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Canine parvovirus enteritis: epidemic situation analysis and perspectives

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SUMMARY

Parvovirus enteritis is one of canine dangerous diseases which poses a particular concern for practitioners and dog owners around the world. Parvovirus type 2 (CPV-2) can affect dogs at any age, but puppies between 6 weeks and 6 months old are most susceptible to infection. One of the main biological properties of parvovirus is its continuous genetic evolution, which led to the replacement of the original virus type by new antigenic variants – CPV-2a, CPV-2b and CPV-2c. According to the literature data, all three variants of the virus are currently circulating in the domestic dog population worldwide. The paper presents analysis of the epidemic situation and seasonal occurrence of canine parvovirus enteritis in certain regions of the Russian Federation in 2017–2019. It was shown that parvovirus enteritis was ranked first among the registered infectious diseases of dogs and accounted for 37% during the study period. It has been established that the disease is registered all year round, but the frequency of disease cases depends on the season. Canine parvovirus infection mainly occurs in spring, late autumn and early winter, which is probably associated with changes in daily temperature during these periods and decreased animal resistance. Despite extensive vaccination, the main reason for the wide spread of the virus is either interference with maternal antibodies in vaccinated puppies or low level of immune protection in adult dogs. It has been concluded that it is necessary to monitor the parvovirus circulation and spread in order to study the genetic and antigenic properties of newly identified isolates for the timely update of vaccine strains used for development of specific means of prevention.

Key words: parvovirus (CPV), canine parvovirus enteritis, canine diseases, epidemic situation.

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Парвовирусный энтерит собак: анализ эпизоотической ситуации и перспективы

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РЕЗЮМЕ

Парвовирусный энтерит является одним из опасных заболеваний собак и вызывает определенную обеспокоенность у практикующих врачей и владельцев собак по всему миру. Парвовирус 2-го типа (CPV-2) может поражать собак в любом возрасте, но наиболее подвержены риску заражения щенки в возрасте от 6 недель до 6 месяцев. Одним из основных биологических свойств парвовируса является его непрерывная генетическая эволюция, которая привела к тому, что исходный тип вируса был заменен новыми антигенными вариантами – CPV-2a, CPV-2b и CPV-2c. Согласно литературным данным, в настоящее время все три варианта вируса циркулируют в популяции домашних собак по всему миру. В работе представлен анализ эпизоотической ситуации и сезонности заболеваемости собак парвовирусным энтеритом в 2017–2019 гг. в отдельных округах Российской Федерации. Показано, что среди регистрируемых инфекционных болезней собак парвовирусный энтерит находится на первом месте, его доля за исследуемый период составила 37%. Установлено, что заболевание фиксируется круглогодично, но частота случаев зависит от сезона. Заражение собак парвовирусом в основном происходит весной, поздней осенью и ранней зимой, что, вероятно, связано с перепадами суточной температуры в эти периоды и снижением резистентности организма животных. Несмотря на обширную вакцинацию, основной причиной широкого распространения вируса является либо вмешательство материнских антител у вакцинированных щенков, либо низкая эффективность иммунной защиты у взрослых собак. Сделан вывод о необходимости проведения мониторинга циркуляции и распространения парвовируса с целью изучения генетических и антигенных свойств вновь выявляемых изолятов для своевременного обновления вакцинных штаммов, используемых при создании средств специфической профилактики.

Ключевые слова: парвовирус (CPV), парвовирусный энтерит собак, болезни собак, эпизоотическая ситуация.

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INTRODUCTION

The causative agent of canine parvovirus enteritis is parvovirus type 2 (Canine parvovirus type 2, CPV-2), which belongs to the genus *Protoparvovirus* in the family *Parvoviridae*. It is one of the most dangerous canine intestinal pathogens. CPV-2 is closely related to feline panleukopenia virus and mink enteritis virus. There is also canine parvovirus type 1 (CPV-1, or MVC – minute virus of canines) that was first isolated from dog faeces in 1967. It significantly differs from CPV-2 in its molecular biological and antigenic properties and does not play an important role in canine infectious pathology. Canine parvovirus type 2 was identified in the late 1970s and caused serious outbreaks in dog breeding kennels and shelters worldwide. This virus, like all parvoviruses, replicates in rapidly dividing cells and is very resistant to environmental conditions: it can survive for more than six months in faeces, on contaminated surfaces of objects used for pet care, and bedding. The virus is resistant to fat solvents, such as ether and chloroform, but is inactivated by many detergents and disinfectants (sodium hypochlorite, etc.) [1].

