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POSTNATAL DEVELOPMENT OF HEIFER AND MILK PRODUCTIVITY OF UKRAINIAN BLACK-SPOTTED DAIRY COWS OF DIFFERENT TYPES OF CONSTITUTION

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Abstract

Groups of animals were formed at six months based on the physiological and selection index we invented. We studied postnatal development in heifers of the high-enzyme (experimental group) and low-enzyme (control group) constitution type. Thus, due to the main diameters of body parts, which characterize the exterior in postnatal ontogenesis, animals of the high-enzyme type (experimental group) prevailed over their analogues of the low-enzyme type (control group). According to indices of the body structure in postnatal ontogeny, the development of some relative to others is evaluated. In our studies, significant superiority in the experimental group over the control analogues wasn't noted in terms of these indicators. Consonant to the leading indicators characterizing oxidation-reduction processes in the body, animals of the high-enzyme type (experimental group) significantly outnumbered their analogues of the low-enzyme type (control group). Therefore, this indicates that the level of metabolic processes in the experimental group was much more intense compared to the control group. Thus, animals of the high-enzyme type (experimental group) significantly outnumbered their analogues of the low-enzyme type (control group).

***Key words**: Black-Spotted dairy breed, heifers, milk productivity, postnatal development.*

INTRODUCTION

The Black-Spotted breed of cattle is bred on five continents in almost all countries. Out of the total number of cattle worldwide (1.2 billion heads), black-spotted dairy breed cattle account for more than 10% of the herd (Novak, 2012; Ugnivenko et al., 2022). In Western Europe, over the past 10-15 years, the specific weight of black-spotted cattle from the total cattle population has increased by 6% and is 41%, and in the countries of the European Economic Community - 46%. In the EEC countries, between 1970 and 1981, the milk productivity of cows increased on average from 3400 kg to 4127 kg per head, or by 21%, and by 2000, the number of cows in these countries increased one and a half times (Novak, 2012; Kohut et al., 2015). An increase in milk productivity was expected due to the improvement in the selection, breeding work, and feeding conditions. As a result, a change in the breed structure led to a significant increase in black-spotted cattle (Kudlác et al., 1975; McAllister, 2002; Novak, 2012; Tóthová et al., 2017; Sizova et al., 2022).

In Germany and the former GDR, the specific weight of black-spotted cattle is 80%; in Poland and Great Britain - 90%. On the other hand, the number of black-spotted Holstein cattle in the USA and Canada is more than 80% among other dairy breeds (Novak, 2012). As a result, the milk yield per cow in many farms in these countries is 8.0-10.0 thousand kg of milk.

Thus, in many countries of the world, the specific weight of black-spotted cattle is relatively high and increases every year due to the great potential of its milk productivity.

The growth rate of livestock, Black-Spotted cattle, is the second most numerous in the CIS countries. In the total number of cattle, its specific weight (26.9%) is only 1% inferior to the Simmental breed (Novak, 2012).

In Ukraine, Black-Spotted cattle are bred in all its regions, and in terms of the number of livestock, it ranks second after the red steppe breed (Kohut et al., 2015; Sachuk et al., 2019; Zhelavskyi et al., 2020; Stadnytska et al., 2022; Maksymyuk et al., 2022).

The history of breeding black-spotted cattle in the western region of Ukraine dates back to the middle of the 19th century. In the 1950s and 1960s, a small number of black and spotted cattle were brought from Germany to the territory of the Rivne region for the first time (Novak, 2012). However, this did not significantly affect the formation of black-spotted cattle massif. A little later, many animals were imported from Holland and Estonia. In the 970s, the Black-Spotted cattle of the Rivne region largely corresponded to the type of Dutch cattle (Novak, 2012). These cattle were distinguished by high milk productivity and good slaughter performance. Black-Spotted cattle bred in the 50s and 70s of the 20th century are of the combined type of productivity - milk and meat direction.

To increase the milk productivity of the “local” Black-Spotted cattle of the western region of Ukraine, from 1974, they widely began to use the Holstein breed bulls. But, unfortunately, there was no genetic “explosion” from the use of Holstein breed sires. And the intermediate genotypes were at the same level as the mother breed animals in terms of milk productivity, and in low-yielding herds (2000-2500 kg), they were even slightly lower. These negative signs could have been avoided if the selection work had been carried out as a scientific experiment in several farms of the basic level or at a control and testing station with different levels of animal feed. Then, and only after correction, determination of the most optimal variants, and clarification of target standards could such a scheme be recommended for production implementation under compliance with specific selection techniques that reduce contradictions between the genotype and the environment (Novak, 2012; Bomko et al., 2018).

In Ukraine, complex conglomerates of animals with different productivity, body structure, and genotype have been created, which have practically lost the breed's attributes in the classical sense (Novak, 2012; Bomko et al., 2018). Therefore, a national program is needed to regulate the processes of creating breeds and their structures and genetic transformation of complex dairy cattle populations, including those tested as new breeding achievements, into competitive and consolidated breeds. M.S. Pelekhaty (Pelekhatyi & Kucher, 2013) understands by consolidation the high hereditary conditioning of parents' transmission of their qualities to their offspring.

In the 90s of the last century, there were more than 190,000 cattle in the Lviv region, including 100,000 cows. The specific gravity of the black and mottled breed was 91.5% (Pelekhatyi & Kochuk-Yashchenko, 2014). At that time, the specific weight of Black-Spotted cattle was approximately the same in other regions of western Ukraine. By 1970, work was completed in the Western region by structuring its breeding base of black and spotted cattle (Novak, 2012). In the genealogical structure of black and spotted cattle in the Western region, a sufficient number of highly productive animals were rationally used in the breeding process in the breed. Such structural units primarily include the lines of Atleta 4098, Varkumer 4086, Futo-Zenita 3, Edison 801, Klimata 2222, Annas Ademi 30587, Nero 173-4003, as well as the Anker 1608 family group. Further, interbreed breeding improved these lines using highly productive material of many related breeds, primarily Holstein (Novak, 2012).

Currently, Holstein animals from the lines Vis Bek Ideala 1013415, Vis Ideala 0933122, Reflection Sovering 198998, Sealing Tryjun Rokita 252803, Chifa 1427381/502027, and Monteynak are widely used in the massif of Black-Spotted cattle in the western region of Ukraine (Novak, 2012).

The modern massif of the Black-Spotted breed of the Western Ukrainian population in terms of body structure and productivity indicators, its high milk productivity, and good meat qualities should be noted (Novak, 2012; Roman et al., 2020; Slivinska et al., 2020). It is precious that Black-Spotted cattle have a high genetic potential for milk production, as evidenced by the performance indicators of record-breaking cows (Kohut et al., 2015; Mazur et al., 2020). Thus, 10513 kg of milk with an average fat content of 3.75% was milked from Shuta 1375 cow in 5 lactations; 10040 kg of milk with a fat content of 4.14% was milked from the cow Vydra 1103 in 4 lactations. These animals carried the blood of Dutch and Estonian breeding. In addition, 12,681 kg of milk with a fat content of 3.89% was milked from Holstein cow Kiyanka 3386 in 4 lactations. Black-Spotted cattle from the western region of Ukraine, bred in the late 1950s and early 1970s with Dutch and Estonian genotypes, are characterized by excellent slaughter performance. These are animals of the combined milk-meat productivity type (Fedak et al., 2002; Loboda, 2012; Shevchenko & Hmelnichiy, 2014; Griffiths et al., 2018; Foris et al., 2019; Goncu et al., 2019; Gieseke et al., 2022).

The improvement of the Black-Spotted cattle of the Western region in the middle of the 20th century was due to the use of the Dutch and Estonian breeds. And from 1974 to the present - the Holstein breed. When breeding black and spotted cattle in Ukraine as a whole, and in the western region in particular, it is necessary to create a national and regional program of breeding and selection of various breeds. Regional programs should be an integral part of the national program. It is known that Holsteinization over the last 20 years did not increase the productivity of the black and spotted breed (Duff & McMurphy, 2007; Novak, 2012; da Silva et al., 2016; He et al., 2018; VanRaden et al., 2020). Therefore, it is necessary to adjust and differentiate the selection process when breeding this livestock, that is, to use those bloodlines and genotypes adapted to our conditions. These animals should have high milk and meat productivity (Novak, 2012; Borshch et al., 2020; Slivinska et al., 2021; Bashchenko et al., 2021; Mylostyvyi et al., 2021).

The work aims to investigate body weight growth, linear measurements, biochemical blood parameters, pulmonary gas exchange of heifers and firstborns, and milk productivity in cows of the Ukrainian Black-Spotted dairy cow of the western inbred type of different constitution types. The type of constitution was evaluated according to the physiological and selection index we developed.

MATERIALS AND METHODS

Groups of animals were formed at the age of 6 months based on the physiological and selection index developed by us. Postnatal development was studied in heifers with a high physiological selection index (experimental group) and a low physiological selection index (control group). In the process of research, animals of different age groups and different physiological conditions (heifers, cows) were studied: growth of body weight, linear development (we took the primary measurements of the sexes of the body - the height at the withers and sacrum, depth and width of the chest, oblique length of the body, chest circumference behind the shoulder blades, width in the hip joints, wrist circumference, vertical and horizontal semi-girth of the rear) according to methods generally accepted in zootechnical practice Siratskyi et al. (2001) Based on weighing, absolute (kg), average daily gains (g) and live weight growth factors (%), and based on measurements (cm) - body structure indices (%) according to methods generally accepted in zootechnical practice.

