-headed breed was 0.004-0.999 for live weight at birth, 0.001-0.998 at weaning, 0.002-0.998 at 12 months of age and 0.001-0.965 for an adult animal. The estimated breeding value of the milking capacity of cows is 0.018-0.990.

Table 5: Percentile distribution of calculated EBV values of the milking capacity of mothers of the Kazakh white-headed breed

Percentile (%)	Year of observation				
	2018	2019	2020	2021	2022
0	+34.79	+46.70	+46.68	+46.65	+46,73
5	+4.36	+4.04	+4.41	+4.93	+5,00
10	+3.18	+2.80	+3.05	+3.44	+3,76
20	+1.88	+1.45	+1.60	+1.87	+2,26
25	+1.43	+1.00	+0.72	-	+1,26
30	+1.05	+0.63	+0.17	+0.91	+0,52
40	+0.48	+0.12	+0.001	+0.28	0,01
50	+0.08	+0.00	0.00	0.00	0,00
60	+0.00	+0.00	-0.08	0.00	0,00
70	-0.28	-0.08	-0.60	-0.01	-0,54
75	-0.52	-0.31	-1.60	-	-1,56
80	-0.83	-0.60	-2.66	-0.53	-2,61
90	-1.87	-1.59	-27.41	-1.53	-35,84
95	-2.99	-2.66	-27.41	-2.57	-35,84
100	-35.55	-28.85	+46.68	-30.26	+46,73
Minimum	-35.55	-28.85	-27.41	-30.26	+46,73
Maximum	+34.79	+46.70	+46.68	+46.65	+5,00

Table 6: Percentile distribution of calculated accuracy for EBV of productive indicators of Kazakh white-headed breed animals, according to 2021 data

Percentile (%)	Accuracy of EBV of live weight, kg			Accuracy of EBV of dairy cows	Accuracy of the EBV of an adult animal
	At birth	At weaning	At the age of 12 months		
0	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000
20	0.004	0.001	0.002	0.000	0.001
30	0.015	0.006	0.007	0.018	0.005
40	0.084	0.032	0.042	0.077	0.028
50	0.265	0.147	0.171	0.164	0.117
60	0.472	0.256	0.267	0.213	0.183
70	0.515	0.296	0.333	0.260	0.220
80	0.530	0.321	0.368	0.318	0.242
90	0.554	0.350	0.397	0.448	0.270
95	0.601	0.369	0.418	0.594	0.302
100	0.999	0.998	0.998	0.990	0.965
Minimum	0.004	0.001	0.002	0.018	0.001
Maximum	0.999	0.998	0.998	0.990	0.965

Table 7: Percentile distribution of calculated EBV values of average daily gain of Kazakh white-headed cattle breed

Percentile (%)	EBV, g/day		
	SP 0-205	SP 205-12	SP 0-12
0	370.43	663.76	813.34
5	51.06	50.10	72.40
10	39.72	36.13	55.61
20	27.45	22.49	37.46
30	19.16	14.09	25.67
40	12.50	7.57	16.11
50	6.40	2.02	7.63
60	0.39	-3.32	-0.52
70	-6.02	-9.34	-9.47
80	-13.91	-17.08	-20.05
90	-25.61	-29.07	-35.80
95	-36.11	-40.47	-49.96
100	-183.56	-224.36	-250.99
Minimum	-183.56	-224.36	-250.99
Maximum	370.43	663.76	813.34

Table 8: Percentile distribution of calculated accuracy for EBV of productive indicators of Kazakh white-headed cattle

Percentile (%)	EBV accuracy of average daily gain, g/day		
	SP 0-205	SP 205-12	SP II 0-12
0	0.000	0.000	0.000
5	0.424	0.194	0.211
10	0.455	0.220	0.238
20	0.473	0.245	0.284
30	0.488	0.263	0.316
40	0.502	0.276	0.333
50	0.512	0.289	0.346
60	0.519	0.301	0.358
70	0.527	0.314	0.370
80	0.537	0.333	0.385
90	0.558	0.353	0.405
95	0.581	0.364	0.416
100	0.999	0.996	0.997

Table 9: Average live weight of Kazakh white-headed cattle

Gender and age group	Live weight, kg					
	At birth		At weaning (on the 210 days)		At the age of 12 months (on the 365 days)	
	n	X ± Sx	n	X ± Sx	n	X ± Sx
2018						
Bulls	77 629	27.80±0.130	54 286	210.62±8.200	44 229	321.12±9.400
Heifers	130 661	25.77±0.010	112 454	195.31±4.900	91 183	285.83±5.900
2019						
Bulls	101 717	27.31±0.110	74 552	209.91±7.600	67 138	316.40±8.300
Heifers	201 241	25.23±0.070	179 043	195.61±4.100	164 855	283.46±6.900
2020						
Bulls	104984	27.34±0.110	85 611	209.43±6.700	64907	316.10±8.600
Heifers	174 780	25.46±0.080	156840	193.93±4.000	129215	281.71±5.900
2021						
Bulls	120 011	27.49±0.100	94 267	208.38±6.400	69 265	315.97±7.800
Heifers	212 695	25.65±0.070	186 266	193.27±3.700	148780	281.67±3.700
2022						
Bulls	158 873	27.70±0.009	122 428	206.32±0.060	86 727	315.34±0.081
Heifers	346 172	25.83±0.006	300 504	192.48±0.030	234 087	281.76±0.034

Table 10: Average EBV of the live weight index of an adult (5-year-old) animal of the Kazakh white-headed breed

Bulls		Cows	
Number, n	M ± m	Number, n	M ± m
2018			
39	878.5±9.1000	2 353	533.7±8.6000
2019			
63	828.3±18.300	3 745	536.5±7.1900
2020			
55	874.5±13.7400	1292	545.28±5.650
2021			
70	862.21±8.5700	1 870	543.11±4.800
2022			
111	801.42±13.838	4 308	536.81±0.583

Conclusion

An increase in the proportion of non-zero accuracy EBV of the Kazakh white-headed cattle breed indicates better content for the last 4 years (2018-2022) of the database on productive indicators.

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Author's Contributions

Anuarbek Temirbekovich Bissembayev: Responsible executor, experimental part of the research. Share of implementation and contribution to the preparation of the article 20%.

Dastanbek Asylbekovich Baimukanov: The idea, analysis, and generalization of the obtained data. Share of implementation and contribution to the preparation of the article 20%.

Vladimir Ivanovich Trukhachev: Contractor, conducting experimental research, 15%

Altai Batyrkhanovich Nazarbekov: Performer, analysis of experimental data. Share of implementation and contribution to the preparation of the article 15%.

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Ethics

When conducting the research work, all the principles of scientific ethics are observed. No conflict of interests.

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