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Joint use of polyvalent serum and immunomodulators for calves in early postnatal period

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SUMMARY
The paper demonstrates how a joint use of polyvalent serum and immunomodulators affects morbidity, survival, and resistance of calves in the early postnatal period. The objectives of the research are: to study how a joint administration of polyvalent serum and immunomodulators changes dynamics of morpho-biochemical and immunological blood parameters in calves; to determine an optimal ratio between the polyvalent serum and immunomodulators and frequency of administration so that to increase overall body resistance, ensure survival of calves in the early postnatal period; to assess cost-effectiveness of the joint use of polyvalent serum and immunomodulators. Research and production testing was done in Simmental calves. For this purpose one control group and five experimental groups were formed (at least 5 animals in each group). Polyvalent serum (20.0 mL) was once administered subcutaneously to the control calves on the first day of life and the animals of the experimental groups received the serum and immunomodulators according to the relevant dosing instructions. The obtained results demonstrate that the optimal protocols include a single administration of "Ribotan" in combination with serum on the first day of life, as well as a double administration of a polyvalent serum 7 days later, alternating "Fosprenil" with "Immunophane". Administration of polyvalent serum together with an immunomodulator to newborn calves can reduce the morbidity by 70.0% and achieve 100.0% survival, improving this indicator by 22.3% compared to the control. Cost-effectiveness assessment of the veterinary measures specified in these protocols shows that each rouble spent on the measures saves 25.29 roubles. To increase nonspecific resistance of calves in the early postnatal period, preference shall be given to those veterinary medicinal product that can not only normalize the immune system, but also have a combined positive effect on homeostasis in general, stimulate the growth and development of young animals at the early stages of ontogenesis.

Keywords: immunomodulators, polyvalent serum, calves, morbidity, survival, resistance

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Сочетанное применение поливалентной сыворотки и иммуномодуляторов в ранний постнатальный период выращивания телят

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РЕЗЮМЕ
Представлены данные о влиянии сочетанного применения поливалентной сыворотки и иммуномодулирующих препаратов на заболеваемость, сохранность, резистентность в ранний постнатальный период выращивания телят. Задачами исследования было: изучение влияния комбинированного введения поливалентной сыворотки и иммуномодуляторов на динамику морфобиохимических, иммунологических показателей крови телят; определение оптимального сочетания, кратности введения поливалентной сыворотки и иммуномодуляторов для повышения общей резистентности организма, сохранности телят в ранний постнатальный период выращивания; расчет экономической эффективности применения поливалентной сыворотки и иммуномодуляторов. Научно-производственный опыт проведен на телятах симментальской породы. Для этого сформировали одну контрольную и пять опытных групп, содержащих не менее 5 особей в каждой. Телятам контрольной группы однократно подкожно в первый день жизни вводили поливалентную сыворотку в дозе 20,0 мл, животным опытных групп – сыворотку и иммуномодуляторы в дозах согласно наставлению по их применению. На основании полученных результатов сделан вывод, что оптимальными протоколами являются: однократное введение в первый день жизни «Риботана» в комбинации с сывороткой, а также двукратное введение через 7 дней поливалентной сыворотки с чередованием «Фоспренила» и «Иммунофана». Инъекции новорожденным телятам поливалентной сыворотки в комбинации с иммуномодулятором позволяют снизить заболеваемость телят на 70,0%, добиться 100,0%-й сохранности, улучшив данный показатель на 22,3% по сравнению с контролем. Экономическая эффективность ветеринарных меро-

приятий в результате использования указанных протоколов на 1 рубль затрат в среднем составила 25,29 рубля. Для повышения уровня неспецифической резистентности организма телят в ранний постнатальный период выращивания предпочтение необходимо отдавать препаратам, способным не только нормализовать работу иммунной системы, но и оказывать комплексное положительное воздействие на гомеостаз в целом, стимулировать рост и развитие молодняка на ранних этапах онтогенеза.