In all experimental animals at the age of 6-8 months, depending on the breed and type of constitution, the activity of AST and ALT in blood serum was determined according to the Reitman-Frenkel method as modified by Pashkina. The activity of AST and ALT was determined in the blood serum of heifers at 3, 6, 9, 12, 15, and 18 months, heifers at 8-9 months of gestation, and firstborns - at 2-3 months of lactation. In these experiments, a complex physiological indicator was studied in young animals in postnatal ontogeny.

To study the general level of metabolic processes in the body by periods of growth and development (3, 6, 9, 12, 15, and 18 months, 8-9 months of gestation, and firstborns at 2-3 months of lactation) in the blood of animals in each group, the following were determined:

- hemoglobin content (g/l) and number of erythrocytes (1012l) - on erythrohemometer model 065;

- the content of total, reduced, and oxidized glutathione (mg/l) - according to the Woodward-Free method;
- catalase activity (mg H2O2) - according to the method of Bach and Zubkova;

The following were determined in blood serum:
- total protein content (g/l) - refractometrically and according to the Reiss table;
- the content of sulfhydryl groups (mg/l) - according to the method of Ryzhkova and others

Pulmonary gas exchange was studied in heifers at the age of 6, 9, 12, 15, and 18 months, in heifers at 8-9 months of gestation and 2-3 months of lactating cows - by mask method during three adjacent days before morning and evening feeding; the analysis of exhaled air was carried out on a GHP-100 gas analyzer. Calculations of pulmonary gas exchange were carried out according to the method of Kudryavtsev.

The control slaughter of bulls was carried out at the Rava-Ruska slaughterhouse of the Zhovkva district of the Lviv region.

In three animals from each group, the chemical composition of the average meat sample, the longest muscle of the back, and the morphological and varietal composition of the carcasses were determined according to generally accepted methods.

The study of milk productivity of cows for a separate lactation was carried out employing control of milking every decade. During each month of lactation, the following were determined in milk:
- fat content - acid method according to Gerber;
- protein content - refractometrically;
- dry substance - by drying in a drying cabinet;
- subclinical forms of mastitis of every fourth udder of cows - Whiteside's test (at the beginning, middle, and end of lactation).

Experimental studies were conducted following the Law of Ukraine “On the Protection of Animals from Cruelty Treatment” dated 03/28/2006 and the rules of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes dated 11/13/1987.

The analysis of research results was carried out using the Statistica 6.0 software package. The probability of differences was assessed by Student's t-test.

RESULTS AND DISCUSSIONS

Growth of live weight and linear development of experimental animals. Live weight is one of the integral indicators that characterize an animal's body both externally and internally. In these studies, the task was to study the growth of live weight and the linear development of heifers, heifers, and cows of different types of the constitution of the Western Ukrainian population of the Black-Spotted breed from birth to the end of the third lactation.

Table 1 shows that according to the live weight of newborns at 3, 6, 12, 18, and 21 months, heifers of the experimental group exceeded the control analogs by 1.3, respectively; 0.3; 7.5; 8.5; 5.7, and 2.8%.

The live weight of heifers in the control group was at the level of the breed standard at 18 months, and the analogs of the experimental group in this age period exceeded the analogs standard by 5.79%.

Higher indicators of live weight caused higher average daily increases in the live weight of animals of the experimental group compared to the control analogs (Table 2).

From birth to 3 months of age, the average daily gains in live weight were at the level of 840 and 839 grams, respectively, in animals of the control and experimental groups.

In the age periods of 4-6, 7-12, 0-18, and 0-21 months, heifers of the experimental group outnumbered the control analogs by 19.19, respectively; 9.97; 6.08; 2.99%, and in the age periods of 13-18, 19-21 months, heifers of the control group exceeded the experimental counterparts by 3.87 and 20.28%, respectively, in terms of average daily live weight gains. There was a different intensity of live weight gain in animals of the control and experimental groups at different age periods. This indicates the rhythmic growth of the live weight of heifers in postnatal ontogeny. There is such a pattern: animals that lag in growth in specific age periods try to catch up with their development when feeding is improved, which happens in animals of the control group in the age periods of 13-18 and 19-21 months. From birth to 21 months, heifers of the research group had a live weight gain of 654, and their control counterparts - 635 grams, respectively.

Table 1. Dynamics of the live weight of Ukrainian Black-Spotted heifers dairy breed, kg (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Newborns	28.9 ± 0.67	29.3 ± 0.45	+ 0.4
3	104.5 ± 3.46	104.8 ± 2.93	+ 0.3
6	169.2 ± 4.48	181.9 ± 3.68****	+ 12.7
12	288.4 ± 5.92	313.0 ± 4.09****	+ 24.6
18	375.3 ± 9.23	396.7 ± 7.82**	+ 21.4
21	429.2 ± 8.85	441.5 ± 9.71	+ 12.3

Table 2. Average daily live weight gains of Ukrainian heifers Black-Spotted dairy breed, g (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
0–3	840 ± 10.0	839 ± 10.0	-1
4–6	719 ± 11.0	857 ± 11.0	+ 138
7–12	662 ± 12.0	728 ± 10.0	+ 66
13–18	483 ± 14.0	465 ± 11.0	- 18
0–18	641 ± 15.0	680 ± 11.0	+ 39
19–21	599 ± 11.0	498 ± 10.0	- 101
0–21	635 ± 10.0	654 ± 11.0	+ 19

Live weight does not fully characterize the growth and development of animals. This deficiency is complemented by the measurements, which are used to assess the linear growth of individuals. Therefore, in zootechnical practice, basic measurements are used, by which, in general, the volumetric development of animals can be studied in detail (Table 3).

According to the height at the withers of heifers at 3, 6, 12, and 18 months, heifers at 8-9 months of gestation, and cows at 2-3 months of lactation, the experimental group exceeded the control females by 0.43, respectively; 0.40; 2.08; 1.50; 1.60; 1.93%. In the age mentioned above, a similar pattern was noted for such an indicator as the height at the sacrum. In terms of breast depth, heifers at 3, 6, and 12 months, heifers at 8-9 months of gestation, and cows of 2-3 months of lactation of the experimental group exceeded the control females by 0.56, respectively 0.67, 0.72, 0.32, 1.30%, and the animals of the experimental group exceeded the control analogs by 1.49-1.78% in the oblique length of the trunk in all studied age periods.

Experimental heifers at the age of 3, 6, 12, 18 months, at 8-9 months of lactation, and cows at 2-3 months of gestation exceeded the control ones by 2.88, respectively; 0.95; 3.77; 0.95; 0.65; 0.46%. A similar regularity is noted for the width index in the hip joints. In the above research periods, the width of the hips of the animals of the experimental group exceeded the control counterparts by 2.76, respectively 2.37, 2.76, 0.86, 2.89%.

Heifers of the experimental group at 3, 6, 12, 18 months, at 8-9 months of gestation and cows at 2-3 months of lactation exceeded the control females by 0.94, respectively 1.10, 1.66, 0.35, 0.55, 0.44%, and by wrist girth - by 1.44, respectively 1.37, 1.16, 3.28, 2.20, 2.19%.

Thus, according to the main diameters of body parts, which characterize the exterior in postnatal ontogenesis, animals of the high-enzyme type (experimental group) prevailed over their analogs of the low-enzyme type (control group).

According to indices of the body structure in postnatal ontogeny, the development of some sexes relative to others is evaluated. In our studies, no significant superiority of the animals of the experimental group over the control analogs was noted for these indicators (Table 4).

Table 3. Measurements of the body of Ukrainian heifers and cows Black-Spotted dairy breed, cm (M±m)

