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Role of rotavirus, coronavirus and *Escherichia coli* in disease etiology in young cattle (review)

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ABSTRACT

Introduction. One of the most prevalent groups of pathologies detected in young cattle involves gastrointestinal diseases. They are often caused by infectious agents, among which rotavirus, coronavirus and pathogenic *Escherichia coli* are predominant.

Objective. Analysis and systematization of up-to-date information on the role of rotavirus, coronavirus and pathogenic *Escherichia coli* strains in the etiology of diseases of cattle, including young animals, data on the incidence of these infections in the Russian Federation and other countries of the world as well as relevance of vaccination against the above-mentioned pathogens.

Results. The paper provides information on the structure of rotavirus, coronavirus and *Escherichia coli*, on the biological properties of the pathogens, and factors affecting the disease form and severity. Based on the analysis of domestic and foreign scientific publications, data on the prevalence of colibacillosis, rotavirus and coronavirus infections are presented, and the main methods of their control are described. The significance of the vaccines for the prevention of these diseases is confirmed, the factors influencing the vaccine prevention effectiveness are listed, and measures to increase it are given.

Conclusion. The average global incidence of rotavirus infection is 32.7%, coronavirus infection is 18.4%, and colibacillosis is 39.1%. In Russia, the prevalence rate of the above-mentioned diseases is 41.4, 33.1 and 30.2%, respectively. Thus, in the Russian Federation, the incidence of bovine rotavirus and coronavirus infections exceeds the global average by 8.7 and 14.7%, respectively. The colibacillosis situation in Russia is better than in most countries: the disease is reported by 8.9% less frequently than the global average. High genetic diversity and prevalence of the above-mentioned pathogens require an integrated approach to their control. One of the most effective methods is vaccination, which makes the development of effective and safe vaccines against rotavirus, coronavirus and *Escherichia coli* infections an urgent task.

Keywords: review, rotavirus, coronavirus, *Escherichia coli*, young cattle, respiratory and intestinal pathologies

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Значение ротавируса, коронавируса и *Escherichia coli* в этиологии болезней молодняка крупного рогатого скота (обзор)

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РЕЗЮМЕ

Введение. Одной из самых распространенных групп патологий, встречающихся у молодняка крупного рогатого скота, являются болезни желудочно-кишечного тракта. Частой их причиной являются возбудители инфекций, среди которых преобладающее значение имеют ротавирус, коронавирус и патогенная форма кишечной палочки.

Цель исследования. Анализ и систематизация актуальной информации о роли рота-, коронавируса и патогенных штаммов *Escherichia coli* в этиологии болезней крупного рогатого скота, в том числе молодняка, сведений о заболеваемости этими инфекциями на территории Российской Федерации и других стран мира, а также актуальности вакцинопрофилактики против вышеназванных патогенов.

Результаты. В статье представлена информация о строении ротавируса, коронавируса и *Escherichia coli*, биологических свойствах возбудителей, факторах, влияющих на форму и тяжесть течения болезней. На основании анализа научной литературы отечественных и зарубежных авторов представлены данные о распространенности колибактериоза, ротавирусной и коронавирусной инфекций, а также описаны основные методы их контроля.

Подтверждена важность вакцин для профилактики указанных болезней, перечислены факторы, влияющие на эффективность вакцинопрофилактики, и приведены меры ее повышения.

Заключение. Средний уровень заболеваемости ротавирусной инфекцией в мире составляет 32,7%, коронавирусной инфекцией – 18,4%, колибактериозом – 39,1%. В России показатель превалентности вышеупомянутых болезней равен 41,4; 33,1 и 30,2% соответственно. Таким образом, в Российской Федерации уровень заболеваемости рота- и коронавирусной инфекциями крупного рогатого скота превышает средний показатель в мире на 8,7 и 14,7% соответственно. Эпизоотическая ситуация по колибактериозу в России благополучнее, чем в большинстве стран: болезнь регистрируется реже среднего мирового значения на 8,9%. Большое генетическое разнообразие и распространенность вышеупомянутых возбудителей требуют комплексного подхода для борьбы с ними. Одним из наиболее эффективных способов является вакцинопрофилактика, что делает разработку эффективных и безопасных вакцинных препаратов против ротавирусной, коронавирусной инфекций и эшерихиоза актуальной задачей.