Ключевые слова: иммуномодуляторы, поливалентная сыворотка, телята, заболеваемость, сохранность, резистентность

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INTRODUCTION

Modern animal husbandry inevitably causes problems with feeding and keeping newborn calves. These problems result in gastrointestinal disorders and bronchopneumonia, followed by reduced nonspecific resistance and immunodeficiencies in animals [1–3]. High morbidity and mortality rates during the first days of life are primarily explained by the undeveloped self-regulatory mechanisms of the body, imperfect digestion and poor immunity [4, 5]. The solution here is to develop comprehensive and effective protocols that both optimize the work of the immune system and have a positive effect on the body as a whole, activate metabolic processes, homeostasis, growth and development of newborn calves [6, 7]. Modern medicine and veterinary science offer quite a lot of natural and synthetic pharmacological products to stimulate immunogenesis and general resistance of the animals. However, their limited use for veterinary purposes indicates that no effective or simple ways of pharmacological influence on the animal immune status have been found so far [8]. Ensuring a high level of protection and adaption of animals to negative environmental factors during critical early postnatal periods remains an urgent issue. Creation of new and improvement of the current schemes for the use of polyvalent serum together with immunomodulators will optimize the protocols for the production purposes.

The aim of the research was to study the effect of the joint use of polyvalent serum with an immunomodulator on morbidity, survival, and resistance of calves during the early postnatal period.

To achieve this goal, the following tasks were set:

1. To study the effect of joint administration of polyvalent serum and immunomodulators on dynamics of morpho-biochemical, immunological blood parameters.

2. To determine optimal ratio and frequency of administration of the polyvalent serum and immunomodulators to increase general resistance and survival rate of calves in the early postnatal period.

3. To analyze cost-effectiveness of the joint use of polyvalent serum and immunomodulators in the early postnatal period.

MATERIALS AND METHODS

Research and production testing was conducted on one of the farms of the Altai Krai to study the joint use of a polyvalent serum (against pasteurellosis, salmonellosis, escherichiosis, parainfluenza-3 and infectious bovine rhinotracheitis; Armavir Biofactory, Russia) and immunomodulators: "Fosprenil" (CJSC "Micro-Plus", Russia), "Mixoferon" (AO "Mosagrogen", Russia), "Immunophane" (OOO NPP "BIONOX", Russia), "Ribotan" (OOO firm "NPViZTS "VETZVEROTSENTR", Russia). For this purpose, animal groups were formed: a control group (K-1) and 5 experimental (O-1–O-5) groups of Simmental calves (at least 5 animals in each). Polyvalent serum (at a dose of 20.0 mL) was once administered intramuscularly to the control animals, on the first day of life. The calves of the experimental groups were given serum and immunomodulators according to the scheme given in Table 1. The animals were kept under the same conditions and had the same diet.

Effectiveness of the joint use of immunomodulators and polyvalent serum was assessed based on the results of the following tests: tests for erythrocyte and leukocyte total count, test for hemoglobin (using conventional methods [9]); sera biochemical test: total protein (refractometric analysis, IRF-22), protein fractions (nephelometry) [10]; bactericidal (BAS) and lysozyme (LAS) activity of sera (photonephelometric method) [11]; methemoglobin concentration in blood (by colorimetric method) [12]; total IgG levels (enzyme immunoassay using the appropriate kit); phagocytic activity of neutrophils (by the methods of A. I. Ivanov and B. A. Chukhlovin [13] using a test culture of *Escherichia coli* O111 grown during one day on meat-peptone agar; test for T- and B-lymphocyte levels in peripheral blood using spontaneous rosettes with sheep erythrocytes and mouse erythrocytes according to S. V. Burtseva and O. Yu. Rudishin [14]; cost-effectiveness was calculated according to method offered by Yu. E. Shatokhin et al. [15].

Blood was sampled before administration of serum and immunomodulators and 10 days after the administration.

All experiments were carried out in strict accordance with the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (ETS No. 123).

Table 1
Scheme of joint administration of polyvalent serum against associated bovine infections and immunomodulators to calves

Group	Number of animals	Frequency / interval between injections, days	Veterinary medicinal product, mL				
			polyvalent serum	"Ribotan"	"Mixoferon", doses	"Fosprenil"	"Immunophane"
K-1	9	1	20.0	–	–	–	–
O-1	5	1	20.0	1.0	–	–	–
O-2	5	2/14	20.0	–	–	2.5	–
O-3	5	2/14	20.0	–	5	–	–
O-4	5	2/7	20.0	–	–	2.5	1.0
O-5	5	2/7	20.0	–	–	–	1.0

The reliability of the mean values was evaluated by method of variational statistics according to the Student – Fisher criterion.

