

## The effect of the red blood cell system disorders on the further development and productivity of Holstein calves that had had bronchopneumonia

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### ABSTRACT

The aim of this research was to study the effect of red blood cell system disorders on the further development and productivity of calves that had had bronchopneumonia. The study included 170 Holstein heifers at the age of 180-195 days: healthy heifers (n = 92) and heifers with moderate bronchopneumonia (n = 78). All animals had been under constant clinical supervision for 27 months. Blood sampling was performed in 10 animals from each group at the beginning of the experiment and on day 22, and also when they reached a body weight of 380 kg (the first artificial insemination), 30 days before the planned calving date, and on days 7, 90, 180 of lactation. The blood samples obtained were examined by a hematological analyzer, and the content of fetal hemoglobin was determined by Singer's method. It was shown that after completion of the course of treatment the clinical symptoms of bronchopneumonia disappeared in calves, but microcytic hypochromic anemia appeared. Further, in these animals an increase was registered in the age of fruitful fertilization by 10.8% and of the insemination index by - 36.7%. After calving and during lactation, the severity of hypochromia decreased, but there was a tendency for macrocytosis, which, combined with increased anisocytosis, indicated hypoplastic anemia. This form of anemia occurred against the background of pathological residual changes after pneumonia due to the depletion of the compensatory potential of the bone marrow and its functional overload during lactation. The operational anemia revealed in lactating cows caused a decrease in milk productivity by 23.2-26.7% (P<0.01).

**Key words:** cattle; respiratory diseases; anemia; pubescence; milk productivity

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### Introduction

The red blood cell system (RBC system), which determines the viability and functional level of the body, includes red blood cells (RBCs) located in the vascular bed, the organs of their production and destruction, as well as the regulatory mechanisms that provide red blood cell homeostasis (RBC homeostasis) and the range of its

compensatory-adaptive fluctuations (LIPUNOVA and SKORKINA, 2004). Currently, many aspects of the effect of the season, breed, age, and animal productivity on RBC parameters have been studied (MOHRI et al., 2007; SATTAR and MIRZA, 2009; BOURGON et al., 2017). However, many pathophysiological mechanisms of hematological

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abnormalities have not been yet studied sufficiently, which reduces the objectivity of the interpretations of their clinical and prognostic value (LITVITSKY, 2015; ABRAMOWICZ et al., 2019). Our previous studies showed that of the residual effects after pneumonia, the most common were violations of the structural and functional parameters of RBCs, which persisted for a long time after the disappearance of specific symptoms of the disease (ALEKHIN et al., 2017). It is known that the parameters of crane blood affect feed intake, growth activity and the full development of the animals, including replacement heifers (RIEDESEL and ENGEN, 2015; CÔNSOLO et al., 2018). Therefore, the aim of our work was to study the effect of RBC system disorders on the further development and productivity of calves that had had bronchopneumonia.

### Materials and methods

*Animals.* The experiment was conducted from January 9, 2017 to March 28, 2019 on an industrial dairy farm where Holstein cattle were kept. One hundred and five heifers at the age of 180-195 days were the subjects of the study. They were divided into two groups: No. 1 - healthy (control, n = 100) ones, No. 2 - animals with moderate pneumonia (n = 95). The diagnosis was made on the basis of clinical, functional, bacteriological, and serological studies. The association of gram-positive and gram-negative bacteria played a leading role in the occurrence of pneumonia. Combining it with specific symptoms made it possible to diagnose Bronchopneumonia (ICD-10: J18.0). The animals' feed and their housing conditions corresponded to the existing recommendations for working with cattle (NATIONAL RESEARCH COUNCIL, 2001). Artificial insemination of heifers was carried out by the mano-cervical method, when they reached a body weight of 380.0 kg.

This study was approved by the ethics committee of FSBSI "ARVRIPP&T" and the rules for humane treatment of animals were observed throughout (THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION, 2010).