Ключевые слова: обзор, ротавирус, коронавирус, *Escherichia coli*, молодняк крупного рогатого скота, респираторные и кишечные патологии

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INTRODUCTION

Gastrointestinal (GI) diseases are one of the most prevalent groups of pathologies in young cattle. The GI disorders are most often associated with the lack of a complex of necessary measures to prevent infectious diseases in young animals: ineffective or untimely vaccination, untimely feeding with colostrum, non-compliance with hygienic standards in the maintenance of production facilities, faulty diet formulation and non-compliances with the feeding technics. The combination of these factors creates conditions for the development of enteritis of infectious etiology in cattle [1, 2].

One of the most common causes of enteritis in young cattle is the effect of rotaviruses, coronaviruses and *Escherichia coli*. Therefore, they make the most significant impact on the health of calves as compared to other infectious agents that cause GI disorders, thus requiring appropriate preventive measures [3, 4].

The novelty of the analytical study lies in the generalization of scientific information on the bovine disease situation caused by rotaviruses, coronaviruses and pathogenic *E. coli* strains in the Russian Federation and other countries of the world.

The purpose of this review is to analyze and systematize up-to-date information on the role of rotavirus, coronavirus and pathogenic *E. coli* strains in the etiology of bovine diseases, *inter alia* in young animals, data on the incidence of these infections in the Russian Federation and other countries of the world, as well as relevance of vaccine prevention of the above-mentioned pathogens.

ROLE OF ROTAVIRUSES IN THE DEVELOPMENT OF BOVINE PATHOLOGIES

The taxonomic group *Reoviridae* includes non-enveloped viruses containing double-stranded, segmented RNA represented by 11 segments. Rotaviruses belong to the family *Sedoreoviridae*. The rotavirus capsid consists of 3 layers. The outer layer is represented by VP4 and VP7 proteins, the middle one – by VP6, the inner one – by VP1, VP2 and VP3, and the virion size is 70 nm. The segmented nature of the genome is the reason for the rotavirus reassortment [2].

Since the rotaviruses are widespread, young cattle can be infected with them from their first days of life. The rotavirus infection in calves is clinically manifested by depression, diarrhea, and dehydration (Fig. 1). During the milk feeding, the feces of the diseased calves are of yellow or white color and of varied consistency (from watery to thick), however, the presence of blood in the feces is not typical for rotavirus infection. In case of secondary bacterial infection, the mortality rate of newborn calves can reach 60%. During autopsy, catarrhal or catarrhal-hemorrhagic enteritis is reported in dead animals [2].

Fig. 1. Clinical manifestation of rotavirus infection, characterized by diarrhea and depression (photo from the personal archive of A. V. Kononov)

Rotavirus infection is most acute during the cold season, and the severity of the disease depends upon the decrease in the indoor temperature. The risk of severe disease is also increased by feeding with colostrum from cows that lack rotavirus antibodies as well as by the presence of other enteropathogenic infectious agents [2].

In addition to young animals, the adult animals can also be infected with rotavirus, but their infection is asymptomatic. The number of asymptomatic carriers on the infected farms can reach 44%. The infected adult animals play a significant role in the virus spread: within a few weeks, one such animal can shed up to 10^{10} viral particles per 1 g of feces. Since this virus has a high resistance to environmental factors, the pathogen can circulate on the farm for a long time and infect a large number of susceptible animals, including calves [2].

Enteritides of rotavirus etiology are reported in calves more often than other infectious GI diseases. On the infected farms, they can infect up to 100% of calves, and vaccination of cattle may be ineffective due to the rotavirus reassortment and emergence of new recombinant virus variants [5]. The incidence of the rotavirus infection in cattle in the world and in the Russian Federation can reach 70% or higher (Table 1 and 2).

