

RESISTANCE PROPERTIES OF THE ORGANISM UNDER THE INFLUENCE OF THE MINERAL PREMIX "PMVS" AND THERMAL FACTORS

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Abstract

This paper presents the results of the study of low temperature effects of moderate stress intensity and the mineral premix "PMVS" on some indicators of calf defense abilities in postnatal ontogenesis to determine the parameters that can be used as a way of increasing the resistance and the defense abilities of animals to adverse environmental influences. The values obtained from the studied parameters show the change in the resistance of calves in the postnatal period. Thus, the increase of the biological value of the ration, by including the mineral premix "PMVS" and the application of the low temperature of a moderate stress intensity have led to an increased serum phagocytic activity, bactericidal activity and lysozyme activity throughout the experimental period. During the whole research period, the diurnal weight gain in the experimental group was 766 g. Maintenance of the organism's homeostasis within optimal physiological limits is the main task of the animals physiology. Determination of the parameters of influence of the food and heat factors on homeostasis and calf development in postnatal ontogenesis allows to create favorable conditions that can facilitate the acceleration of the functional maturation of vital organs and systems, increase the organism's resistance and adaptive abilities of the organism to the influence of stress factors and the realization of the genetic potential of animals.

Key words: bactericidal activity, calves, mineral premix, phagocytic activity, temperature.

INTRODUCTION

There is a very complex correlation between the organism and the conditions of the environment because the environmental factors act on the organism in most cases combined and the effect of the action depends on their nature and intensity (Чегина, 1993; Hoteteu, 2004; Курденко et al., 2017; Кляпнев, 2019). Moreover, the effects that appear after their separate or combined action are diverse and are manifested by the depth of changes in various physiological processes that determine the development and growth of the organism (Фурдуй, 1986; USDA, 1997; Jegou et al., 2006; González & Partida, 2011; Brouček, 2014; Roland et al., 2016). Since the temperature (the most abiotic physical factor of the environment with the greatest impact) acts in combination with other environmental factors, it is currently of interest to carry out the research in order to study the action of low temperature of moderate stress intensity and food factor (the second most important abiotic factor) on the functional state, endurance and adaptive

capacity of the organism in postnatal ontogenesis. Also of great importance for maintaining homeostasis is the determination of parameters that can be used as a way of increasing the resistance and adaptability of the animal's organisms to the unfavorable effects of environment (Lorenz et al., 2011; Бочаров, 2015; Das et al., 2016; Monteiro et al., 2016; Pusta, 2006; Курденко et al., 2017).

In the carried out research, the effects of influence of the temperature of a moderate stress intensity and the dietary factor on calves in postnatal ontogenesis have been studied according to the periodization developed by the Institute of Physiology and Sanocreatology of the Republic of Moldova in critical periods of development: imprinting, depression of the stress response, immunodeficiency, as well as the beginning of periods of domination and retardation of the growth, functioning and development of organ systems. According to the proposed scheme of the experiments, the organism resistance indices have been investigated: phagocytic activity, bactericidal activity and lysozyme. The body weight of the

calves throughout the experiment was also recorded as an integral index of the action of the studied factors on the animal productivity.

MATERIALS AND METHODS

The scientific investigations have been carried out on a herd of black-spotted calves, selected according to the analogy principle, taking into account breed, age, sex and body weight.

The experiments have been performed according to the calves' growth periodization, developed by the Institute of Physiology and Sanocreatology, which covered the time span from the 3rd to the 90th day of postnatal ontogenesis, the period in which the adaptive capacity of the calves is expected to increase.

The animals in both groups included in the experiment during the research period were in similar conditions of maintenance and consumed the same basic ration, which consisted of hay, straw, silage and concentrate fodder according to the existing norms. The calves access to food has been unlimited. At the same time, each calf in both groups consumed 300 liters of whole milk during the research period. Calves from the additional experimental group received the mineral premix "PMVS" to the main ration from the 7th day in the amount of 2.0 g per 1 liter of the consumed milk. The mineral premix "PMVS" was developed in the Institute of Physiology and Sanocreatology and represents an optimal mixture of micro- and macroelements in different concentrations and excipients. The quantity of mineral substances in the premix was calculated on the basis of the existing norms, the content of the mineral substances in the blood of the animals and their estimated value in fodder. This concentration, depending on the active properties of the integrated compounds, constituted various values in the range from 0.1 mg to 100.0 g.