Measurements	Groups		± before the control
	control (n=10)	experimental (n=10)	
3 months			
Height at the withers	93.7±0.40	94.1±0.50	+ 0.4
Height at the lumbar	96.8±0.30	97.5±0.20*	+ 0.7
Chest depth	35.8±0.20	36.0±0.30	+ 0.6
Oblique length of the body	95.6±0.50	97.3±0.40**	+ 1.7
The width of the chest behind the shoulder blades	24.3±0.30	25.0±0.20*	+ 2.9
Width in hip joints	25.5±0.40	26.5±0.40	+ 1.0
Width at the hips	29.0±0.30	29.8±0.50	+ 0.8
Chest girth behind the shoulder blades	106.2±0.10	107.2±0.15*	+ 1.0
Wrist girth	13.9±0.10	14.1±0.12	+ 0.2
6 months			
Height at the withers	99.9±0.13	100.3±0.17*	+ 0.4
Height at the lumbar	104.2±0.19	104.7±0.18**	+ 0.5
Chest depth	45.0±0.20	45.3±0.15	+ 0.3
Oblique length of the body	103.9±0.17	104.8±0.18**	+ 0.9
The width of the chest behind the shoulder blades	31.5±0.20	31.8±0.25	+ 0.3
Width in hip joints	31.6±0.21	31.8±0.24	+ 0.2
Width at the hips	33.7±0.30	34.5±0.31	+ 0.8
Chest girth behind the shoulder blades	127.2±0.14	128.6±0.17***	+ 1.4
Wrist girth	14.6±0.11	14.8±0.12	+ 0.2
12 months			
Height at the withers	110.6±0.70	112.9±0.50**	+ 2.3
Height at the lumbar	118.7±0.10	118.7±0.12	0
Chest depth	55.1±0.11	55.5±0.13	+ 0.4
Oblique length of the body	121.9±0.18	123.5±0.20***	+ 1.6
The width of the chest behind the shoulder blades	37.1±0.30	38.5±0.30**	+ 1.4
Width in hip joints	39.3±0.15	41.1±0.19****	+ 1.8
Width at the hips	39.8±0.13	40.9±0.18***	+ 1.1
Chest girth behind the shoulder blades	156.7±0.25	159.3±0.30***	+ 2.6
Wrist girth	17.2±0.40	17.4±0.20	+ 0.2
18 months			
Height at the withers	119.0±0.30	120.8±0.35***	+ 1.8
Height at the lumbar	125.5±0.20	127.8±0.30***	+ 2.3
Chest depth	61.6±0.40	61.6±0.20	0
Oblique length of the body	133.3±0.40	135.8±0.41***	+ 2.5
The width of the chest behind the shoulder blades	42.0±0.20	42.4±0.15	+ 0.4
Width in hip joints	45.3±0.17	45.6±0.18	+ 0.3
Width at the hips	44.0±0.44	44.0±0.50	0
Chest girth behind the shoulder blades	172.5±0.30	173.1±0.20	+ 0.6
Wrist girth	18.3±0.17	18.9±0.18**	+ 0.6
Cows for 8-9 months. corporeality			
Height at the withers	124.9±0.30	126.9±0.20***	+ 2.0
Height at the lumbar	130.7±0.15	133.3±0.20***	+ 2.6
Chest depth	63.0±0.11	63.2±0.17	+ 0.2
Oblique length of the body	137.6±0.19	138.5±0.17**	+ 0.9
The width of the chest behind the shoulder blades	44.6±0.40	45.3±0.30	+ 0.7
Width in hip joints	49.5±0.10	49.9±0.11**	+ 0.4
Width at the hips	46.5±0.15	46.9±0.14*	+ 0.4
Chest girth behind the shoulder blades	181.3±0.13	182.3±0.14***	+ 1.0
Wrist girth	18.2±0.17	18.6±0.16	+ 0.4
Cows for 2-3 months of lactation			
Height at the withers	124.4±0.30	126.8±0.15***	+ 2.4
Height at the lumbar	132.0±0.17	134.4±0.18***	+ 2.4
Chest depth	61.4±0.20	62.2±0.19**	+ 0.8

Oblique length of the body	141.2±0.30	143.3±0.25***	+ 2.1
The width of the chest behind the shoulder blades	43.5±0.1	43.7±0.18	+ 0.2
Width in hip joints	47.9±0.20	49.6±0.21***	+ 1.7
Width at the hips	45.0±0.17	46.3±0.13****	+ 1.3
Chest girth behind the shoulder blades	182.7±0.18	183.5±0.14**	+ 0.8
Wrist girth	18.3±0.11	18.7±0.12**	+0.4

Table 4. Indexes of body composition of Ukrainian heifers and cows black and spotted dairy breed, %

Indexes	Groups		± before the control
	control (n=10)	experimental (n=10)	
3 months			
Long-legged	61.8	61.7	- 0.1
Stretching	102.0	103.4	+ 1.4
Thoracic pelvis	83.8	83.9	+ 0.1
Pectoral	67.9	69.4	+ 1.5
Beating	111.0	110.2	- 0.8
Overgrowth	104.0	102.8	- 1.2
Ossification	14.8	15.0	+ 0.2
6 months			
Long-legged	54.9	54.8	- 0.1
Stretching	104.0	104.5	+ 0.5
Thoracic pelvis	93.4	92.2	- 1.2
Pectoral	70..0	70.2	+ 0.2
Beating	122.4	122.7	+ 0.3
Overgrowth	104.3	104.4	+ 0.1
Ossification	14.6	14.7	+ 0.1
12 months			
Long-legged	49.8	51.2	+ 1.4
Stretching	110.2	109.4	- 0.8
Thoracic pelvis	93.2	94.1	+ 0.9
Pectoral	66.8	69.9	+ 3.1
Beating	128.5	129.0	+ 0.5
Overgrowth	107.3	105.1	- 2.2
Ossification	15.5	15.4	- 0.1
18 months			
Long-legged	48.2	49.0	+ 0.8
Stretching	112.0	112.4	+ 0.4
Thoracic pelvis	95.4	96.3	+ 0.9
Pectoral	68.2	68.8	+ 0.6
Beating	129.4	127.4	- 2.0
Overgrowth	105.4	105.8	+ 0.4
Ossification	15.4	15.6	+ 0.2
Cows for 8-9 months. corporeality			
Long-legged	49.4	50.3	+ 0.9
Stretching	110.1	109.1	- 1.0
Thoracic pelvis	97.4	95.1	- 2.3
Pectoral	71.1	70.8	- 0.3
Beating	132.5	130.9	- 1.6
Overgrowth	104.5	105.0	+ 0.5
Ossification	14.6	14.6	0
Cows for 2-3 months of lactation			
Long-legged	50.9	50.6	- 0.3
Stretching	113.0	113.5	+ 0.5
Thoracic pelvis	93.9	95.4	+ 1.5
Pectoral	69.9	71.2	+ 1.3
Beating	128.0	129.4	+ 1.4
Overgrowth	104.0	108.0	+ 4.0
Ossification	14.7	14.7	0

According to the long-leggedness index, in the postnatal ontogeny of experimental animals, the depth of the chest increased more intensively than the height at the withers, as the value of this index decreased from 61.70 to 50.9%.

The overall (volumetric) development of animals in terms of age increased from the distension index, which grew from 102.0 to 113.5%.

From 3 months of age to 8-9 months of gestation, the pelvic index increased in animals of the control and experimental groups. This indicates that the front and back of the body developed proportionally. However, compared to 8-9 months of gestation, the pelvis-thoracic index slightly decreased during the lactation of firstborns.

Chest index characterizes the volumetric development of the animal's chest. In the postnatal ontogeny of experimental animals, the value of this index has a wave-like character of change. In some age periods of growth and development, it is higher, and in others - lower. This indicates the rhythmic development of the chest in animals of the control and experimental groups.

The weight loss index increased from the 3-month age of the heifers to the 8-9 months, and it slightly decreased during the 2 cows' 3 months of lactation. This indicates that in the postnatal ontogeny, the volume of the chest and the length of the body of the experimental animals developed proportionally.

The height measurements of the experimental animals in the postnatal ontogeny had a linear character of increase. The overgrowth index evidences this. Thus, it was 104.0-102.8% in 3-month-old animals and 104.0-108.0% in cows in 2-3 months of lactation.

Due to the ossification index, no significant fluctuations were found in the postnatal ontogeny of the experimental animals.

Thus, the indices of body structure indicate that the animals developed harmoniously and proportionally in the postnatal ontogeny.

Morphological and biochemical indicators of the blood of experimental animals. Blood is a constantly circulating liquid connecting various animal body structures (Grymak et al., 2020; Lesyk et al., 2022; Martyshuk et al., 2022). The main physiological functions of blood include alimentary, excretory, respiratory, protective, mechanical, and others. These functions are performed by a complex of enzymes and proteins, as well as morphological indicators of blood (Kulyaba et al., 2019; Martyshuk et al., 2020).

The content of erythrocytes and hemoglobin in the blood. The erythrocytes perform vital functions in the body, including respiratory (Slivinska et al., 2019). The Table 5 gives an indicator of age-related changes in the number of erythrocytes in the blood of experimental animals.

Table 5. The number of erythrocytes in the blood of heifers and cows
of the Ukrainian Black-Spotted dairy breed, 10^{12}/l (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	6.12 ± 0.22	6.38 ± 0.05	+ 0.26
6	6.86 ± 0.25	7.54 ± 0.38	+ 0.68
12	4.58 ± 0.17	5.03 ± 0.04**	+ 0.45
18	5,16 ± 0.09	5.20 ± 0.11	+ 0.04
Cows for 8-9 months. corporeality	6.15 ± 0.05	6.83 ± 0.10***	+ 0.68
Cows for 2-3 months. lactation	6.31 ± 0.12	6.67 ± 0.08**	+ 0.36
On the average	5.81 ± 0.15	6.27 ± 0.13**	+ 0.46

The erythrocytes number in the blood of heifers at 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation of the experimental group was higher than that of the control group by 4.25, respectively; 9.91; 9.82; 0.77; 11.06; 5.70; 7.92%. On average, during the entire growing period, the animals of the experimental group outnumbered the control analogs by 7.92%.

Another essential component of blood, part of erythrocytes, is hemoglobin, which carries oxygen from the lungs to the tissues and transports carbon dioxide back to the lungs (Table 6).