Based on the systematized data, it can be concluded that the average prevalence of rotavirus infection in cattle in the countries of the world was 32.7% in 1981–2021.

Table 1
Bovine rotavirus infection prevalence in the countries of the world

Country	Region	Estimated prevalence, %	Source
Australia (2011)	Australia	79.90	[6]
Australia (2004–2005)		26.00	[7]
China (1984–2021)	Asia	35.70	[8]
Iran (2000)		34.00	[9]
Iran (1981)		31.74	[10]
Iran (2001)		28.80	[10]
Iran (2010)		27.90	[10]
Norway (2004–2007)	Europe	67.70	[11]
Switzerland (2005–2006)		58.70	[12]
Spain (2000)		43.50	[10]
Spain (1998)		42.70	[10]
Turkey (2007)		41.17	[10]
Belarus (2020–2021)		39.60	[13]
Ukraine (2012)		28.60	[14]
Sweden (2003)		13.00	[15]
Sweden (1987–1988)		5.40	[16]
Argentina (1994–2003)	South and North America	42.00	[17]
Brazil (2007)		33.00	[10]
USA (2010)		12.20	[18]
Brazil (2007)		11.00	[19, 20]
Costa Rica (1981)		10.00	[10]
Costa Rica (1998)		7.00	[10]

Table 2
Bovine rotavirus prevalence in the Russian Federation

Region of the Russian Federation	Federal district	Estimated prevalence, %	Source
Republic of Dagestan (2001–2005)	North Caucasian	77.90	[21]
Irkutsk Oblast (2020)	Siberian	44.40	[22]
Irkutsk Oblast (2004–2017)		17.60	[5]
Central Black Earth Region (2017–2018)	Central	22.30	[23]
12 Oblasts (2007–2011)	Central, Volga and Far Eastern	44.55	[24]

As for the Russian Federation, the issue of the rotavirus infection prevalence in cattle also remains relevant. The data in Table 2 show that over the past 20 years, the incidence on farms in the Russian Federation has averaged 41.4%, which exceeds the same indicator in other countries by 8.7%. Such a high prevalence may be due to the non-compliances with calf housing conditions and lack of appropriate preventive measures targeted to all age groups of cattle on the farms of the Russian Federation.

ROLE OF CORONAVIRUSES IN THE DEVELOPMENT OF BOVINE PATHOLOGIES

Bovine coronavirus belongs to the *Coronaviridae* family, genus *Betacoronavirus*, and species *Betacoronavirus gravedinis*. The genome is represented by a single-stranded (+) RNA and it is the longest among the RNA viruses. The virion is 65–210 nm in diameter and contains a supercapsid.

Coronavirus infection is ubiquitous. During their lifetime, up to 90% of animals become infected with coronavirus. Based on the clinical picture, there are three disease forms: intestinal, respiratory, and so-called winter dysentery. The development of one disease form or another depends not on the serotype of the pathogen, but on the age of the recipient [2].

The intestinal form is most typical for young animals from the first days of life to the age of five months. It is characterized by inflammatory lesions of the large and small intestines, which lead to severe diarrhea (often with blood), as well as to high mortality rate, which can reach 20% [2, 5].

The respiratory infection is typical for calves from two to six months of age, which is characterized by rhinitis, cough, fever, loss of appetite, and often by concurrent diarrhea (Fig. 2). In severe cases, dyspnea, bronchopneumonia, and weight loss up to exhaustion and death are reported [2].

Fig. 2. Clinical manifestation of coronavirus infection, characterized by depression (photo from the personal archive of A. V. Kononov)

In adult animals, the disease occurs in the form of winter dysentery, which is characterized by the following clinical signs: profuse diarrhea (up to 100% of cases), often with blood, cough, seromucous nasal discharge, harsh rapid breathing. The disease leads to the decrease in milk yield from 25 to 90%, while restoring the previous milk yield can take from 2.5 to 4 months [25].