At the same time, low temperatures of moderate stress intensity were applied to the calves in the experimental group for increasing the organism's adaptive capacity and resistance to environmental factors. The temperature of +5°C has been applied as a stress factor. The application of the temperature of moderate stress intensity on the calves was performed during the

early postnatal ontogenesis at the age of 3, 7, 15, 20, 25, and 30 days. After placing the animals into the „Zootron” climate chamber and adapting them to the new conditions within 1 hour, the temperature has gradually been decreased from the temperature recorded in the „Zootron” (which corresponds to the temperature in the stall for keeping calves) to +5°C. A gradual decrease in temperature is carried out for 30 minutes. At the age of 3, 7 and 15 days the exposure to "low temperatures" lasts 1 hour, and at the age of 20, 25 and 30 days - 2 hours. Blood samples were collected at 3, 7, 30, 60, and 90 days of postnatal ontogenesis.

The following indices of natural resistance were investigated in order to determine the effect of low temperature of moderate stress intensity and the mineral premix "PMVS" on the resistance of the calves organisms according to the scheme of the proposed experiment: phagocytic activity (after Gostev), bactericidal activity (after Matusevici) and lysozyme (by photoelectrocolorimetric method). The statistical processing of the results has been performed according to the laws of variable statistics and probability theory. All biological indices investigated have been distributed according to the legitimacy of the normal distribution. In the statistical processing of the obtained data, special attention was paid to determining the reliability of the difference between the comparative values. The main conclusions in the paper are based on the statistically authentic differences between the control and experimental groups. The results are expressed as Mean \pm standard deviation. The significance threshold shown: $P < 0.05$ (Ивантеев, 2010).

RESULTS AND DISCUSSIONS

The resistance of the calves' organisms to the application of moderate intensity stress temperature and the mineral premix "PMVS" was assessed by the level of phagocytic activity, bactericidal activity and lysozyme in the blood serum. The data showing the values of the cellular factor (phagocytic activity) of the natural resistance are presented in table 1.

Table 1. Indices of phagocytic activity in calves subjected to the effect of low temperature of moderate stress intensity and the mineral premix "PMVS" in postnatal ontogenesis

Age of calves (days)	Phagocyte activity (%), M±m	
	Control Group (CG) (10 heads)	Experimental Group (EG) (10 heads)
3	63.41±1.93	63.97±1.84
7	62.00±2.00	64.67±3.72
30	54.67±1.34	60.67±4.67
60	35.33±1.77	42.00±1.16*
90	55.33±1.91	62.67±1.77*

Note: * - the differences are statistically truthful between the experimental and the control groups (P<0,05). Here and further: CG - Control Group; EG - Experimental Group.

The level of phagocytic activity in 3-day-old calves in both groups was sufficiently high and amounted to 63.41±1.93%, and 63.97±1.84%. This fact shows that at the beginning of the experiments the colostrum immunity was quite high in both groups of animals. At the age of 30 days, phagocytic activity in the control and experimental group decreased in comparison with the initial level to 54.67±1.34% and 60.67±4.67%. The most obvious influence of the combination of the studied factors on phagocytic activity was recorded in 60-day-old calves. In the experimental group this amounted to 42.00±1.16%, and in the control group to 35.33±1.77% (P<0.05).

A similar tendency was observed in more mature calves. At the age of 90 days, the calves in the experimental group surpassed the calves of the control group in phagocytic activity. At the same time, the level of phagocytic activity in the experimental group (62.67±1.77%) is significantly higher in comparison with its level in the control group (55.33±1.91%) (P<0.05).

At the same time, a decrease in phagocytic activity was observed from the 3rd to the 60th day in both groups. In the control group it

decreased from 63.41±1.93% to 35.33±1.77% (1,79 times), and in the experimental group from 63.97±1.84% to 42.00±1.16% (1.52 times). The obtained data correlate with those of the specialized literature, which show that in the early postnatal period cellular factors of immunity predominate and they compensate for the deficiency of humoral factors, which are formed during the growth and development of calves in different periods. Later, with age, the phagocytic activity of calves decreases slightly and the activity of humoral factors increases significantly. As early as 1987, Плященко observed an increase in the level of phagocytosis in calves at the age of up to five days, and in the following days, starting from the age of ten, a decrease in phagocytes was observed. In the course of these processes, the bactericidal activity of the blood serum gradually and continuously increased. Therefore, up to the age of ten days of calves, the high level of phagocytic activity compensates for the low level of bactericidal activity. At the age of two months, the level of bactericidal activity in calves is close to the level recorded in adult animals. In this context, Фурдуй (1986, 1994), as well as Петрянкин (2014) points out that the calves defense system begins to stabilize only at the age of 1.5-2 months.