*Treatment of sick animals.* The course of treatment for animals with bronchopneumonia included intravenous administration of calcium

chloride and glucose solutions (days 1 and 3 of treatment), intramuscular injections of Eleovitum (days 1 and 7), and antibiotics (days 1-7) selected on the basis of an assessment of the sensitivity of the pathogens (gentamicin sulfate 4%, Baytril 5%). In addition, on days 2 (on the left side) and 4 (on the right side) the novocaine blockade of stellate sympathetic ganglion was performed. A clinical examination of the animals was conducted 24 hours after the completion of the course of treatment. The results showed that the specific symptoms of bronchopneumonia had disappeared in all the calves.

*Clinical examination.* All animals participating in the experiment had been under clinical observation for 27 months. The age of pubescence (the first estrus) and the first artificial insemination (age of reaching a body weight of 380 kg) were determined in the heifers. The milk productivity of the cows was evaluated by the average daily milk yield during the early (0-90 days) and mid (91-180 days) lactation phases. The artificial insemination index (AII), which was the average number of inseminations that led to fertilization of the heifers, was calculated. In this case, the following formula was used:

$$IAI = NI / NF$$

where:

NI - the number of inseminations performed to fertilize all animals in the group;

NF - the number of fertilized animals in the group.

Blood samples were taken from 10 animals from each group on days 1 and 22 of the experiment (in calves from group 2, this was the height of the disease and day 15 after the completion of the course of treatment), as well as when they reached a body weight of 380 kg (first artificial insemination), 30 days before the planned date of calving, and on days 7, 90 and 180 of lactation.

*Laboratory research.* Blood samples were taken before morning feeding from the jugular vein into IMPROVACUTER vacuum tubes with an anticoagulant (K3EDTA) to maintain its intact state (Guangzhou Improve Medical Instruments CO., LTD, China). Blood was examined using an ABXMicros 60 CT / OT hematology analyzer (France), which determined the number of red blood

cells (RBCs), total hemoglobin (HbT), hematocrit (HCT), the mean corpuscular volume (MCV), the mean corpuscular hemoglobin (MCH), the mean corpuscular hemoglobin concentration (MCHC) and the red cell distribution width (RDW). The content of fetal hemoglobin (HbF) was studied by Singer's method (MEN'SHIKOV et al., 1987).

*Statistical analysis.* Statistical analysis of the results was carried out using the program Statistica v6.1. The arithmetic mean (M) and standard deviation (SD) were calculated. The differences between the experimental groups was evaluated by the Student's test, and the presence and strength of the relationship between the two signs was determined by Spearman's rank correlation, with calculation of the correlation coefficient (r).

## Results

Throughout the experiment, most animals from the control group remained clinically healthy. The exceptions were 3 head of cattle, which were diagnosed with bronchopneumonia at the age of 215-228 days, and 5 head of cattle, which had fallen ill with endometritis during the first week after calving. Respiratory diseases were detected in 7 heifers from group 2 at the age of 210-230 days, 6 heifers had the symptoms of endometritis, and 4 heifers had uterine subinvolution within two weeks after calving. All the above mentioned sick animals were excluded from the experiment, so the sample size in the comparable groups was adjusted: group 1 - 92 head group 2 - 78 head.

The results of the hematological study showed that the majority of the studied parameters of the gas-transport link of the blood in heifers from group 1 at the age of 6-6.5 months reached the level of adult animals, although some parameters stabilized at a later age. So, there was a tendency towards an increase in RBCs and hemoglobin, but a decrease in HCT in heifers during the period from the beginning of the experiment to reaching a body weight of 380 kg (14.3-14.8 months). In addition, the degree of anisocytosis in them was 30.3% lower ( $P < 0.001$ ) than in animals in the younger age period. Significant changes also occurred in the ratio of hemoglobin types, where the proportion of fraction F decreased by 70.5%. Despite the

processes occurring in the body during gestation, the parameters studied in heifers 30 days before the estimated calving date did not significantly differ from the parameters of heifers of covering age.

In calves with bronchopneumonia, in comparison with healthy ones, the level of RBCs was higher by 37.7%, hematocrit - by 5.9% and fetal hemoglobin - by 11.4%, but total hemoglobin was 4.2% lower, mean corpuscular volume by 22.4%, and the content and concentration of hemoglobin in them by 30.6 and 9.4%, respectively (Table 1).