According to the content of hemoglobin in the blood, experimental heifers at the age of 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation, exceeded control females by 6.67, respectively; 8.20; 10.83; 3.62; 6.35; 10.90%. On average, during the entire growing period, the animals of the experimental group outnumbered the control analogs by 7.64%.

Table 6. Hemoglobin content in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g/l (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	105.0 ± 2.0	112.0 ± 0.7***	+ 7.0
6	122.0 ± 4.1	132.0 ± 2.1**	+ 10.0
12	109.0 ± 3.8	120.8 ± 3.0**	+ 11.8
18	115.9 ± 2.1	120.1 ± 0.3*	+ 4.2
Cows for 8-9 months. corporeality	110.2 ± 1.9	117.2 ± 1.1***	+ 7.0
Cows for 2-3 months. lactation	105.5 ± 2.4	117.0 ± 0.7***	+ 11.5
On the average	111.3 ± 2.7	119.8 ± 2.6**	+ 8.5

Thus, according to the main morphological parameters of the blood, animals of the high-enzyme type (experimental group) significantly outnumbered the analogs of the low-enzyme type (control group) in postnatal ontogenesis. This shows that the level of metabolic processes in the body was more intense in the animals of the experimental group than in the control counterparts.

The level of protein metabolism in the body of animals. One of the main components of protein metabolism in the body of animals is the content of total protein in blood serum, the activity of peramination enzymes in blood serum, as well as the index for assessing the type of constitution of animals, which is calculated based on the activity of AST and ALT in blood serum and economically useful characteristics of animals (Gutyj et al., 2019; Gutyi et al., 2019).

The content of total protein in the blood serum of heifers at the age of 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation of the experimental group exceeded the control analogs by 1.81, respectively 6.25; 9.77; 7.47; 15.23; 8.64% (Table 7).

On average, during the entire growing period, the animals of the experimental group outnumbered the control analogs by 8.09%.

Table 7. Content of total protein in blood serum of heifers and cows of the Ukrainian Black-Spotted dairy breed, g/l (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	66.4 ± 1.7	67.6 ± 2.1	+ 1.2
6	68,8 ± 1.2	73.1 ± 1.7**	+ 4.3
12	68.6 ± 2.5	75.3 ± 1.3**	+ 6.7
18	70.9 ± 0.9	76.2 ± 1.4****	+ 5.3
Cows for 8-9 months. corporeality	66.3 ± 1.9	76.4 ± 1.2****	+ 10.1
Cows for 2-3 months. lactation	74.1 ± 0.8	80.5 ± 1.4****	+ 6.4
On the average	69.2 ± 1.50	74.8 ± 1.52**	+ 5.6

Another important indicator that characterizes protein metabolism in the animal body is the activity of aminotransferases in blood serum. Regarding AST activity in blood serum, on average, over the entire period of rearing, the animals of the experimental group exceeded the control group by 11.78% (Table 8).

We found a similar pattern in the activity of ALT in blood serum. Thus, according to this indicator, the heifers of the experimental group at 3, 6, 12, 18 months, at 8-9 months of gestation and cows at 2-3 months of lactation were superior to the same age control group by 4.72, respectively 22.55, 26.12, 8.13, 8.01, 10.28% (Table 9).

Table 8. AST activity in the blood serum of heifers and cows of the Ukrainian Black-Spotted dairy breed, units/l^3 (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	34.14 ± 0.58	35.47 ± 0.44*	+ 1.33
6	29.70 ± 0.44	33.03 ± 0,58****	+ 3.33
12	30.36 ± 1.07	39.12 ± 2.24****	+ 8.86
18	37.02 ± 0.38	44.33 ±0.32****	+ 7.31
Cows for 8-9 months. corporeality	44.73 ± 0.41	47.26 ± 0.48****	+2.53
Cows for 2-3 months. lactation	33.47 ± 0.51	34.80 ± 0.23**	+ 1.33
On the average	34.89 ± 0.56	39.00 ± 0.71****	+ 4.11

Table 9. ALT activity in blood serum of heifers and cows of the Ukrainian Black-Spotted dairy breed, units/l^{-3} (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	18.84 ± 0.81	19.73 ± 0.80	+ 0.89
6	15.74 ± 0.58	19.29 ± 0.38****	+ 3.55
12	16.96 ± 0.83	21.39 ± 0.26****	+ 4.43
18	21.90 ± 0.29	23.68 ± 0.40***	+ 1.78
Cows for 8-9 months. corporeality	28.48 ± 0.73	30.76 ± 0.58**	+ 2.28
Cows for 2-3 months. lactation	25.38 ± 0.29	27.99 ± 0.73***	+ 2.61
On the average	21.22 ± 0.59	23.81 ± 0.52***	+ 2.59

Due to this indicator, the average difference in favor of experimental animals was 12.20% during the growing period.

A comprehensive indicator of the body's protein metabolism in combination with economically advantageous traits is the index of evaluation of the type of constitution of heifers of the Western Ukrainian population of the Black-Spotted breed, which we determined at the age of 3, 6, 12, and 18 months (Table 10).

The animals of the experimental group at 3, 6, 12, 18 months of age exceeded the control analogues by 4.52, respectively, due to the constitution type assessment index, 23.81, 39.06, 22.00%. On average, over the entire growing period, the heifers of the experimental group outperformed the control heifers by 25.05% according to the constitution type evaluation index.

Therefore, according to the leading indicators of protein metabolism, the animals of the research group significantly outnumbered the control analogues, which indicates a more intense level of metabolic processes in their body.

Table 10. Physiological and selection index of evaluation of the type of constitution of heifers of the Ukrainian Black-Spotted dairy breed

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
3	20.81	21.75	+ 0.94
6	28.90	35.78	+ 6.88
12	51.20	71.20	+ 20.00
18	83.13	101.42	+ 18.29
On the average	46.01	57.54	+ 11.53

Sulfhydryl groups are part of sulphur-containing amino acids and also characterize protein metabolism in the animal body. Therefore, residual and protein SH-groups are generally determined in physiological and biochemical practice.

In experimental animals, the change in the content of total and protein groups had a wave-like character, which is obviously due to the rhythmicity of animal growth.

Analysis of the indicators is given in the Table 11, shows that the content of total sulfhydryl groups in the blood of heifers of the experimental group at 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation exceeded the control analogues by

10.85, respectively 27.50, 23.44, 18.01, 22.08, 8.86%.
It was established that the content of residual SH-groups decreased with age in the body of both groups of animals.

Due to the content of residual SH-groups in the animals of the experimental group in the postnatal ontogeny, they prevailed in the control group by 24.34% (Table 12).

Table 11. The content of total sulfhydryl groups in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g^{-3}/l cysteine (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	605.7 ± 8.7	671.4 ± 50.5	+ 65.7
6	459.3 ± 5.0	585.6 ± 13.13***	+ 126.3
12	689.0 ± 28.7	850.5 ± 54.6**	+ 161.5
18	504.7 ± 17.9	595.6 ± 22.0***	+ 90.9
Cows for 8-9 months. corporeality	651.3 ± 35.8	795.1 ± 21.8****	+ 143.8
Cows for 2-3 months. lactation	578.0 ± 15.3	629.2 ± 12.1**	+ 51.2
On the average	581.3 ± 18.6	687.9 ± 29.0***	+ 106.6

Table 12. The content of residual SH-groups in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g $^{-3}$/l cysteine (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	157.4 ± 1.4	173.6 ± 4.0	+ 16.2
6	135.3 ± 5.3	178.7 ± 5.3****	+ 43.4
12	131.2 ± 7.2	159.5 ± 5.3***	+ 28.3
18	123.1 ± 8.1	149.3 ± 4.0***	+ 26.2
Cows for 8-9 months. corporeality	118.2 ± 7.6	171.7 ± 2.0****	+ 53.5
Cows for 2-3 months. lactation	126.2 ± 2.7	151.4 ± 3.5****	+ 25.2
On the average	131.9 ± 5.4	164.0 ± 4.0****	+ 32.1

Heifers of the experimental group at 3, 6, 12, 18 months, at 8-9 months of gestation and cows at 2-3 months of lactation exceeded the control analogues by 4.98, respectively, in terms of the content of protein sulfhydryl groups in the blood; 18,11; 13.22; 8.78; 0.86; 2.69% (Table 13).
Therefore, according to the content of total, residual, and protein SH-groups, animals of the high-enzyme type (experimental group) in the postnatal ontogeny significantly outnumbered the analogues of the low-enzyme type (control group). This indicates that according to the given indicators of protein metabolism in the body of the animals of the experimental group, metabolic processes were more intense than in the control analogs.

Table 13. The content of protein SH-groups in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g^{-3}/l of cysteine (M±m)

Age, months	Groups		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	6855.5 ± 158.9	7197.1 ± 610.8****	+ 341.6
6	4712.3 ± 62.2	5565.7 ± 246.4***	+ 853.4
12	8105.3 ± 576.2	9176.5 ± 764.4	+ 1071.2
18	5378.9 ± 187.7	5851.2 ± 136.9*	+ 472.3
Cows for 8-9 months. corporeality	8090.0 ± 830.0	8160.0 ± 210.0	+ 70
Cows for 2-3 months. lactation	5940.0 ± 210.0	6100.0 ± 290.0	+ 160
On the average	6513.7 ± 337.5	7008.4 ± 376.4	+ 494.7

Redox processes in the blood of experimental animals. The respiratory pigment hemoglobin, catalase, and glutathione, are contained in erythrocytes and play an important act in redox processes in the cells and tissues of the body. In addition, glutathione in the blood performs a redox function and generally participates in the body's respiratory process. Therefore, the content of total, reduced, and oxidized glutathione in the blood indicates the intensity of redox processes in the body of animals.