RESULTS AND DISCUSSION

Analysis of the basic blood parameters in newborn calves before administration of serum and immunomodulators on the first day of life revealed that the total amount of serum protein was lower than the reference limit [16] by 17.3%, alpha-globulin fraction – by 19.1%, IgG was absent in 40.0% of experimental animals (Table 2).

Blood tests conducted at the end of the experiment demonstrated a significant decrease in total protein in the control group by 28.0% ($P < 0.05$) in contrast to the baseline parameters. A significant increase in this parameter in comparison with this parameter in the controls was recorded in groups O-1–O-5 with a simultaneous decrease in the serum albumin within the normal range in all experimental groups, except for O-3. Serum alpha-globulin fraction in all experimental calves demonstrated a positive trend towards normalization with a significant increase in O-2 group ($P < 0.05$). A decrease in serum gamma-globulin fraction in comparison with the controls was detected in groups O-1–O-3 ($P < 0.05$), groups O-4 and O-5 demonstrated a 22.5% and 11.8% increase in this parameter ($P < 0.01$), respectively. An increase in total IgG by a factor of 2.2 and by 32.5% in comparison to the baseline parameters was noted in sera of calves from groups O-3 and O-4, respectively, at the same time IgG was detected in blood of 100.0% of the examined animals. A maximum IgG increase in comparison to the controls was recorded in group O-3 (by a factor of 3.4), in group O-4 (by a factor of 2.0), in group O-5 (by 34.6%), an IgG decrease was observed in groups O-1 and O-2 by 38.4% and 19.2%, accordingly. The albumin-globulin ratio was within the normal physiological range only in groups O-2 and O-3.

The hematological profile of the calves used in the experiment is given in Table 3. Analyses of the baseline blood parameters revealed that the total count of erythrocytes and leukocytes was within the reference range, while the total hemoglobin was 21.8% lower than normal, the color index was 2.8%. Experimental calves

Table 2
Total protein and its fractions in the sera of experimental calves

Group	Total protein content, g/L	Albumins, %	Globulins, %			Total IgG, Units/mL	Ratio albumin/ globulin, Units
			α	*β*	*γ*		
Reference	60–85	33–50	12–20	10–16	25–40	< 10	0.83–1.19
baseline blood parameters							
	49.6 ± 3.93	42.6 ± 6.65	9.7 ± 2.10	16.1 ± 3.89	30.7 ± 7.90	4.0 ± 2.51	0.72 ± 0.163
in 10 days							
K-1	35.7 ± 1.49*	46.9 ± 5.74	11.2 ± 1.57	16.0 ± 3.96	25.3 ± 2.32	2.6 ± 0.94	0.73 ± 0.090
O-1	64.2 ± 4.72**(*)	35.7 ± 1.50	11.7 ± 1.86	17.0 ± 0.94	17.0 ± 0.94(*)	1.6 ± 0.52	0.55 ± 0.040
O-2	44.5 ± 0.98(*)	44.4 ± 0.94	16.7 ± 0.39*	12.9 ± 1.33	17.0 ± 0.94(*)	2.1 ± 1.01	0.83 ± 0.058
O-3	47.0 ± 1.70(*)	47.0 ± 1.82	13.8 ± 1.17	13.4 ± 1.59	15.1 ± 0.41(*)	8.8 ± 1.77(**)	0.89 ± 0.060
O-4	57.8 ± 1.49(*)	35.6 ± 4.51	11.5 ± 2.36	14.5 ± 1.52	31.0 ± 0.42(**)	5.3 ± 2.14	0.51 ± 0.030
O-5	49.7 ± 0.41(*)	41.8 ± 3.53	12.9 ± 1.77	16.9 ± 2.13	28.3 ± 4.48	3.5 ± 2.32	0.73 ± 0.101

* $P < 0.05$, ** $P < 0.01$ – to the initial values;
(*) $P < 0.05$, (**) $P < 0.01$ – to control.