The nature of the hematological profile revealed indicated a high probability of the presence of hemoconcentration and disorder of the erythropoiesis process in sick animals, with the formation of RBCs with relatively low functional capabilities. During 7 days of treatment and 15 days of convalescence, the number of RBCs decreased by 37.4%, and anisocytosis by 18.5%, but HbF increased by 42.8%. An imbalance in the blood gas transport system remained after completion of the course of treatment and the disappearance of the clinical symptoms of bronchopneumonia. The number of RBCs was 15.7% lower in the animals that had had the disease than in healthy ones, the level of HbT - by 23.6%, HCT - by 25.8%, MCV - by 30.6%, and MCH - by 9.6%. The hematological profile formed indicated the presence of microcytic hypochromic anemia in these calves. There was a tendency for the symptoms of anemia to level out during the period from the completion of the course of treatment ( $12.9 \pm 0.5$  months) until they reached a body weight of 380 kg ( $16.4 \pm 1.15$  months).

However, in cases of animals that had had bronchopneumonia and were subjected to fertilization (380 kg), in comparison with the control, the parameters of RBCs (by 11.2%), hemoglobin (by 18.5%), hematocrit (by 23.3%), MCV (by 13.6%) and MCH (by 8.3%) were significantly lower, which indicated the preservation of microcytosis and hypochromia. The value of MCHC did not depend on the number of RBCs ( $MCHC = HGB / HCT \times 100$ ), therefore, its increase (by 6.2%) against the background of a lowered level of MCH indicated a violation of the hemoglobin synthesis processes, with the corresponding imbalance of erythropoiesis.

Table 1. The state of the gas transport link of the respiratory system at the height of bronchopneumonia and during the convalescence period (M ± SD)

Parameter	Group	Periods of disease		Heifers subjected to fertilization (BW 380 kg)	Heifers, 30 days before calving
		Height of disease	Reconvalescence (15 days)		
RBC, 10 <sup>12</sup> /L	1	6.50 ± 0.474	6.64 ± 1.106	6.70 ± 0.341	6.67 ± 0.967
	2	8.95 ± 0.063***	5.60 ± 0.853	5.95 ± 0.373***	7.6 ± 0.853**
HbT, g/L	1	119.0 ± 3.82	117.8 ± 7.52	120.3 ± 9.64	117.5 ± 7.99
	2	114.0 ± 3.70***	90.0 ± 5.75***	98.0 ± 7.11**	119.0 ± 5.94
HbF, g/L	1	14.9 ± 3.32	14.7 ± 3.79	4.4 ± 2.50	3.1 ± 0.85
	2	16.6 ± 5.25	23.7 ± 6.38***	7.6 ± 4.04**	6.0 ± 2.53***
HCT, %	1	34.0 ± 1.64	33.7 ± 1.74	33.5 ± 2.53	33.7 ± 0.79
	2	36.0 ± 2.62*	25.0 ± 0.98***	25.7 ± 1.96***	34.8 ± 0.95**
MCV, fl	1	52.3 ± 2.56	50.7 ± 2.91	50.0 ± 1.42	50.5 ± 1.67
	2	40.6 ± 1.33***	44.6 ± 1.11***	43.2 ± 0.88***	45.8 ± 0.98***
MCH, pg	1	18.3 ± 1.17	17.7 ± 0.63	18.0 ± 0.76	17.6 ± 0.38
	2	12.7 ± 0.79***	16.0 ± 0.47***	16.5 ± 0.63***	15.6 ± 0.54***
MCHC, g/L	1	350.3 ± 10.11	352.0 ± 11.94	359.0 ± 9.83	348.0 ± 10.46
	2	317.1 ± 8.85***	360.0 ± 12.96	381.3 ± 8.85***	342.0 ± 11.69
RDW, %	1	16.5 ± 0.38	16.5 ± 0.35	11.5 ± 0.44	12.0 ± 0.32
	2	15.7 ± 0.25***	12.8 ± 0.22***	16.8 ± 1.11***	17.7 ± 0.41***

The difference with the data of animals from group 1, statistically significant: \* - P ≤ 0.05; \*\* - P ≤ 0.01; \*\*\* - P ≤ 0.001.