Experimental heifers at 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation exceeded the control analogues by the content of total glutathione, respectively, by 8.38, 20.25, 7.44, 5.48, 18,11, 1.80% (Table 14).

A similar pattern was observed in the reduced glutathione content in the animals' blood. The individuals of the experimental group over the entire period of cultivation prevailed over the control females of the same age by an average of 9.56% (Table 15).

According to the content of oxidized glutathione in the blood of heifers at 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation, the experimental group exceeded the counterparts of the control group by 7.92, respectively 15.13, 7.77, 6.52, 46.88, 4.01% (Table 16).

On average, during the entire growing period, the animals of the experimental group exceeded the control animals by 10.98% in terms of the oxidized glutathione content in the blood.

It was established that experimental heifers at 3, 6, 12, 18 months, at 8-9 months of gestation and cows at 2-3 months of lactation exceeded the control heifers by 0.89, respectively, in blood catalase activity, 15.57, 4.53, 3.93, 22.61, 3.68% (Table 17).

Table 14. Content of total glutathione in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g^{-3}/l

Age, months	Groups (M+m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	366.3 ± 17.5	397.0 ± 4.9*	+ 30.7
6	313.1 ± 7.0	376.5 ± 5.4****	+ 63.4
12	375.2 ± 6.9	403.1 ± 2.6***	+ 27.9
18	428.7 ± 4.5	452.2 ± 5.3***	+ 23.5
Cows for 8-9 months. corporeality	396.0 ± 7.7	467.7 ± 3.7****	+ 71.7
Cows for 2-3 months. lactation	455.3 ± 2.7	463.5 ± 5.3	+ 8.2
On the average	389.1 ± 7.72	426.7 ± 4.53****	+ 37.6

Table 15. The content of reduced glutathione in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g^{-3}/l

Age, months	Groups (M+m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	339.7 ± 22.8	368.3 ± 7.1	+ 28.6
6	279.4 ± 12.4	337.7 ± 3.5****	+ 58.3
12	334.8 ± 9.4	360.1 ± 3.7**	+ 25.3
18	385.2 ± 3.8	412.4 ± 3.7****	+ 27.2
Cows for 8-9 months. corporeality	359.2 ± 9.2	413.4 ± 5.4****	+ 54.2
Cows for 2-3 months. lactation	379.6 ± 1.0	384.7 ± 2.7*	+ 5.1
On the average	346.3 ± 9.8	379.4 ± 7.3**	+ 33.1

Table 16. The content of oxidized glutathione in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g^{-3}/l

Age, months	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	26.5 ± 5.4	2.6 ± 4.1	+ 2.1
6	33.7 ± 5.3	38.8 ± 4.1	+ 5.1
12	39.9 ± 2.6	43.0 ± 2.8	+ 3.1
18	39.9 ± 3.1	42.5 ± 3.4	+ 2.6
Cows for 8-9 months. corporeality	36.9 ± 1.8	54.2 ± 5.1***	+ 17.3
Cows for 2-3 months. lactation	75.7 ± 1.5	78.8 ± 4.1	+ 3.1
On the average	42.53 ± 3.3	47.2 ± 3.9	+ 4.7

On average, over the entire experiment period, the experimental group's animals exceeded the control analogues by 7.60% in terms of catalase activity in the blood.

Therefore, according to the leading indicators characterizing oxidation-reduction processes in the body, animals of the high-enzyme type (experimental group) significantly outnumbered the analogues of the low-enzyme type (control group). Furthermore, the level of metabolic processes in the experimental animals was much more intense than that of the counterparts of the control group.

Table 17. Catalase activity in the blood of heifers and cows of the Ukrainian Black-Spotted dairy breed, g^{-3} H_2O_2 /l

Age, months	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	6.77 ± 0.27	6.83 ± 0.22	+ 0.06
6	6.23 ± 0.34	7.20 ± 0.05	+ 0.97
12	7.07 ± 0.06	7.39 ± 0.13	+ 0.32
18	6.62 ± 0.05	6.88 ± 0.30	+ 0.26
Cows for 8-9 months. corporeality	5.13 ± 0.12	6.29 ± 0.19****	+ 1.16
Cows for 2-3 months. lactation	9.24 ± 0.20	9.58 ± 0.05	+ 0.34
On the average	6.84 ± 0.17	7.36 ± 0.16**	+ 0.52

Pulmonary gas exchange in animals. The growth and development of animals are based on complex processes of assimilation and oxidation of nutrients in the body. The intensity of growth and development in different age periods is not the same, and the level of metabolic processes in the body of animals is also different.

In the process of growth and development, the metabolic processes in an animal's body are influenced by the external environment and hereditary factors.

The intensity of complex metabolic processes in the animal body can be tested by the level of gas-energy exchange, which is an integral indicator of the body's complex biochemical and physiological processes.

Inspiratory capacity and pulmonary ventilation. In the growth and development of young animals, pulmonary breathing is characterized by the frequency and depth of breathing and pulmonary ventilation. With age, the indicators of pulmonary respiration in animals have a corresponding pattern.

The characteristics of the breathing rate of experimental animals are given in Table 18.

Table 18. Frequency of air inhalation per minute by heifers and cows of the Ukrainian Black-Spotted dairy breed

Age, months	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	28.8 ± 1.94	32.4 ± 0.91*	+ 3.6
6	26.9 ± 0.03	25.5 ± 0.79	- 1.4
12	21.8 ± 0.47	19.8 ± 0.87*	- 2.0
18	20.7 ± 0.50	17.8 ± 1.44*	- 2.9
Cows for 8-9 months. corporeality	18.0 ± 0.14	15.9 ± 0.48****	- 2.1
Cows for 2-3 months. lactation	11.0 ± 0.08	9.9 ± 0.43**	- 1.1
On the average	21.2 ± 0.53	20.22 ± 0.82	- 0.98

Table 19. The depth of air inhalation by heifers and cows of the Ukrainian black and spotted dairy breed, Jr

Age, months	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	867 ± 71.88	787 ± 5,78	- 80
6	1276 ± 34.12	1575 ± 41.60****	+ 299
12	2114 ± 34.12	2638 ± 185.30**	+ 524
18	3012 ± 77.88	3695 ± 319.57*	+ 683
Cows for 8-9 months. corporeality	3065 ± 61.85	3760 ± 50.59****	+ 695
Cows for 2-3 months. lactation	7457 ± 383.58	9049 ± 484.12**	+ 1592
On the average	2965 ± 110.0	3584 ± 181.2***	+ 619

Heifers of the control group at 6, 12, 18 months, at 8-9 months of gestation and cows at 2-3 months of lactation prevailed over experimental counterparts by 5.49, respectively 10.10, 16.29, 13.21, 11.11%. It should be noted that at the age of 3 months, heifers of the experimental group outnumbered the control counterparts by 12.5%. On average, over the entire experiment period, the animals of the control group exceeded the experimental ones by 4.95% in terms of breathing frequency.
Thus, the animals' breathing frequency in the experimental group's postnatal ontogeny was lower than that of the control counterparts.
If the breathing frequency of the animals in the experimental group was lower than that of the control group, on the contrary, according to the index of the depth of breathing, they significantly exceeded the control analogues (Table 19). Heifers at 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation, the experimental group outnumbered the control analogues by 23.43, respectively 24.78, 22.68, 22.67, 21.35%. At the age of 3 months, heifers of the control group outnumbered the experimental counterparts by 10.16%.
According to the indicators of pulmonary ventilation in all age periods, the animals of the experimental group significantly exceeded the control peers (Table 20).

Table 20. Pulmonary ventilation of heifers and cows of the Ukrainian Black-Spotted dairy breed, l/min

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	24.78 ± 0.34	24.85 ± 0.33	+ 0.07
6	34.30 ± 0.87	39.80 ± 0.43****	+ 5.50
12	48.11 ± 0.70	51.57 ± 0.98**	+ 3.46
18	62,20 ± 0.15	64.70 ± 1.30*	+ 2.50
Cows for 8-9 months. corporeality	67.10 ± 1.16	69.10 ± 0.33***	+ 2.00
Cows for 2-3 months. lactation	93.82 ± 3.42	102.80 ± 1.63**	+ 8.98
On the average	55.38 ± 0.97	58.47 ± 0.97**	+ 3.09

Heifers of the experimental group at the age of 3, 6, 12, 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation exceeded the control counterparts by 0.28, respectively 16.03, 7.19, 4.02, 2.98, 9.57%. On average, during the entire growing period, the animals of the experimental group outnumbered the control animals by 5.58%.
Thus, according to the depth of breathing and pulmonary ventilation, the high-enzyme type (experimental group) animals significantly outnumbered the low-enzyme type (control group) analogs.
Gas-energy exchange in animals. The intensity of oxidation-reduction processes in the animal body depends on the digestion level and assimilation of nutrients supplied with feed. The level of oxygen consumption in growth and development essentially characterizes the intensity of metabolic processes in the animal body. Important indicators of gas exchange are the consumption of oxygen and the release of carbon dioxide by the body in absolute and relative units.
In terms of total oxygen consumption, test heifers at 6, 12, and 18 months, at 8-9 months of gestation, and cows at 2-3 months of lactation exceeded the control analogs by 6.93, respectively 9.22, 2.34, 20.69, 1.48% (Table 21).