Table 3
Hematological parameters observed in experimental calves before and after administration of immunomodulators together with polyvalent serum

Group	Erythrocytes, 10^9/L	Hemoglobin, g/L	Methemoglobin, %	Leukocytes, 10^{12}/L	Color index, Units	BAS, %	LAS, %
Reference	5.0–7.5	99–129	0–5	4.5–12.0	0.7–1.1	23–28	25–33
baseline blood parameters							
–	6.7 ± 0.80	77.4 ± 6.13	20.0 ± 0.62	5.5 ± 1.21	0.68 ± 0.10	33.3 ± 9.86	5.2 ± 0.37
blood parameters at the end of the experiment in 14 days							
K-1	7.7 ± 0.64	79.0 ± 3.09	18.1 ± 0.91	5.4 ± 0.42	0.71 ± 0.06	34.3 ± 4.47	6.7 ± 1.45
O-1	9.3 ± 0.47(*)	90.5 ± 2.33(**)	0	5.4 ± 0.54	0.62 ± 0.06	41.8 ± 1.6**	21.2 ± 3.10*(*)
O-2	8.0 ± 0.04	82.5 ± 2.89	19.7 ± 0.22	7.5 ± 0.47(*)	0.61 ± 0.01	34.3 ± 4.29	15.5 ± 1.36*
O-3	7.7 ± 0.44	107.3 ± 6.42(*)	13.5 ± 0.6*(*)	6.5 ± 0.65	0.82 ± 0.03	46.3 ± 6.95	20.8 ± 0.88*(*)
O-4	8.4 ± 0.75	85.5 ± 4.28	13.1 ± 0.75*(*)	5.8 ± 0.28	0.7 ± 0.09	45.7 ± 6.82	20.2 ± 0.95*(*)
O-5	8.1 ± 0.50	88.7 ± 3.75	17.7 ± 0.28*	6.8 ± 1.01	0.65 ± 0.06	38.2 ± 4.50	14.9 ± 0.26*(*)

* P < 0.05, ** P < 0.01 – to the initial values;
(*) P < 0.05, (**) P < 0.01 – to control.

demonstrated a 4-time increase in methemoglobin in comparison with the reference limits, BAS – by 18.9%, and a decrease in LAS – by 79.2%.

At the end of the experiment, a significant increase in total erythrocyte count was reported in group O-1 by 20.8% (P < 0.05), group O-2 by 3.9%, group O–4 by 9.1%, group O-5 by 5.2%, as compared to the control. Total hemoglobin significantly increased as compared to the baseline parameters and to the blood tests in the control group: i.e. in O-1 group by 14.6% (P < 0.01) and in O-3 group by 35.8% (P < 0.05). A decrease in total methemoglobin was observed in groups O-3–O-5 (P < 0.05) with a significant difference, thus, suggesting a decreased tissue hypoxia due to reduced levels of oxidized trivalent iron in blood of experimental animals. The leukocytes were within the reference limits. In comparison with the control group, the color index grew by 15.5% in group O-3 and decreased by 1.4–14.1% in groups O-1, O-2, O-4, O-5. BAS grew in group O-1 by 21.9% (P < 0.01), in groups O-3 – by 35.0%, O-4 – by 33.2%, O-5 – by 11.4% relative to the control. LAS in all experimental groups significantly increased by a factor of 2.2–3.2 (P ≤ 0.05) in comparison with the parameter observed in the control group.

Functional immune system in the experimental calves was assessed and the corresponding results are given in Table 4. Increased proliferation activity of T-lymphocytes with a significant difference (P ≤ 0.05; P ≤ 0.01) in relation to the baseline parameters was reported in all animals: in K-1 group this parameter increased by 17.7%, in the experimental groups – by 22.8–29.9%. The B-lymphocytes count significantly differed only in groups O-1 and O-4 (P ≤ 0.05). The phagocytic activity of neutrophils increased in the control group by 11.9%, in the experimental group – by 14.6–21.8% (P ≤ 0.05) in comparison with the baseline parameters. Increased number of phagocytic cells by 15.4–30.8% was found in the blood of experimental calves without any significant differences.