Table 2. Reproductive characteristics of heifers and milk productivity of cows

Parameters	Group 1	Group 2
Breeding age (first estrus), days	261.0 ± 10.50	288.0 ± 15.00
Age of reaching a body weight of 380 kg (the first artificial insemination), days	444.0 ± 12.010	492.0 ± 16.02*
Artificial insemination index	1.80 ± 0.090	2.46 ± 0.080***
Average daily milk yield (0-90 days), kg	27.0 ± 0.72	19.8 ± 0.47***
Average daily milk yield (91-180 days), kg	19.0 ± 0.55	14.5 ± 0.88**

The difference with the data of animals from group 1, statistically significant: \* - P ≤ 0.05; \*\* - P ≤ 0.01; \*\*\* - P ≤ 0.001.

The latter was confirmed by the intensification of anisocytosis (by 46.1%) in sick animals that had had the disease and the preservation of active synthesis of fetal hemoglobin, the level of which was 72.7% higher than in healthy animals. Heifers from group 2, compared with the control, showed a higher level of RBCs (by 13.9%) and RDW (by 47.5%), but lower parameters of MCV (by 9.3%) and MCH (by 11.4%), which indicated compensatory activation of erythropoiesis and leveling of hemoglobin deficiency. However, the proportion

of fetal hemoglobin in them was twice that in the control, and the resulting RBCs had relatively low functional potential due to moderate microcytosis, severe hypochromia and anisocytosis.

In animals that had had bronchopneumonia (group 2), symptoms of the first estrus appeared 27 days (10.3%) later than in animals from the control group (Table 2). However, this difference was not significant (P = 0.099).

The first artificial insemination of heifers was carried out when they reached a body weight of 380 kg.

Animals that had bronchopneumonia reached the indicated weight 48 days (10.8%) later than the heifers from group 1. Their insemination was less effective, as indicated by a 36.7% reduction in the artificial insemination index.

The effect of changes in the RBC system in calves that had had bronchopneumonia on their growth and reproductive development was confirmed by the Spearman rank correlation method (Table 3).

Table 3. Parameters of the degree of correlation of the reproductive characteristics of heifers and milk productivity of cows, depending on the parameters of the RBC system in calves.

Parameter	Age of the first estrus	Age of the first artificial insemination	Artificial insemination index	Average daily milk yield (0-90 days)	Average daily milk yield (91-180 days)
RBC	-0.23	-0.35	-0.48	0.34	0.29
HGB	-0.58*	-0.68*	-0.73*	0.66*	0.68*
HbF	0.59*	0.76*	0.71*	-0.74*	-0.78*
HCT	-0.55*	-0.71*	-0.78*	0.71*	0.72*
MCV	-0.59*	-0.72*	-0.61*	0.68*	0.71*
MCH	-0.36	-0.27	-0.15	0.28	0.32
MCHC	0.004	0.24	0.34	-0.24	-0.23
RDW	-0.54	-0.75*	-0.79*	0.74*	0.70*

\*-  $P < 0.01$

Table 4. The state of the gas transport link of the blood system in clinically healthy animals (numerator) and sick animals that had had bronchopneumonia (denominator) ( $M \pm SD$ )