The adult animals can be asymptomatic coronavirus carriers, while being a source of infection transmission with feces (96%) and nasal mucus (84%). Over 70% of adult animals can shed the virus despite the presence of antibodies. This is due to the fact that a long period of persistence and shedding by the recovered animals are typical for the coronavirus [2].

Low temperatures and lesser exposure to UV rays in winter not only contribute to the pathogen persistence,

Table 3
Prevalence of bovine coronavirus infection in the countries of the world

Country	Region	Estimated prevalence, %	Source
Australia (2011)	Australia	21.60	[6]
Japan (1995–1997)	Asia	57.00	[27]
Iran (2010)		3.10	[10]
Norway (2004–2007)	Europe	39.30	[11]
Belarus (2020–2021)		28.70	[13]
Ukraine (2012–2019)		22.40	[14]
Switzerland (2005–2006)		7.80	[12]
Spain (1998)		7.30	[10]
Turkey (2007)		1.96	[10]
Sweden (2003)		1.00	[15]
Brazil (2007)	South and North America	22.00	[10]
Brazil (2007)		16.00	[20]
Costa Rica (1998)		9.00	[10]
USA (2010–2011)		20.90	[18]

Table 4
Prevalence of bovine coronavirus infection in the Russian Federation

Region of the Russian Federation	Federal district	Estimated prevalence, %	Source
Republic of Dagestan (2001–2005)	North Caucasian	62.60	[21]
Siberia (2010)	Siberian	71.30	[28]
Siberia (2022)		11.80	[29]
Irkutsk Oblast (2020)		11.10	[22]
Irkutsk Oblast (2004–2017)		2.20	[5]
Central Black Earth Region (2017–2018)	Central	26.70	[23]
14 oblasts (2007–2011)	Central, Volga, Southern and Far Eastern	45.90	[24]

but also reduce the overall level of animal resistance, which leads to 50–60% increase in the amount of virus shed into the environment, which, in turn, results in the increase in the number of cases of coronavirus infection. In addition to the time of year, the bovine infection with the coronavirus is also affected by the physiological condition of the animal, for example, during the calving period and the first two weeks after it, the number of the virions shed by the infected animal increases [2].

The virus can enter the body of calves not only by alimentary route (through contaminated surfaces or contaminated udder and perineum of cows), but also by airborne route, thus resulting in a high risk of infection [2, 26].

The analysis of publications from 1995 to 2022 showed that the prevalence of bovine coronavirus in the world was 18.4% (Table 3), in Russia – 33.1% (Table 4), which is 14.7% more than the global average.

DEPENDENCE OF THE DISEASE FORM IN YOUNG CATTLE ON *E. COLI* PATHOGENIC PROPERTIES

Among the bacterial diseases of young cattle, colibacillosis (escherichiosis) caused by various *E. coli* serovariants is the most prevalent.

E. coli bacteria have a complex antigenic structure comprising three types of antigens: somatic O-antigen (contains 164 variants); capsular K-antigen (90 variants) and flagellar H-antigen (55 variants). These antigens in various combinations make more than 9,000 serovariants, 170 of which demonstrate pathogenic properties [2, 30].

E. coli strains that cause animal diseases have various pathogenicity factors, which include polysaccharides, adhesins, enterotoxins, etc. Their functions include the following: hindering and weakening the immune response (capsular polysaccharides), destruction of body cells (enterotoxins), attachment of bacteria to the surface of susceptible cells (adhesins), etc. [2].

The escherichiosis causative agents are subdivided into two groups: diarrheagenic (DEC – diarrheagenic *E. coli*) and extraintestinal pathogenic (ExPEC – extraintestinal pathogenic *E. coli*). Five main diarrheagenic groups are relevant for cattle: enterotoxigenic (ETEC), enteropathogenic (EPEC), enterohemorrhagic (EHEC), Shiga toxin-producing (STEC) and necrotoxigenic (NTEC) *E. coli* [31].