Table 4
Functional activity of blood cells in calves before and after the combined administration of immunomodulators and polyvalent serum

Group	B-lymphocytes, %	T-lymphocytes, %	Phagocytic activity, %	Phagocytic number, %
baseline parameters	11.2 ± 1.48	25.4 ± 0.35	55.4 ± 1.56	1.3 ± 0.13
blood parameters at the end of the experiment, in 14 days				
K-1	15.6 ± 2.43	29.9 ± 2.65*	62.0 ± 2.22	1.5 ± 0.16
O-1	20.4 ± 2.50*	33.0 ± 1.75*	67.5 ± 2.26*	1.6 ± 0.14
O-2	16.6 ± 2.13	32.8 ± 2.21*	65.1 ± 1.96*	1.5 ± 0.12
O-3	17.8 ± 2.48	31.2 ± 1.32*	64.2 ± 1.26*	1.6 ± 0.13
O-4	17.8 ± 1.72*	32.2 ± 1.28**	65.3 ± 2.48*	1.7 ± 0.15
O-5	16.4 ± 2.55	32.0 ± 2.21*	63.5 ± 2.35*	1.5 ± 0.21

* P ≤ 0.05, ** P ≤ 0.01.

The joint administration of serum with "Ribotan" (O-1), serum with "Fosprenil" and "Immunophane" (O-4) to newborn calves made it possible to achieve 100.0% survival in these groups, which is by 22.3% higher than in the control group (K-1), by 20.0% – in comparison with groups O-2, O-3 and O-5, where "Fosprenil", "Mixoferon" and "Immunophane" were injected together with the serum (Fig. 1).

The morbidity in the control group was 100.0%, in groups O-1 and O-4 – 20.0%, in O-2 and O-5 – 40.0%, and in group O-3 – 60.0%, average morbidity in experimental groups was 36.0%.

The 1st control weighing (see Fig. 2) shows that an absolute body weight gain in calves increased by 64.2% in group O-1; by 59.9% in group O-2; by 1.8% in group O-3 and by 75.6% in group O-5; a decrease in this indicator by 24.1% was reported in group O-4 as compared to the control (K-1). The trend continued during the whole 3-month observation with the maximum body weight gain by 19.1% in group O-5; by 1.6–15.1% – in O-1–O-3 groups and a decrease by 6.4% in O-4 group in comparison with the controls.

Cost-effectiveness of the joint use of immunomodulators and polyvalent serum against bacterial and viral infections to increase nonspecific resistance in calves in the early postnatal period was calculated as the difference between the probable (potential) and actual economic damage prevented on the farm. Calculations were based on the data obtained in the research and production test.

The damage caused by the death of calves was calculated by the formula:

$$Y_1 = M \times (Sp + Vp \times T \times C) - Sf,$$

where M – the number of dead animals; Sp is the cost of the offspring at birth (roubles), Sp = 3.61 × Cp, where 3.61 is the amount of milk (c) that can be produced from feeds consumed for the fetus formation, Cp is the purchase price of one centner of whole milk (roubles): Sp = 3.61 × 2,900 = 10,469.00 roubles; Vp – daily average body weight gain in young farm animals, kg; T is the age of the dead animal, day; C – the sale price for a unit of product, roubles; Sf – proceeds from the sale of slaughter products, roubles.

Y_1 (K-1) = 2 × (10,469.00 + 0.333 × 7 × 175) – 380 = 21,373.85 roubles;

Y_1 (O-2) = 1 × (10,469.00 + 0,531 × 3 × 175) – 180 = 10,567.78 roubles;

Y_1 (O-3) = 1 × (10,469.00 + 0.338 × 7 × 175) – 175 = 10,708.05 roubles;

Y_1 (O-5) = 1 × (10,469.00 + 0.583 × 4 × 175) – 165 = 10,712.10 roubles;

Y_1 (O-1, O-4) = 0 roubles.

Calculation of the damage caused by a decrease in the productivity of calves:

$$Y_2 = Ms \times (Vh - Vs) \times T \times C,$$

where Ms – number of sick animals; Vh and Vs – daily-average productivity of healthy and sick animals, kg; T – average observation of changes in animal productivity, days, C – sales price for a unit of product, roubles.