Parameters	Group	Cows, day of lactation		
		7	90	180
RBC, $10^{12}/L$	1	$6.04 \pm 0.585$	$5.82 \pm 0.338$	$6.00 \pm 0.307$
	2	$5.75 \pm 0.948$	$5.40 \pm 0.600^*$	$5.45 \pm 0.632^*$
HbT, g/L	1	$108.0 \pm 6.95$	$99.5 \pm 4.49$	$116.2 \pm 6.95$
	2	$96.7 \pm 9.73^{**}$	$90.6 \pm 11.69^*$	$88.0 \pm 10.81^{***}$
HbF, %	1	$3.9 \pm 0.60$	$2.7 \pm 0.85$	$3.2 \pm 0.57$
	2	$5.7 \pm 0.82^{***}$	$4.2 \pm 2.09^{***}$	$3.6 \pm 1.83$
HCT, %	1	$30.6 \pm 1.01$	$29.1 \pm 1.17$	$30.9 \pm 1.01$
	2	$29.2 \pm 1.45$	$30.9 \pm 1.42^{***}$	$32.8 \pm 1.26^{***}$
MCV, fl	1	$50.7 \pm 2.05$	$50.0 \pm 1.64$	$51.5 \pm 2.21$
	2	$50.8 \pm 2.81$	$57.2 \pm 1.26^{***}$	$60.2 \pm 2.37^{***}$
MCH, pg	1	$17.9 \pm 0.88$	$17.1 \pm 1.11$	$19.4 \pm 0.76$
	2	$16.8 \pm 0.82^{**}$	$16.6 \pm 0.47$	$16.0 \pm 0.41^{***}$
MCHC, g/L	1	$353.0 \pm 12.96$	$342.3 \pm 12.04$	$376.0 \pm 14.22$
	2	$330.2 \pm 15.8^{**}$	$293.1 \pm 10.43^{***}$	$268.0 \pm 18.04^{***}$
RDW, %	1	$11.8 \pm 0.79$	$12.9 \pm 0.54$	$13.7 \pm 1.33$
	2	$15.9 \pm 0.70^{***}$	$19.0 \pm 0.32^{***}$	$18.9 \pm 1.42^{***}$

The difference in the data of animals from group 1, statistically significant: \* -  $P \leq 0.05$ ; \*\* -  $P \leq 0.01$ ; \*\*\* -  $P \leq 0.001$ .

A positive relationship was found between the fetal hemoglobin content and the artificial insemination index (high strength according to the Chaddock scale), the age of the first estrus (medium strength) and the first artificial insemination (high strength). A negative correlation of the average bond strength was observed when studying the relationship between pubescence (the first estrus) and HGB, HCT, MCV, and RDW. A closer negative relationship between these blood parameters was identified with the age of the first artificial insemination and the artificial insemination index.

Calving and the onset of lactation had a pronounced effect on the erythron system, so, in fresh cows from group 1, in comparison with the parameters of the pregnant ones, the level of RBCs was lower by 9.4% ( $P \leq 0.05$ ), hemoglobin - by 8.1% ( $P \leq 0.01$ ), HCT - by 9.2% ( $P \leq 0.001$ ), but there were no significant changes in RBC parameters in fresh cows from group 1 in comparison with the parameters of pregnant animals (Table 4).

At the end of the early (90 days) lactation phase, in addition to an increase in RDW (by 9.3%,  $P \leq 0.01$ ) and a decrease in the content of HGB (by 7.9%,  $P \leq 0.01$ ), there was a tendency towards a decrease in HCT (4.9%) and RBC (3.6%). Over the next 90 days of lactation, the processes of optimizing the gas transport potential of the blood occurred, in particular, the level of RBCs (by 3.1%,  $P > 0.05$ ), hemoglobin (by 16.8%,  $P \leq 0.001$ ) and hematocrit (by 6, 2%,  $P \leq 0.01$ ). The changes registered were accompanied by an increase in MCH (by 13.5%,  $P \leq 0.001$ ) and MCHC (by 9.9%,  $P \leq 0.001$ ), which indicated a tendency towards hyperchromia. Combined with the expansion of RBCs volume range, it was a compensatory mechanism under the functional load on the organs of erythropoiesis (DYGAI and ZHDANOV, 2012).