Enterotoxigenic *E. coli* attach to the surface of enterocytes using fimbrial adhesins. The distinctive feature of the representatives of this pathogroup is presence of thermostable (stI and stII) and/or thermolabile (ltI and ltII) toxins that induce the secretion of electrolytes and water. This leads to diarrhea in infected animals and, as a result, to dehydration and death [2, 32, 33].

Despite the fact that EPEC less frequently cause GI disorders in calves than EHEC and ETEC, they require monitoring by the veterinarians due to their continuous on-farm circulation. The analysis of the frequency of occurrence of different *E. coli* pathogens in calves demonstrated that EPEC circulates almost twice as frequently in the healthy animals (14.6%) than in the diseased ones (7.5%) [4].

Enteropathogenic *E. coli* is characterized by the presence of the *eae* gene encoding the adhesive pathogenicity factor intimin and by the lack of ability to produce Shiga toxin (stx). Due to intimin, the bacterium attaches to enterocytes, after which they are rejected that further leads to diarrhea [4].

Based on the presence of the *eae* gene, Shiga toxic *E. coli* are divided into 2 groups: EHEC (STEC LEE+), which have the specified gene in their genome, and STEC (STEC LEE-), which lack it. The common features of the both groups include long-term persistence in the host, localization in the small intestine, and presence of genes encoding the ability to produce stx [2, 32].

Based on the studies on the identification of various *E. coli* pathogens in calves conducted in 18 countries, it was found that STEC LEE+ is less common than STEC LEE–: in healthy calves, the frequency of their occurrence is 10.7 and 19.4%, respectively, and in the diseased ones – 6.0 and 18.2% [4].

Necrotoxigenic *E. coli* has a specific set of genes encoding cytotoxic necrotizing factor (CNF) and cytolethal distending toxin (CDT). This pathogroup has many properties of *E. coli* that cause diseases with extra-intestinal symptoms, such as presence of different fimbrial and afimbrial adhesins and the ability to resist the complement system [4, 33].

Currently, there are two known types of cytotoxic necrotizing factors: CNF1 and CNF2. Presence of genes encoding the cytotoxic necrotizing factor 1 (CNF1) is more common in strains that cause diarrhea. The genes encoding the cytotoxic necrotizing factor 2 (CNF2) are found in *E. coli*, causing sepsis [33, 34].

It should be noted that commensal *E. coli*, when interacting with pathogenic species, can acquire new genetic determinants encoding not only cell protective mechanisms, but also pathogenicity factors. Therefore, it is a mistake to classify a strain as pathogenic only on the basis

Table 5
Prevalence of bovine colibacillosis in the countries of the world

Country	Region	Estimated prevalence, %	Source
Australia (2011)	Australia	17.40	[6]
Iran (2013)	Asia	86.70	[9]
Iran (2010)		76.45	[34]
India (2009)		75.00	[9]
Pakistan (1997)		54.00	[9]
India (1993)		23.00	[9]
Germany (1997)	Europe	42.00	[9]
Spain (2008)		35.90	[9]
Ukraine (2012–2019)		31.68	[14]
France (1999)		20.30	[9]
Sweden (1987–1988)		11.50	[16]
Sweden (1993)		11.50	[9]
Switzerland (2005–2006)		5.50	[12]
Brazil (2007)	South and North America	69.00	[20]
Mexico (2000)		63.70	[9]
USA (2010–2011)		1.80	[18]