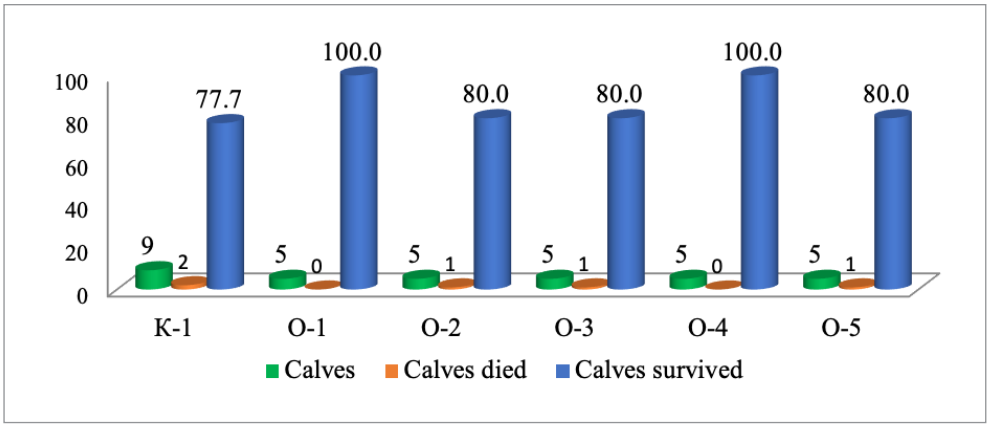

Fig. 1. Calves survived after joint administration of immunomodulators and polyvalent serum

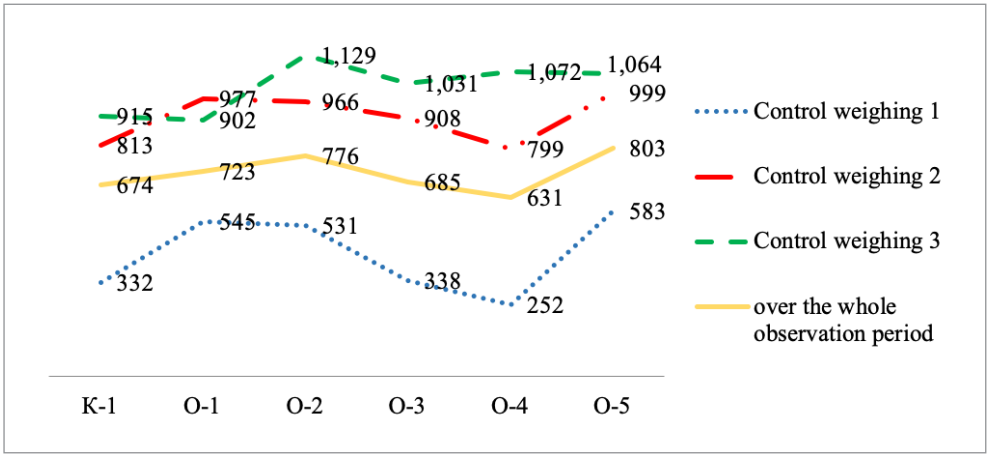

Fig. 2. Absolute weight gain in grams

Y_2 (K-1) = 9 × (0.332 – 0.213) × 4.5 × 175 = 843.41 roubles;

Y_2 (O-1) = 1 × (0.545 – 0.429) × 3.5 × 175 = 71.05 roubles;

Y_2 (O-2) = 2 × (0.531 – 0.492) × 4 × 175 = 54.60 roubles;

Y_2 (O-3) = 3 × (0.338 – 0.251) × 5 × 175 = 228.38 roubles;

Y_2 (O-4) = 1 × (0.252 – 0.215) × 4 × 175 = 25.90 roubles;

Y_2 (O-5) = 2 × (0.583 – 0.432) × 4 × 175 = 211.40 roubles.

Total damage and damage per 1 animal, roubles:

$Y = Y_1 + Y_2$.