Table 21. Absolute oxygen consumption by heifers and cows of the Ukrainian Black-Spotted dairy breed, l/min

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	0.66 ± 0.018	0.65 ± 0.005	- 0.01
6	1.01 ± 0.007	1.08 ± 0.02***	+ 0.07
12	1.41 ± 0.07	1.54 ± 0.02*	+ 0.13
18	1.71 ± 0.02	1.75 ± 0.01	+ 0.04
Cows for 8-9 months. corporeality	1.45 ± 0.08	1.76 ± 0.11**	+ 0.31
Cows for 2-3 months. lactation	2.70 ± 0.01	2.74 ± 0.11	+ 0.04
On the average	1.49 ± 0.03	1.59 ± 0.05	+ 0.10

At the age of 3 months, the animals of the control group had a slight advantage over experimental peers in terms of total oxygen consumption. A similar pattern was observed in the relative oxygen consumption of the experimental animals (Table 22). According to this indicator, the animals of the experimental group exceeded the control analogs by 6.10% on average during the entire growing period.

Table 22. Relative oxygen consumption by heifers and cows of the Ukrainian Black-Spotted dairy breed, l^{-3}/min/kg

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	5.61 ± 0.14	6.12 ± 0.27	+ 0.51
6	6.02 ± 0.16	6.32 ± 0.24	+ 0.30
12	5.12 ± 0.08	5.12 ± 0.16	0
18	4.41 ± 0.31	4.83 ± 0.11	+ 0.42
Cows for 8-9 months. corporeality	3.16 ± 0.02	3.67 ± 0.23**	+ 0.51
Cows for 2-3 months. lactation	6.18 ± 0.10	6.28 ± 0.29	+ 0.10
On the average	5.08 ± 0.13	5.39 ± 0.22	+ 0.31

Therefore, in terms of absolute and relative oxygen consumption in the postnatal ontogeny, the animals of the experimental group probably exceeded the control counterparts.

According to the absolute indicators of carbon dioxide excretion, heifers of the experimental group at 6-, 12- and 18 months of age, heifers at 8-9 months of gestation, and cows at 2-3 months of lactation prevailed over peers of the control group by 15.28, respectively 4.59, 7.20, 14.65, 1.79% (Table 23).

Table 23. Absolute release of carbon dioxide by heifers and cows of the Ukrainian Black-Spotted dairy breed, l/min

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	0.50 ± 0.01	0.50 ± 0.01	0
6	0.72 ± 0.09	0.83 ± 0.02	+ 0.11
12	1.09 ± 0.03	1.14 ± 0.02	+ 0.05
18	1.25 ± 0.02	1.34 ± 0.01***	+ 0.09
Cows for 8-9 months. corporeality	1.16 ± 0.04	1.33 ± 0.04***	+ 0.17
Cows for 2-3 months. lactation	2.24 ± 0.11	2.28 ± 0.02	+ 0.04
On the average	1.16 ± 0.04	1.24 ± 0.02*	+ 0.08

During the entire growing period, according to the above indicator, the animals of the experimental group exceeded the control ones by an average of 6.90%.

The animals of the experimental group also outperformed the control peers in relative carbon dioxide excretion. Thus, heifers at 3, 6, 12, 18 months, at 8-9 months of gestation and cows at 2-3 months of lactation of the experimental group prevailed by this indicator of the analogues of the control group, respectively, by 13.73, 11.37, 0.53, 9.14, 9.88, 7.41% (Table 24).

Table 24. Relative excretion of carbon dioxide by heifers and cows of the Ukrainian Black-Spotted dairy breed, l^{-3}/min/kg

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	4.15 ± 0.07	4.72 ± 0.15***	+ 0.57
6	4.31 ± 0.22	4.80 ± 0.19*	+ 0.49
12	3.80 ± 0.16	3.82 ± 0.12	+ 0.02
18	3.39 ± 0.12	3.70 ± 0.10*	+ 0.31
Cows for 8-9 months. corporeality	2.53 ± 0.03	2.78 ± 0.14*	+ 0.25
Cows for 2-3 months. lactation	5.13 ± 0.32	5.51 ± 0.27	+ 0.38
On the average	3.89 ± 0.15	4.22 ± 0.17	+ 0.33

The advantage of the experimental group over the control group in terms of the relative release of carbon dioxide was 8.48%.

Therefore, according to the absolute and relative release of carbon dioxide in the postnatal ontogeny, animals of the high-enzyme type (experimental group) probably outnumbered the analogs of the low-enzyme type (control group). This indicates that the oxidation-reduction processes level in the animals of the experimental group was more intense than that of the control counterparts.

According to the respiratory coefficient, no significant difference was found between the animals of the experimental and control groups (Table 25). In heifers at 3-, 6-, 12-, and 18 months of age and heifers at 8-9 months of gestation, the respiratory coefficient was within 0.71-0.80. In this range, experimental animals undergo fat metabolism.

In firstborns at 2-3 months of lactation, this indicator was in the range of 0.86-0.84. This testifies that protein exchange was more intense in the animal's body during this period.

Table 25. The respiratory ratio in heifers and cows of Ukrainian Black-Spotted dairy breed

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	0.76 ± 0.005	0.77 ± 0.008*	+ 0.01
6	0.71 ± 0.02	0.76 ± 0.006**	+ 0.05
12	0.75 ± 0.05	0.74 ± 0.01	- 0.01
18	0.74 ± 0.007	0.77 ± 0.005	+ 0.03
Cows for 8-9 months. corporeality	0.80 ± 0.15	0.76 ± 0.04	- 0.04
Cows for 2-3 months. lactation	0.86 ± 0.02	0.84 ±0.04	- 0.02
On the average	0.77 ± 0.05	0.78 ± 0.02	+ 0.01

Table 26. Total energy allocated by heifers and cows of the Ukrainian Black-Spotted dairy breed, kJ/h

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	792.4 ± 13.67	779.1 ± 7.09	- 13.3
6	1187.8 ± 55.51	1295.1 ± 22.15***	+ 107.3
12	1726.2 ± 30.25	1791.4 ± 29.34	+ 65.2
18	2024.2 ± 28.73	2097.3 ± 17.73**	+ 73.1
Cows for 8-9 months. corporeality	1760.2 ± 89.26	2150.8 ± 105.22**	+ 390.6
Cows for 2-3 months. lactation	3199.4 ± 11.75	3331.0 ± 10.73****	+ 131.6
On the average	1781.7 ± 38.19	1907.4 ± 32.04**	+ 125.7

Energy exchange in the body of animals in postnatal ontogenesis is characterized by the total energy released by animals and the relative accumulation of heat production.

According to the unconditional release of energy, experimental heifers at 6, 12, 18 months, 8-9 months of gestation, and cows at 2-3 months of lactation exceeded the control analogues by 9.03, respectively 3.78, 3.61, 22.19, 4.11% (Table 26).

At the age of 3 months, heifers of the control group exceeded the heifers of the experimental group by 8.68% in terms of absolute energy release.

During the entire growing period, the animals of the experimental group exceeded the control analogs by 7.06% in terms of absolute energy release.

The heifers of the research group, according to the relative indicators of heat production at 3-, 6-, and 18 months of age, 8-9 months of gestation, and cows at 2-3 months of lactation prevailed over the control heifers by 9.40, respectively 6.19, 5.86, 14.70, 5.18% (Table 27). At 12 months, according to this indicator, a particular advantage of heifers of the control group was observed. Over the entire growing period, the advantage of the animals of the experimental group over the analogues of the control group in terms of relative indicators of heat production was, on average, 6.07%.

Table 27. Relative indicators of heat production in heifers and cows of the Ukrainian Black-Spotted dairy breed, kJ/h/kg

Age, month	Groups (M±m)		± before the control
	control (n=10)	experimental (n=10)	
Heifers: 3	6.70 ± 0.17	7.33 ± 0.30*	+ 0.69
6	7.11 ± 0.22	7.55 ± 0.29	+ 0.44
12	6.09 ± 0.21	6.18 ± 0.21	+ 0.09
18	5.46 ± 0.15	5.78 ± 0.14	+ 0.32
Cows for 8-9 months. corporeality	3.81 ± 0.01	4.37 ± 0.26*	+ 0.56
Cows for 2-3 months. lactation	7.33 ± 0.32	7.71 ± 0.21	+ 0.38
On the average	6.10 ± 0.15	6.47 ± 0.23	+ 0.37

Thus, according to indicators of energy metabolism in postnatal ontogenesis, animals of the high-enzyme type (experimental group) significantly outnumbered their analogues of the low-enzyme type (control group). This indicates that the energy exchange in the animals of the experimental group was much more intense than in the control counterparts.