Table 6
Prevalence of bovine colibacillosis in the Russian Federation

Region of the Russian Federation	Federal District	Estimated prevalence, %	Source
Amur Oblast (2003–2005)	Far Eastern	33.00	[36]
Amur Oblast (2016–2019)		28.50	[37]
Republic of Bashkortostan (2014–2016)	Volga	30.00	[38]
Perm Krai (2010–2020)		14.40	[38]
Irkutsk Oblast (2004-2017)	Siberian	18.50	[39]
Irkutsk Oblast (2001–2010)		10.35	[38]
Rostov Oblast (2021)	Southern	74.20	[40]
Krasnodar Krai (1996–2015)		43.55	[38]
Rostov Oblast (2017)		19.26	[41]

of a serovariant, since there are *E. coli* that are included in the same serovar, but belong to different pathogroups and, as a result, cause different pathological processes. Such a tendency to variability may even lead to the acquisition of pathogenicity factors of different pathogens by one microorganism. For example, one of the publications mentions a hybrid strain containing EHEC and NTEC genes [31, 35].

Infection of young animals with the colibacillosis causative agent occurs by the alimentary route. Infected adult animals play an important role in the *E. coli* spread, contaminating water, various indoor surfaces and bedding with bacteria, as a result of contact with which the infectious agent can get on the udder and later be transmitted to the calf [2].

In the beginning of the postnatal period, colibacillosis in calves takes more often an enteritic form and less often a septic form. The severe enteritic form is manifested by heavy diarrhea, rapid dehydration of the animal, sunken eyes, depression and exhaustion, dry and grayish skin. This disease form often ends with the death of the animal. When calves are housed in good sanitary conditions and the animal has colostral antibodies, the enteritis form may be mild [2].

Septic escherichiosis is caused by non-diarrheagenic *E. coli* (ExPEC). This form of colibacillosis develops due to untimely feeding with colostrum (primary) or in the presence of viral diseases (secondary). The septic disease clinical signs are expressed by ataxia, lameness, anorexia, hard breathing. The animal dies in 24–48 hours after their onset [2].

According to the scientific publications for the period from 1987 to 2021, the most escherichiosis-infected countries are Mexico, Brazil, India and Iran. The average global disease prevalence is 39.1% (Table 5). In Russia, the incidence rate is at the level of 30.2% (Table 6).

It should be noted that *E. coli* causes diseases not only in calves, but also in adult animals, which, depending on the pathogen properties, can develop such infections as mastitis, metritis and endometritis. Tests of milk from mastitis-diseased animals demonstrated that the level of *E. coli* was four times higher than in the milk of healthy cows, which confirms the role of *E. coli* as one of the causative agents of bovine mastitis [42].

Currently, it has not been fully clarified whether any pathogenic *E. coli* strains cause mastitis, or whether the cause of infection are *E. coli* of some individual pathogroup. There is evidence that the mastitis causative agent is an individual pathogenic *E. coli* group – MPEC (mammary pathogenic *E. coli*), which includes many extra-intestinal pathogenic *E. coli* strains: when studying the genome of *E. coli* isolated from mastitis-diseased cows, the ExPEC-typical pathogenicity factors were identified. However, there is evidence of isolation of *E. coli* of STEC group from the diseased animals, which indicates its possible involvement in the disease onset [42, 43].

Metritis and endometritis are also common *E. coli*-induced pathologies on the farms, which should not be underestimated, since under certain conditions they can lead to infertility and further culling of cows. Despite the fact that there is currently no clear opinion about the presence of a separate *E. coli* pathogroup that causes metritis and endometritis, some scientists identify six virulence genes, on the basis of which the *E. coli* strain that causes these pathologies can be presumably identified. kpsMTII gene is emphasized among them, which is probably responsible for the disease severity. Some publications note that presence of this gene carrying *E. coli* in the uterine microflora 9.2-fold reduces the probability of successful insemination [44].

MEASURES FOR PREVENTION OF VIRAL AND BACTERIAL DISEASES IN YOUNG CATTLE

All the above-mentioned data demonstrate that the issue of escherichiosis, rotavirus and coronavirus infections is quite acute for the Russian Federation and foreign countries and requires effective measures to solve it.

Vaccine prevention remains one of the most effective ways to control infectious diseases, including enteritis of viral and bacterial etiology, which is confirmed by publications of domestic and foreign authors.