Y (K-1) = 21,373.85 + 843.41 = 22,217.26 / 9 = 2,468.58 roubles;

Y (O-1) = 0 + 71.05 = 71.05 / 5 = 14.21 roubles;

Y (O-2) = 10,567.78 + 54.60 = 10,622.38 / 5 = 2,124.48 roubles;

Y (O-3) = 10,708.05 + 228.38 = 10,936.43 / 5 = 2,187.29 roubles;

Y (O-4) = 0 + 25.90 = 25.90 / 5 = 5.18 roubles;

Y (O-5) = 10,712.10 + 211.40 = 10,923.50 / 5 = 2,184.70 roubles.

The cost of one animal treatment, roubles: K-1 = 20.00 roubles, O-1 = 99.90 roubles, O-2 = 54.05 roubles, O-3 = 51.75 roubles, O-4 = 70.82 roubles, O-5 = 87.60 roubles.

Cost-effectiveness of one animal treatment:

$$Ec = (Sb + Ub) – (Sn + Un),$$

where Sb and Sn stand for the current production costs for veterinary measures, respectively, in the basic and new versions per treated animal, roubles; Ub and Un stand for a specific economic damage per unit of work, respectively, in the basic and new versions, roubles.

Ec (O-1) = (0 + 2,187.88) – (99.90 + 14.21) = 2,073.77 roubles;

Ec (O-2) = (0 + 2,187.88) – (54.05 + 2,124.48) = 9.35 roubles;

Ec (O-3) = (0 + 2,187.88) – (51.75 + 2,187.29) = –51.16 roubles;

Ec (O-4) = (0 + 2,187.88) – (70.82 + 5.18) = 2,111.88 roubles;

Ec (O-5) = (0 + 2,187.88) – (87.60 + 2,184.70) = –84.42 roubles.

The economic effect of preventive measures calculated per one rouble of expenses according to the formula:

$$Ee = Ec / Zv,$$

where Ec – cost-effectiveness of one animal treatment; Zv – veterinary costs per one animal, roubles.

O-1 = 2,073.77 / 99.90 = 20.76 roubles;

O-2 = 9.35 / 54.05 = 0.17 roubles;

O-3 = -51.16 / 51.75 = –0.99 roubles;

O-4 = 2,111.88 / 70.82 = 29.82 roubles;

O-5 = -84.42 / 87.60 = –0.96 roubles.

The economic effect of preventive measures calculated per one rouble of expenses in the experimental groups ranged from 0.17 roubles in group O-2, to 29.82 roubles in group O-4, negative values were obtained in groups O-3 and O-5.

The joint use of polyvalent serum and immunomodulators shows that the use of "Ribotan" together with serum (O-1), administered once on the first day of life, is the most effective option. The following scheme ranks second among other options, i.e. double administration of a polyvalent serum with "Fosprenil" and "Immunophane" (O–4) used on a rotational basis (with a 7-day interval). These two immunomodulators activate immunity of calves, which is confirmed by a significant increase in T- and B-lymphocytes and by growing phagocytic activity of neutrophils. It should be noted that the injection of a polyvalent serum into newborn calves in combination with immunostimulants reduces mortality of calves by 70.0%, helped to achieve 100.0% survival, improving this indicator by 22.3% in comparison to the control. Therefore, all other things being equal during the use of polyvalent serum together with immunomodulators, those veterinary medicinal products shall be preferred that can both normalize the immune system and have a complex positive effect on homeostasis in general, stimulate growth and development of young animals in the early stages of ontogenesis.

CONCLUSIONS

1. A single intramuscular injection of polyvalent serum at a dose of 20.0 mL to newborn calves together with a subcutaneous injection of "Ribotan" at a dose of 1.0 mL normalizes morpho-biochemical blood parameters with a significant increase in total hemoglobin, erythrocytes, serum protein, gamma globulin fraction, T- and B-lymphocytes, phagocytic activity of neutrophils, lysozyme and bactericidal activity of sera in the early postnatal period.

2. A double administration of the polyvalent serum at the same dose with "Fosprenil" (which is administered on Day 1 at a dose of 2.5 mL) and "Immunophane" (which is administered 7 days later at a dose of 1.0 mL) significantly reduces methemoglobin in the blood of calves, and increases total protein, gamma globulins, T- and B-lymphocytes, phagocytic lysozyme activity in comparison with the control calves and the baseline blood parameters.