Milk productivity of cows. Milk productivity of cows is one of the leading indicators that characterize the growth of live weight, linear development, and redox processes of young animals in the postnatal ontogenesis during the formation of economically valuable traits.

As noted above, the heifers of the control and experimental groups were kept on the same feed rations. At the same time, in the process of growth and development, the heifers of the experimental group were characterized by higher indicators of body weight growth, linear development, and the level of synthetic processes compared to control females of the same age. Therefore, according to the National Academy of Sciences norms, we also set ourselves the task of determining the future milk productivity of cows of different types during the I, II, and III lactations at a moderate feeding level. Indicators of the milk productivity of cows and the content of fat and protein in milk are given in Table 28.

Table 28. Milk productivity of experimental cows per lactation

Indicators	Groups (M±m)	
	control (n=10)	experimental (n=10)
I lactation		
A cow's milk yield, kg	3066±141	3642±193**
Fat content in milk, %	3.58±0.07	3,66±0.02
Amount of milk fat, kg	104.74±10.0	133.20±12.4
Protein content in milk, %	3.24±0.05	3.32±0.02
The amount of protein in milk, kg	99.34±7.20	120.91±10.11
II lactation		
A cow's milk yield, kg	3403±156	4043±214*
Fat content in milk, %	3.61±0.08	3.70±0.04
Amount of milk fat, kg	122.51±9.40	149.54±8.40
Protein content in milk, %	3.30±0.05	3.40±0.02*
The amount of protein in milk, kg	112.30±8.50	137.46±11.00
III lactation		
A cow's milk yield, kg	4078±187	4844±257**
Fat content in milk, %	3.63±0.06	3.75± 0.01*
Amount of milk fat, kg	148.02±8.40	181.6±15.00
Protein content in milk, %	3.31±0.03	3.42±0.01**
The amount of protein in milk, kg	134.98±6.55	165.66±9.47

The cows of the experimental group exceeded the control analogs by 18.70, respectively, in terms of milk yield for the I, II, and III lactations; 18.81 and 18.79% (P>0.90...95), and according to the fat content in milk - by 2.2, respectively 2.5 and 3.3% (P>0.90).

It is known that at the current stage in the world, work is being carried out on selecting cows for milk protein. Therefore, we want to pay attention to the fact that the cows of the experimental group exceeded the control analogs by 2.5, respectively, in terms of protein content in milk during the I, II, and III lactations; 3.0 and 3.3% (P>0.95).

CONCLUSIONS

Thus, the cows of the research group in the section of three lactations at a moderate level of feeding following the norms of the National Academy of Sciences in terms of milk yield per lactation, and the fat and protein content in milk, probably exceeded the control counterparts. This indicates that in the body of the animals of the experimental group, both young and mature age, redox processes were more intense than in the control counterparts. Therefore, the high-enzyme type (experimental group) cows should be left to the tribe and carry out the selection process. In contrast, cows of the low-enzyme type (control group) should be sorted into the industrial group. Animals classified as industrial should be crossed with meat breeders of domestic or foreign breeding to create an array of meat cattle in the western region, which will make it possible to increase the production of high-quality beef.

REFERENCES

Bashchenko, M.I., Boiko, O.V., Honchar, O.F., Sotnichenko, Yu.M., Tkach, Ye.F., Gavrysh, O.M., Nebylytsja, M.S., Lesyk, Ya.V., & Gutyj, B.V. (2021). The cow's calving in the selection of bull-breeder in Monbeliard, Norwegian Red and Holstine breed. *Ukrainian Journal of Ecology*, 11(2), 236-240. doi: 10.15421/2021_105

Bomko, V., Kropyvka, Yu., Bomko, L., Chernyuk, S., Kropyvka, S., & Gutyj, B. (2018). Effect of mixed ligand complexes of Zinc, Manganese, and Cobalt on the Manganese balance in high-yielding cows during first 100-days lactation. *Ukrainian Journal of Ecology*, 8(1), 420-425. doi: 10.15421/2018_230

Borshch, O.O., Gutyj, B.V., Sobolev, O.I., Borshch, O.V., Ruban, S.Yu., Bilkevich, V.V., Dutka, V.R., Chernenko, O.M., Zhelavskyi, M.M., & Nahirniak, T. (2020). Adaptation strategy of different cow genotypes to the voluntary milking system. *Ukrainian Journal of Ecology*, 10(1), 145-150. doi: 10.15421/2020_23

Borshch, O.O., Ruban, S.Yu., Gutyj, B.V., Borshch, O.V., Sobolev, O.I., Kosior, L.T., Fedorchenko, M.M., Kirii, A.A., Pivtorak, Y.I., Salamakha, I.Yu., Hordiichuk, N.M., Hordiichuk, L.M., Kamratska, O.I., & Denkovich, B.S. (2020). Comfort and cow behavior during periods of intense precipitation. *Ukrainian Journal of Ecology*, 10(6), 98-102. doi: 10.15421/2020_265

da Silva, M. H. M. A., Malhado, C. H., Costa, J. L., Cobuci, J. A., Costa, C. N., & Carneiro, P. L. (2016). Population genetic structure in the Holstein breed in Brazil. *Trop Anim Health Prod,* 48(2), 331-336. doi: 10.1007/s11250-015-0956-7

Duff, G. C., & McMurphy, C. P. (2007). Feeding Holstein steers from start to finish. *Vet Clin North Am Food Anim Pract*, 23(2), 281-297. doi: 10.1016/j.cvfa.2007.04.003

Fedak, V., Bobrushko, T., Fedak, N., & Liashchuk, O. (2002). A black and spotted breed of cattle. *Proposal*, 8-9, 73.

Foris, B., Thompson, A.J., & Weary, D.M. (2019). Automatic detection of feeding- and drinking-related behaviour and dominance in dairy cows of black and white breed. *Journal of Dairy Science*, 102, 9176-9186. doi: 10.3168/jds.2019-1669730

Gieseke, D., Lambertz, C., & Gauly, M. (2022). Effects of Housing and Management Factors on Selected Indicators of the Welfare Quality Protocol in Loose-Housed Dairy Cows. *Veterinary Sciences,* 9, 353. doi: 10.3390/vetsci9070353

Goncu, S., Yesil, M. I., & Yilmaz, N. (2019). The Cattle Grooming Behavior and Some Problems with Technological Grooming Instruments for Cow Welfare. *Journal of Environmental Science* and *Engineering*, 8, 190-196.

Griffiths, B. E., Grove White, D., & Oikonomou, G. (2018). A Cross-Sectional Study into the Prevalence of Dairy Cattle Lameness and Associated Herd-Level Risk Factors in England and Wales. *Frontiers in Veterinary Science*, 5, 65–72. doi: 10.3389/fvets.2018.00065

Grymak, Y., Skoromna, O., Stadnytska, O., Sobolev, O., Gutyj, B., Shalovylo, S., Hachak, Y., Grabovska, O., Bushueva, I., Denys, G., Hudyma, V., Pakholkiv, N., Jarochovich, I., Nahirniak, T., Pavliv, O., Farionik, T., & Bratyuk, V. (2020). Influence of "Thireomagnile" and "Thyrioton" preparations on the antioxidant status of pregnant cows. *Ukrainian Journal of Ecology*, 10(1), 122-126. doi: 10.15421/2020_19

Gutyi, B., Ostapiuk, A., Kachmar, N., Stadnytska, O., Sobolev, O., Binkevych, V., Petryshak, R., Petryshak, O., Kulyaba, O., Naumyuk, A., Nedashkivsky, V., Nedashkivska, N., Magrelo, N., Golodyuk, I., Nazaruk, N., & Binkevych, O. (2019). The effect of cadmium loading on protein synthesis function and functional state of laying hens' liver. *Ukrainian Journal of Ecology*, 9(3), 222-226.

Gutyj, B.V., Ostapyuk, A.Y., Sobolev, O.I., Vishchur, V.J., Gubash, O.P., Kurtyak, B.M, Kovalskyi, Y.V., Darmohray, L.M., Hunchak, A.V., Tsisaryk, O.Y., Shcherbatyy, A.R., Farionik, T.V., Savchuk, L.B., Palyadichuk, O.R., & Hrymak, K. (2019). Cadmium burden impact on morphological and biochemical blood indicators of poultry. *Ukrainian Journal of Ecology*, 9(1), 236-239.

He, J., Qian, C.S., Tait, R.G., Bauck, S., & Wu, X. L. (2018). Estimating genomic breed composition of individual animals using selected SNPs. *Yi Chuan*, 40(4), 305-314. doi: 10.16288/j.yczz.17-394

Kohut, M. I., Bratiuk, V. M., & Fedak, V. D. (2015). Evaluation of cows of the black and spotted breed by type. *Biology of animals*, 17(3), 173.

Kudlác, E., Bechyně, K., & Kapoun, B. (1975). Conception ability of early mated heifers of Bohemiam spotted and black-pied lowland cattle and their crossbreeds. *Vet Med (Praha)*, 20(9), 501-510.

Kulyaba, O., Stybel, V., Gutyj, B., Turko, I., Peleno, R., Turko, Ya., Golovach, P., Vishchur, V., Prijma, O., Mazur, I., Dutka, V., Todoriuk, V., Golub, O. Dmytriv, O., & Oseredchuk, R. (2019). Effect of experimental fascioliasis on the protein synthesis function of cow liver. *Ukrainian Journal of Ecology*, 9(4), 612-615.