For example, the study conducted in Canada in 2022 showed a two-fold decrease in the disease incidence in calves immunized with a live vaccine against coronavirus infection [45].

The results of immunization of pregnant cows with an inactivated vaccine against rotavirus and coronavirus infections on the infected farms of the Russian Federation, Belarus and Ukraine demonstrated that feeding newborn calves with colostrum and milk derived from vaccinated animals reduced the disease incidence in young animals 7 times and their mortality 6.4 times [46].

In Estonia, when studying the effect of the duration of feeding newborn calves from cows immunized with various inactivated vaccines against rotavirus, coronavirus infections and colibacillosis with colostrum and transitional milk, it was demonstrated that vaccination of pregnant animals reduced the mortality of young animals in comparison with the control groups. Feeding calves with colostrum and milk from vaccinated animals during the first 14 days after birth resulted in four-fold decrease in their mortality due to diarrhea. However, reduced period of colostrum and transitional milk feeding resulted in the decrease of the colostral immunity level in young animals [47].

In addition to preventing GI diseases, the vaccines with an optimal set of rotavirus, coronavirus and *E. coli* antigens can potentially reduce the number of pneumonia, mastitis and metritis cases in older animals on the farms.

When developing new products, it should be borne in mind that the effectiveness of specific preventive measures is influenced by such factors as the vaccine composition and the vaccination program implementation.

The first group of factors includes use of ineffective adjuvants or low-quality virus-containing source materials, as well as use of the active vaccine ingredient comprising strains with a low degree of antigenic matching with the field isolates circulating in a particular region. In this regard, monitoring of field isolates of rotavirus, coronavirus and pathogenic *E. coli* circulating in the Russian Federation and tracing changes in their genome will make it possible to timely adjust preventive measures and determine the most relevant vaccine composition when choosing from existing products or when developing new ones.

The effect of antigenic affinity of the pathogen vaccine strains and field isolates on the quality of vaccine prevention may indicate a greater effectiveness of the use of domestic products, since they are developed basing on the strains isolated in the Russian Federation.

The decrease in the effectiveness of immunization depends on the incorrect use of specific preventive measures: non-compliance with the dose, frequency and deadlines of vaccination; insufficient susceptible animal immunization coverage; non-compliance with the conditions of the vaccine storage and preparation for use; immunization of the diseased animals, etc.

CONCLUSION

Rotavirus-, coronavirus- and *E. coli*-induced infections are of great importance for animal husbandry, as they affect not only newborn calves (GI disorders, shortage of the replacement population, mortality of calves, treatment costs, etc.), but also adult cattle (mastitis, metritis, source of infection, etc.) thus resulting in significant economic losses.

The pathogens are widespread in many countries of the world. Herewith, the average incidence of rotavirus infection is 32.7%, coronavirus infection is 18.4%, and colibacilliosis is 39.1%.

The issue of the aforementioned infections does not lose its relevance for our country either. Thus, in Russia, the incidence of rotavirus and coronavirus infections exceeds the global average by 8.7 (41.4%) and 14.7% (33.1%), respectively. Of these diseases, escherichiosis is the least prevalent (30.2%), which may be due to significant seasonal temperature fluctuations in our country throughout the year and the active use of antibiotics on the Russian farms.

The wide variety and prevalence of the above-mentioned pathogens require an integrated approach to prevent infection of cattle (both young and adult animals);

an adequate diet, practicing good hygiene, housing and feeding, implementation of animal quarantine measures, etc. are essential. When speaking of measures to prevent rotavirus, coronavirus infections and colibacilliosis, it should be mentioned that vaccination is one of the most effective ways to control them. Using a vaccine with an optimal set of antigens will not only protect calves from developing GI disorders and reduce their mortality, but also potentially reduce the number of pneumonia, mastitis and metritis cases in older animals on the farms, which makes the development of effective and safe vaccines against rotavirus, coronavirus infections and escherichiosis an urgent task.

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