In cows from group 2, after calving, the values of RBCs decreased by 24.3%, total hemoglobin - by 18.7% and hematocrit - by 16.1%. As a result, their parameters approached the level of the control group. However, they continued to have a tendency towards hypochromia and hypervariability of corpuscular volume, which indicated a risk of developing anemia. Visualization of the risk of anemia occurred at the end of the early (90 days)

lactation phase, when it turned out to be lower in animals that had had bronchopneumonia than in cows from group 1, with lower levels of RBCs (by 7.2%), HGB (by 8.9%) and MCHC (by 14.3%), but higher content of fetal hemoglobin (2.3 times), corpuscular volume and its variability - by 14.4 and 47.3%, respectively. Over the next 90 days of lactation, symptoms of the RBC system pathology persisted. Cows from group 2 exceeded the level of the control parameters of fetal hemoglobin by 2.19 times, corpuscular volume - by 16.9% and its variability - by 38.0%. Moreover, the number of RBCs was 9.2% lower, the content of total hemoglobin by 24.3%, MCH and MCHC values - by 17.5 and 28.7%, respectively.

The milk productivity of cows that had previously had pneumonia was lower than in the control group by 26.7% during the first 90 days of lactation and by 23.2% during the period from 91 to 180 days (Table 2). Correlation analysis showed a strong negative relationship between the content of fetal hemoglobin in the blood of calves and their future milk productivity when they become cows (Table 3). At the same time, a positive correlation was found between the average and high strength of the average daily milk yield with HGB, HCT, MCV and RDW.

## Discussion

The RBC link of the body's oxygen supply system is an obligatory participant in the formation of the homeostatic profile of animals, which determined their state of health and level of productivity. According to the results of our studies, it was noted that most parameters of the RBCs of calves at the age of 6 months had already been within the reference range of adults, but their stabilization did not end until 14.3-14.8 months. At this age, RBC variability in volume decreased, which reflected the stabilization of the bone marrow and the formation of a relatively homogeneous pool of these cells, which was also accompanied by an increase in their lifespan (HAJNALKA et al., 2001). In addition, there were significant changes in the structure of hemoglobin, with a decrease in the proportion of the fetal type, which corresponded to the age-related dynamics of the formation of the blood gas

transport system (HAJNALKA et al., 2001). During calving and the first lactation phase, the functional load on the bone marrow increased, and at the end of milking there was a risk of hypoplastic anemia. During the next 90 days of lactation, processes of hyperchromia and anisocytosis occurred, which were a compensatory mechanism with a functional load on the organs of erythropoiesis (DYGAI and ZHDANOV, 2012).

In heifers that had had moderate bronchopneumonia, disorders of the blood gas transport system occurred, which progressed during convalescence with the development of hypochromic microcytic anemia. During the treatment and 15 days of recovery, there was a decrease in anisocytosis and the number of RBCs, therefore we could assume that the erythrocytopenia detected in these animals was due to the death of relatively large and small cells which were more sensitive to negative environmental factors (KAESTNER and BOGDANOVA, 2014). Among non-erythrocyte cytolytic factors, the most frequent was the violation of the acid-base balance, with the accumulation of endogenous acidic metabolic products (SALVAGNO et al., 2015). This probably explained the activation of synthesis of fetal hemoglobin that was more resistant to these metabolites (BARD et al., 1994). The onset of compensatory mechanisms for anemia, such as activation of erythropoiesis and synthesis of fetal hemoglobin, reduced its severity in heifers during the last months of gestation and in fresh cows, although there was an imbalance in hemoglobin fractions, a tendency to hypochromia and anisocytosis. In animals that had previously had pneumonia, lactation exerted a higher functional load on the gas transport system of the blood than in healthy ones. A consequence of this was the failure of the bone marrow, which caused a weakening in the compensatory potential of erythropoiesis, and the development of hypochromic macrocytic anemia, against the background of residual pathological changes. Moreover, this form of anemia was most pronounced during the mid (91-180 day) lactation phase. Thus, in calves with pneumonia, changes in the hematological profile occurred, and they persisted for a long time in animals that had had pneumonia. The main nosological form of the