3. These schemes make it possible to reduce morbidity of calves in early ontogenesis by 70.0%, to achieve a reduction in mortality by 22.3%.

4. Cost-effectiveness assessment of the veterinary measures specified in protocols 1 and 2 used to improve nonspecific resistance of calves in the early postnatal period shows that each rouble spent on the measures saves on average 25.29 roubles.

REFERENCES

1. Semenov V. G., Nikitin D. A., Petryankin F. P., Gerasimova N. I. Application of complex immunotherapeutic preparations of the PS series at cultivation of calfs. *Fundamental research*. 2015; 2 (21): 4671–4675. EDN: TWSZJV. (in Russ.)

2. Bober Yu. N., Voronov D. V., Dolgiy A. A., Kharitonov A. P. Diseases of young animals: a manual. Grodno: GSAU; 2013. 89 p. (in Russ.)

3. Kozitsina A. I. Use of "Elitox" to normalize metabolic processes in mother cows and increase resistance in calves: Thesis for degree of Candidate of Science (Veterinary Medicine). Saint Petersburg; 2018. 179 p. (in Russ.)

4. Petryankin F. P., Petrova O. Yu. Diseases of young animals. 2nd ed., revised and supplemented. Saint Petersburg: Lan'; 2014. 351 p. (in Russ.)

5. Shakhov A. G. Dostizheniya I osnovnye napravleniya issledovanii po izucheniyu boleznei molodnyaka sel'skokhozyaistvennykh zhivotnykh = Achievements and main goals of research in diseases of young farm animals. *Praktik*. 2010; 2: 26–33. EDN: VCCEHX. (in Russ.)

6. Khaitov R. M. Immunology. 2th ed., corrected and supplemented. Moscow: GEOTAR-Media; 2013. 528 p. (in Russ.)

7. Sanin A. V., Savoyskaya S. L., Kozhevnikova T. N., Sanina V. Yu., Sosnovskaya O. Yu. Safety, growth, development and non-specific resistance increasing of calves with help

of modern immunomodulatory preparations. *Veterinaria Kubani*. 2019; 2: 11–14. DOI: 10.33861/2071-8020-2019-2-11-14. (in *Russ.)*

8. Petrjankin F. P. Immunotropnye prepations for treatment and preventive maintenance of illnesses of animals. *Veterinarnaya patologiya*. 2009; 2 (29): 98–105. EDN: OCZFFN. (in Russ.)

9. Kudryavtsev A. A., Kudryavtseva L. A. Clinical hematology of animals. Moscow: Kolos; 1974. 399 p. (in Russ.)

10. Methods of clinical diagnosis used in veterinary laboratories: reference book. Ed. by prof. I. P. Kondrakhin. Moscow: KolosS; 2004. 520 p. (in Russ.)

11. Gugushvili N. N. Immunological tests used in veterinary medicine: a guidance approved by Department of Veterinary Medicine of the Ministry of Agriculture of the Russian Federation No. 13-7-2/2128. Krasnodar: KubSAU; 2001; 50–53. (in Russ.)

12. Guidance on diagnosis, prevention and treatment of nitrate and nitrite poisoning in farm animals: approved by GUV under the Council of Ministers of the USSR dated 28.03.1991. Available at: https://base.garant.ru/71104036. (in Russ.)

13. Ivanov A. I., Chukhlovin B. A. K metodike opredeleniya poglotitel'noi sposobnosti neitrofilov = On the method of determining the ingestive and digestive capability of neutrophils. *Laboratornoe delo*. 1967; 10: 610–613. PMID: 4181349. (in Russ.)

14. Burtseva S. V., Rudishin O. Yu. Biological and biochemical research methods currently used in zootechnics: a textbook. Barnaul: ASAU; 2014; 161–170. (in Russ.)

15. Shatokhin Yu. E., Nikitin I. N., Chulkov P. A., Voskoboynik V. F. Cost-effectiveness analysis of veterinary measures. Moscow: Moscow SAVMB; 1997. 36 p. (in Russ.).

16. Vasil'eva S. V., Konopatov Yu. V. Clinical biochemistry of cattle: a textbook. 2th ed., corrected. Saint Petersburg: Lan'; 2017. 185 p. (in Russ.)

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