Kuziv, M. I., Fedorovych, Ye. I., Kuziv, N. M., & Novak, I. V. (2017). The influence of body measurements of the Ukrainian black and white dairy breed after the first calving and the formation of their subsequent milk productivity. *Animal breeding and genetics*, 53, 135-148.

Lesyk, Y. V., Dychok-Niedzielska, A. Z., Boiko, O. V., Honchar, O. F., Bashchenko, M. I., Kovalchuk, I. I., & Gutyj, B. V. (2022). Hematological and biochemical parameters and resistance of the organism of mother rabbits receiving sulfur compounds. *Regulatory Mechanisms in Biosystems*, 13(1), 60–66. doi:10.15421/022208

Loboda, V. P. (2012). Exterior Features cows firstborn Ukrainian black and white cattle. *Bulletin of Sumy National Agrarian University, series of Animal Husbandry,* 12, 21-23.

Maksymyuk, H. V., Maksymyuk, V. M., Sedilo, H. M., Stadnytska, O. I., Onufrovych, O. K., Vorobets, Z. D., & Gutyj, B. V. (2022). Peculiarities of physico-chemical condition of uterine vaginal mucus during estral cycle. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 5(2), 37-42. doi: 10.32718/ujvas5-2.06

Martyshuk, T., Gutyj, B., Vyshchur, O., Paterega, I., Kushnir, V., & Bigdan, O. (2022). Study of Acute and Chronic Toxicity of “Butaselmevit” on Laboratory Animals. *Arch Pharm Pract*, 13(3), 70-75. doi: 10.51847/XHwVCyfBZ3

Martyshuk, T. V., Gutyj, B. V., Zhelavskyi, M. M., Midyk. S. V., Fedorchenko, A. M., Todoriuk, V. B., Nahirniak, T. B., Kisera, Y. V., Sus, H. V., Chemerys, V. A., Levkivska, N. D., & Iglitskej, I. I. (2020). Effect of Butaselmevit-Plus on the immune system of piglets during and after weaning. *Ukrainian Journal of Ecology*, 10(2), 347-352. doi: 10.15421/2020_106

Mazur, N. P., Fedorovych, V.V., Fedorovych, E. I., Fedorovych, O. V., Bodnar, P. V., Gutyj, B. V., Kuziv, M. I., Kuziv, N. M., Orikhivskyi, T. V., Grabovska, O.S., Denys, H.H., Stakhiv, N. P., Hudyma, V. Y., & Pakholkiv, N. I. (2020). Effect of morphological and biochemical blood composition on milk yield in Simmental breed cows of different production types. *Ukrainian Journal of Ecology*, 10(2), 61-67. doi: 10.15421/2020_110

McAllister, A. J. (2002). Is crossbreeding the answer to questions of dairy breed utilization? *Journal of Dairy Science*, 85(9), 2352-2357. doi: 10.3168/jds.S0022-0302(02)74315-4

Mylostyvyi, R., Sejian, V., Izhboldina, O., Kalinichenko, O., Karlova, L., Lesnovskay, O., Begma, N., Marenkov, O., Lykhach, V., Midyk, S., Cherniy, N., Gutyj, B., & Hoffmann, G. (2021). Changes in the Spectrum of Free Fatty Acids in Blood Serum of Dairy Cows during a Prolonged Summer Heat Wave. *Animals*, 11(12), 3391. doi: 10.3390/ani11123391

Novak, I. V. (2012). Ukrainian black and spotted dairy breed and ways of its creation. *Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies. Series: Agricultural Sciences*, 14(3(53), 113-118.

Pelekhatyi, M. S., & Kochuk-Yashchenko, O. A. (2014). The influence of the genotype of first-born cows of the Ukrainian black and spotted dairy breed on their exterior type, milk productivity and reproductive capacity. *Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies. Series: Agricultural Sciences*, 16(31) (60), 143-157.

Pelekhatyi, M. S., & Kucher, D. M. (2013). Economic and useful characteristics of first-born cows of the Ukrainian Black-Spotted dairy breed at different levels of heterogeneous selection. *Bulletin of the Sumy National Agrarian University. “Livestock” series*, 7(23), 59-66.

Roman, L., Broshkov, M., Popova, I., Hierdieva, A., Sidashova, S., Bogach, N., Ulizko, S., & Gutyj, B. (2020). Influence of ovarian follicular cysts on reproductive performance in the cattle of new

Ukrainian red dairy breed. *Ukrainian Journal of Ecology*, 10(2), 426-434.

Sachuk, R. M., Stravsky, Y. S., Shevchenko, A. M., Katsaraba, O. A., Kostyshyn, Y. Y., & Zhyhalyuk, S. V. (2019). Distribution, etiology and prevention of subclinical mastitis in cows. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 2(2), 18-21. doi: 10.32718/ujvas2-2.04

Shevchenko, A. P., & Hmelnichiy, L. M. (2014). Linear estimation of stud bulls of Holstein and Ukrainian black and white milk breeds on the exterior type of their daughters. *Bulletin of Sumy National Agrarian University, series of Animal Husbandry*, 2(2), 114-120.

Sizova, E., Yausheva, E., Marshinskaia, O., Kazakova, T., Khlopko, Y., & Lebedev, S. (2022). Elemental composition of the hair and milk of Black-Spotted cows and its relationship with intestinal microbiome reorganization. *Vet World*, 15(11), 2565-2574. doi: 10.14202/vetworld.2022.2565-2574

Slivinska, L. G., Shcherbatyy, A. R., Lukashchuk, B. O., & Gutyj, B. V. (2020). The state of antioxidant protection system in cows under the influence of heavy metals. *Regulatory Mechanisms in Biosystems*, 11(2), 237–242. doi:10.15421/022035

Slivinska, L. G., Shcherbatyy, A. R., Lukashchuk, B. O., Zinko, H. O., Gutyj, B. V., Lychuk, M. G., Chernushkin, B. O., Leno, M. I., Prystupa, O. I., Leskiv, K. Y., Slepokura, O. I., Sobolev, O. I., Shkromada, O. I., Kysterna, O. S., & Musiienko, O. V. (2019). Correction of indicators of erythrocytopoesis and microelement blood levels in cows under conditions of technogenic pollution. *Ukrainian Journal of Ecology*, 9(2), 127-135.

Slivinska, L., Vlizlo, V., Shcherbatyy, A., Lukashchuk, B., Gutyj, B., Drach, M., Lychuk, M., Maksymovych, I., Leno, M., Rusyn, V., Chernushkin, B., Fedorovych, V., Zinko, H., Prystupa, O., & Yaremchuk, V. (2021). Influence of heavy metals on metabolic processes in cows. *Ukrainian Journal of Ecology*, 11(2), 284-291. doi: 10.15421/2021_112

Stadnytska, O., Gutyj, B., Khalak, V., Fedak, V., Dudchak, I., Zmiia, M., Shuvar, I., Balkovskyi, V., Shuvar, A., Korpita, H., Chyzhanska, N., Kuzmenko, L., & Vakulik, V. (2022). Biological assessment of the constitution of the polissian beef cattle in the conditions of the precarpathian region. *Scientific Papers. Series D. Animal Science*, LXV(2), 46-52.

Tóthová, C., Mudroň, P. & Nagy, O. (2017). The electrophoretic pattern of serum proteins in dairy cows with inflammatory diseases. *Acta Veterinaria*, 67(2), 178-190. doi: 10.1515/acve-2017-0016

Ugnivenko, A., Getya, A., Nosevych, D., Antoniuk, T., Kruk, O., Slobodyanyuk, N., Ivaniuta, A., Omelian, A., Gryshchenko, S., & Israelian, V. (2022). The study of "muscle eye" in bulls of Ukrainian Black-Spotted dairy-meat breed as a factor in improving the properties of meat products. *Potravinarstvo Slovak Journal of Food Sciences*, 16, 519-529. doi: 10.5219/1762

VanRaden, P. M., Tooker, M. E., Chud, T. C. S., Norman, H. D., Megonigal, J. H., Haagen, I. W., & Wiggans, G. R. (2020). Genomic predictions for crossbred dairy cattle. *Journal of Dairy Science*, 103(2), 1620-1631. doi: 10.3168/jds.2019-16634

Vedmedenko, O. V. (2018). Milk productivity of cows from various factors. *Taurian Scientific Bulletin*, 107, 199-204.

Voitenko, S. P., Koruna, T. I., Shaferivskyi, B. S., & Zhelezniak, I. M. (2019). The influence of genotypic and paratypic factors on the realization of milk productivity of cows. *Bulletin of the Sumy National Agrarian University. "Livestock" series,* 1-2(36-37), 21-26.

Zhelavskyi, M. M., Kernychnyi, S. P., Mizyk, V. P., Dmytriv, O. Y., & Betlinska, T. V. (2020). The importance of metabolic processes and immune responses in the development of pathology of cows during pregnancy and postpartum periods. *Ukrainian Journal of Veterinary and Agricultural Sciences*, *3*(2), 36-41. doi: 10.32718/ujvas3-2.06