Blood serum has pronounced bacteriostatic properties against many infectious agents. Therefore, the bactericidal activity of blood serum is an integral expression of antimicrobial properties, which are part of the humoral factors of non-specific defense. The bactericidal activity has also been studied as a humoral index of defense which characterizes stress resistance and adaptive capacities of the organism to the effects of stressors (table 2).

Table 2. Indices of bactericidal activity in calves subjected to the effects of low temperature of moderate stress intensity and the mineral premix "PMVS" in postnatal ontogenesis

Age of calves (days)	Group of animals (CG - 10 heads) (EG - 10 heads)	Bactericidal activity (%), M±m		
		1 hour	3 hours	6 hours
3	CG	78.12±1.84	79.34±2.76	80.87±2.41
	EG	78.53±1.12	79.94±2.03	81.78±1.97
7	CG	80.00±3.00	79.33±4.06	81.33±1.34
	EG	74.33±2.61	82.33±3.53	90.33±2.70*
30	CG	83.00±1.00	88.00±2.65	92.00±2.74
	EG	88.67±2.97	90.33±1.20	94.00±1.16
60	CG	89.33±4.67	87.67±1.45	89.33±4.67
	EG	91.00±1.16	88.33±3.93	91.00±1.16
90	CG	66.00±3.22	76.67±3.34	80.33±2.61
	EG	71.33±3.34	82.33±3.39	88.33±2.19*

Note: * - the differences are statistically truthful between the experimental and the control groups (P<0,05).

The data presented in table 2 show that the application of low temperature of moderate stress intensity and the mineral premix "PMVS" in postnatal ontogenesis had a beneficial effect on bactericidal activity. At almost all studied ages, when exposed to 1, 3 and 6 hours, the bactericidal activity was higher in the experimental group. At the age of 7 days in the experimental group there was observed a significant increase in bactericidal activity, which was higher in comparison with the control group at the 6-hour exposure and amounted to $90.33 \pm 2.70\%$ in comparison with $81.33 \pm 1.34\%$ ($P < 0.05$). At the age of 90 days when exposed to 1, 3 and 6 hours there was an obvious tendency and a significant increase in bactericidal activity in the experimental group, where it amounted, accordingly, to $71.33 \pm 3.34\%$, $82.33 \pm 3.39\%$ and $88.33 \pm 2.19\%$ ($P < 0.05$) in comparison with $66.00 \pm 3.22\%$, $76.67 \pm 3.34\%$ and $80.33 \pm 2.61\%$ in the control group. Further, according to the experimental scheme, the amount of lysozyme in the blood serum was studied as a humoral factor of the nonspecific defense of the organism (table 3).

Table 3. Indices of lysozyme in calves subjected to the action of low temperature of moderate stress intensity and the mineral premix "PMVS" in postnatal ontogenesis

Age of calves (days)	Lysozyme (%), M±m	
	CG (10 heads)	EG (10 heads)
3	26.09±0.33	26.18±0.38
7	27.16±0.07	26.29±0.05
30	22.08±0.17	26.02±0.28*
60	29.84±0.62	33.76±0.71*
90	31.43±0.27	34.06±0.68*

Note: * - the differences are statistically truthful between the experimental and the control groups ($P < 0.05$).

The data in table 3 show that throughout the experiment the lysozyme in the experimental group was higher than in the control group except on the 7th day when its content decreased. At later ages of calves, at 30, 60 and 90 days, the lysozyme content increased accordingly from $22.08 \pm 0.17\%$, $29.84 \pm 0.62\%$ and $31.43 \pm 0.27\%$ to $26.02 \pm 0.28\%$, $33.76 \pm 0.71\%$ and $34.06 \pm 0.68\%$ ($P < 0.05$).

The results obtained are in a reciprocal link with the data of the specialized literature, which show that at the beginning of the postnatal period, the values of lysozyme, and bactericidal activity of the blood serum are low. In the next 2-3 weeks

of calves life, a rapid increase in humoral factors was established, which reached a relative stability at the age of 6 months, and their final formation at the age of 11-12 months (Фурдуй, 1986, 1994; Плященко, 1987; Петрянкин, 2014).