manifestation of hematological profile disorders in heifers that had had pneumonia was anemia. This confirmed the opinion of authors who point to the relationship between anemia and the productivity and reproductive function of cows (SANDOVAL et al., 1995; RAMÍREZ, 2006). In animals that had had pneumonia, hypochromic microcytic anemia was most often diagnosed. The processes of reparative regeneration of the lung parenchyma that occurred during the recovery period (ROCK and KÖNIGSHOFF, 2012) were accompanied by an increase in the sick animals' need for minerals and vitamins, which increased the risk of this type of anemia in growing young animals (STEMME et al., 2005; ALLAN and PLATE, 2018). In addition, the role of post-nosological depression of the blood-forming organs by toxic metabolites of endogenous origin was also important (WEISS and GOODNOUGH, 2005; DOSHI et al., 2011), the level of which remained elevated for a long time in calves that had had pneumonia (ALEKHIN et al., 2020). Our results showed the role of hypochromic microcytic anemia in reducing the growth rate and healthy reproductive development of heifers.

With age, bone marrow functions improve, which is manifested by a decrease in the severity of hypochromia, microcytosis and anisocytosis. However, during the first gestation, a relapse of hypochromic anemia was observed. With the onset of lactation, the functional load on the bone marrow increases. In animals with anemia, this load is inadequate. As a result, macrocytosis occurs and anisocytosis intensifies, which indicates the occurrence of hypoplastic anemia. This form of anemia enhances the severity with increasing lactation. Therefore, we can assume that it arose against the background of pathological residual changes after bronchopneumonia due to the depletion of the compensatory potential and functional overload of the bone marrow, leading to the occurrence of operational anemia in lactating cows.

Our data indicate the urgency of the problem of residual phenomena in animals with pneumonia. The need for diagnostic monitoring and rehabilitation therapy is shown, one of the tasks of which should be to assess the state of the RBC system and leveling anemia.

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**ALEKHIN, Y., M. ZHUKOV, V. MORGUNOVA, Y DRONOVA: Utjecaj poremećaja sustava crvenih krvnih stanica na razvoj i proizvodnost teladi holštajnske pasmine koja je preboljela bronhopneumoniju. Vet. arhiv 91, 473-481, 2021.**

**SAŽETAK**

Cilj rada bio je istražiti utjecaj poremećaja sustava crvenih krvnih stanica na razvoj i proizvodnost teladi holštajnske pasmine koja je preboljela bronhopneumoniju. Istraživanje je obuhvatilo 170 jedinki holštajnske pasmine u dobi od 180 do 195 dana: zdrave životinje ( $n = 92$ ) i životinje s umjerenom bronhopneumonijom ( $n = 78$ ). Sve ženke su klinički praćene 27 mjeseci. Uzorci krvi uzeti su u 10 životinja iz svake skupine na početku istraživanja i 22. dan, te također kad su dosegli tjelesnu masu od 380 kg (prvo umjetno osjemenjivanje), 30 dana prije planiranog datuma teljenja te 7., 90. i 180. dan laktacije. Uz pomoć hematološkog analizatora, Singerovom metodom određivan je sadržaj fetalnog hemoglobina. Pokazalo se da se nakon ciklusa liječenja kliničkih simptoma bronhopneumonija u teladi povukla, ali se pojavila mikrocitna hipohromna anemija. Nadalje, u životinja s preboljelom bronhopneumonijom zapažen porast dobi pri uspješnoj oplodnji od 10,8 % i porast indeksa osjemenjivanja od 36,7 %. Nakon teljenja i za vrijeme laktacije težina hipokromije se smanjila, ali se pojavila sklonost makrocitozi koja je, u kombinaciji s povećanom anizocitozom, uputila na hipoplastičnu anemiju. Ovaj se oblik anemije pojavljuje na podlozi patoloških rezidualnih promjena nakon pneumonije zbog iscrpljivanja kompenzacijskog potencijala koštane moždine i njezina funkcionalnog opterećenja za vrijeme laktacije. Prisutnost anemije u krava tijekom laktacije smanjila je njihovu proizvodnju mlijeka za 23,2 – 26,7 % ( $P < 0,01$ ).

**Ključne riječi:** krava; respiratorne bolesti; anemija; spolna zrelost; proizvodnja mlijeka

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