The experimental data obtained indicate that raising the biological value of the diet by supplementing with the developed mineral premix and the simultaneous action of the thermal factor had a positive effect on the cellular and humoral link of the natural resistance of animals in postnatal ontogenesis. Another important indicator of the effect of the mineral premix "PMVS" and of the studied temperature variation on the functional state, adaptive capacities and resistance of the organism is the productivity of the animals expressed in terms of body weight. The dynamics of the body mass of the experimental animals in the studied periods of age are presented in table 4.

Table 4. The dynamics of weight in calves subjected to the effects of low temperature of moderate stress intensity and the mineral premix "PMVS" in postnatal ontogenesis

Age of calves (days)	Weight (kg), M±m	
	CG (10 heads)	EG (10 heads)
3	29.7±0.76	29.2±0.84
7	32.77±0.86	32.55±1.08
30	47.78±1.37	47.34±2.09
60	67.82±1.99	69.50±1.88
90	90.90±1.11	95.80±1.21*

Note: * - the differences are statistically truthful between the experimental and the control groups ($P < 0.05$).

The data in table 4 show that the studied factors applied in postnatal ontogenesis have influenced the body productivity of calves. At the beginning of the experiments, when the groups of calves were formed according to the "analogy" principle, the average weight of the calves was 29.7 ± 0.76 kg in the control group and 29.2 ± 0.84 kg in the experimental group. Despite the fact that at the age of 7 and 30 days the action of low temperature of moderate stress intensity and the mineral premix "PMVS" had a positive influence on phagocytic activity, bactericidal activity and lysozyme, however, there were not significant changes in body weight. The last one constituted at the age of 7 days in the control group 32.77 ± 0.86 kg and in

the experimental group 32.55 ± 1.08 kg, at the age of 30 days respectively, it was 47.78 ± 1.37 kg in the control group and 47.34 ± 2.09 kg in the experimental group.

The recorded positive deviations of the animals defense capacity indices (phagocytic activity, bactericidal activity and lysozyme) show that the effect of low temperature of moderate stress intensity and the mineral premix "PMVS" was sufficient only for the increase of defense capabilities and maintenance of the functional stability of the body, but it was not enough for increasing the organism's productivity and, in particular, for increasing the body weight.

At the age of 60 days, the weight of the calves in the experimental group was 69.50 ± 1.88 kg compared to 67.82 ± 1.99 kg in the control group and it was 1.02 times higher. The data presented show that at the age of 60 days the studied factors had a positive effect on animals' productivity. This tendency was maintained at the age of 90 days. The weight of the calves during this period was 90.90 ± 1.11 kg in the control group and 95.80 ± 3.21 kg in the experimental group ($P < 0.05$). On the whole, during the whole research period, the diurnal weight increase of the calves in the experimental group was 766 g compared to 703 g and was 1.1 time higher than in the control group.

CONCLUSIONS

Based on the results obtained, it was found that the effect of low temperature of moderate stress intensity and the mineral premix "PMVS" on the body of calves in postnatal ontogenesis causes changes in phagocytic activity, bactericidal activity and lysozyme. The tendency to an increase in phagocytic activity throughout the entire study period in comparison with this activity in the control group has been experimentally determined. Changes in all studied periods of calves age were also observed in the dynamics of bactericidal activity and lysozyme. The recorded growth denotes an increase of the organism's defense capabilities and optimal maintenance of homeostasis.

The increase of the biological value of the food ration, by including the mineral premix "PMVS" and the simultaneous use of the low temperature of a moderate stress intensity also positively

influenced the body growth of the calves in the experimental group.

Maintenance of the organism's homeostasis within optimal physiological limits is the main task of animal physiology. Determining the parameters of the influence of food and heat factors on homeostasis and calves development in postnatal ontogenesis allows to create favorable conditions that can facilitate the acceleration of functional maturation of vital organs and systems, increase the organism's resistance and adaptive capacity to the influence of stressors and realize the genetic potential of animals.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Institute of Physiology and Sanocreatology and was financed from the Project 20.80009.7007.25 "Methods and procedures for maintenance and conservation of biodiversity depending on the integrity of gametogenesis and food variability".

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