Soon after its emergence CPV-2 underwent genetic evolution giving rise to successively two antigenic variants (CPV-2a and CPV-2b), which gradually replaced the original type. In the late 90s a new antigenic variant of the virus, CPV-2c, was detected in Europe and America. In 1996 a number of additional mutations were described, some of which led to antigenic changes in the virus. The studies of CPV-2 strains carried out in Italy revealed emergence of a virus mutant with an amino acid substitution at position Glu-426 in the VP2 capsid protein. The CPV-2c type quickly spread to other countries and is currently circulating together with CPV-2a and CPV-2b. Since its detection, CPV-2c has also been found in Asia, Europe, North and South America and Africa. Canine parvovirus binds to cells using the cell transferrin receptor (TfR); mutations in the capsid protein VP2 gene contribute to broadening the range of potential virus hosts. Thus, the original CPV-2 strains cause intestinal infection only in dogs, as compared with the CPV-2a/2b isolates, which, under experimental and natural conditions, can infect animals belonging to the Felidae family, and the CPV-2c variants, originally isolated from leopards, affect dogs and cats. The experimental infection of ferrets, minks and cats suggested minor manifestations of parvovirus enteritis clinical signs [2–4]. Despite the antigenic differences in the VP2 protein, all parvovirus serovariants give cross-reactions in hemagglutination assays and neutralization tests using polyclonal sera [1, 5]. Canine parvovirus is undergoing continuous evolution, and new genetic variants of the virus, differing in antigenic characteristics, can affect the susceptibility of young animals to infection during the period when the level of protective maternal antibodies in them lowers to minimum values. This variability in the virus genome can negatively impact the effectiveness of vaccination, although it has recently been shown that dogs immunized with a single live attenuated vaccine based on the original CPV-2 strain were protected from infection with the field virus strain type 2c [2, 3].

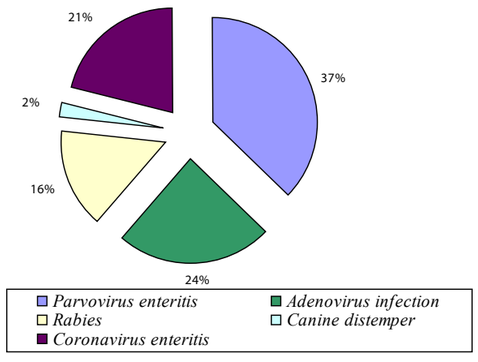

Fig. 1. Morbidity rates for canine infectious diseases in the Russian Federation in 2017–2019

Рис. 1. Заболеваемость собак инфекционными болезнями в Российской Федерации в 2017–2019 гг.

Parvovirus enteritis is a highly contagious viral disease of dogs characterized by vomiting, hemorrhagic gastroenteritis, diarrhea, myocarditis, leukopenia, dehydration, which can cause mortality in animals. The disease is generally acute, death occurs within 2–3 days after onset of clinical signs. The incubation period for natural infection lasts up to 10 days and depends on the organism's resistance and the amount of viral particles entering the gastrointestinal tract of the animal [1, 5, 6]. Parvovirus can affect dogs at any age, but the disease is most severe in puppies between 6 weeks and 6 months old. All dogs are susceptible to this disease, although mixed-breed animals are believed to be less susceptible to infection than purebreds. Dog breeds such as Rottweilers, Doberman Pinschers, English Springer Spaniels, American Pit Bull Terriers and German Shepherds are at risk of parvovirus infection [1, 7, 8].

CPV-2 infection occurs by the alimentary route through oral mucosa after contact with the faeces of infected dogs or contaminated surfaces. The virus enters the body by infecting mainly lymphoid tissues, intestinal epithelium and bone marrow [7]. In newborn puppies the virus causes severe myocarditis which becomes clinically apparent several weeks after infection. Canine parvovirus is also manifested by decreased numbers of leukocytes as a result of inflammation in the bone marrow and lymphoid tissues. After vaccination or inoculation with the field virus strains nearly all adult dogs develop intense immunity to the agent during their lifetime. Infected adult animals have abortive, asymptomatic, persistent and mild clinical forms of the disease. Mortality due to parvovirus enteritis ranges from 30–50%, but in some cases it can reach 100% [3, 4, 8, 9].

Vaccination is the main control method for this disease in domestic animal population. Inactivated and modified live virus vaccines were developed in 1979 being the first products for CPV-2 control. Vaccines provide protective immunity which allow controlling parvovirus infection in dogs. Nevertheless, the virus is still widespread in nature and circulates worldwide. Its genetic evolution and the emergence of new antigenic variants CPV-2a, CPV-2b and CPV-2c cause interest and determine research relevance for many scientists from different countries. This calls for continuous epidemiological surveillance to identify new CPV-2 variants that will help to assess the need to update the currently available canine parvovirus enteritis vaccines.

MATERIALS AND METHODS

The official data of the FGBI "Center for Veterinary Medicine" of the Ministry of Agriculture of the Russian Federation on morbidity rates of canine parvovirus enteritis in some Subjects of the Russian Federation for 2017–2019 were used in the study. The retrospective analysis of the epidemic situation was carried out, the data obtained were provided graphically and cartographically. The data on CPV-2 global distribution used in the study were taken from such bibliographic and reference databases as PubMed, Web of Science, Scopus.

RESULTS AND DISCUSSION

The canine virus disease situation in some regions of the Russian Federation is presented in Figure 1. It shows that parvovirus enteritis was most often registered in 2017–2019 (37%), the morbidity rate for adenovirus infection was 24%, for coronavirus enteritis – 21%, for rabies – 16%, for canine distemper – 2% and for infectious hepatitis – less than 1%.

Analyzing the data obtained over the past three years, it can be noted that parvovirus enteritis is annually recorded in dogs in various regions of the country (Fig. 2–4).

The program of basic comprehensive vaccination in dogs is aimed at formation of immunity to parvovirus, as well as decreased mortality level in the population and a reduction in the risk of the virus spread. However, the circulating field antigenic variants of the virus have completely replaced the original type CPV-2 [3, 4, 7, 10], which is still used in the production of most commercial vaccines,

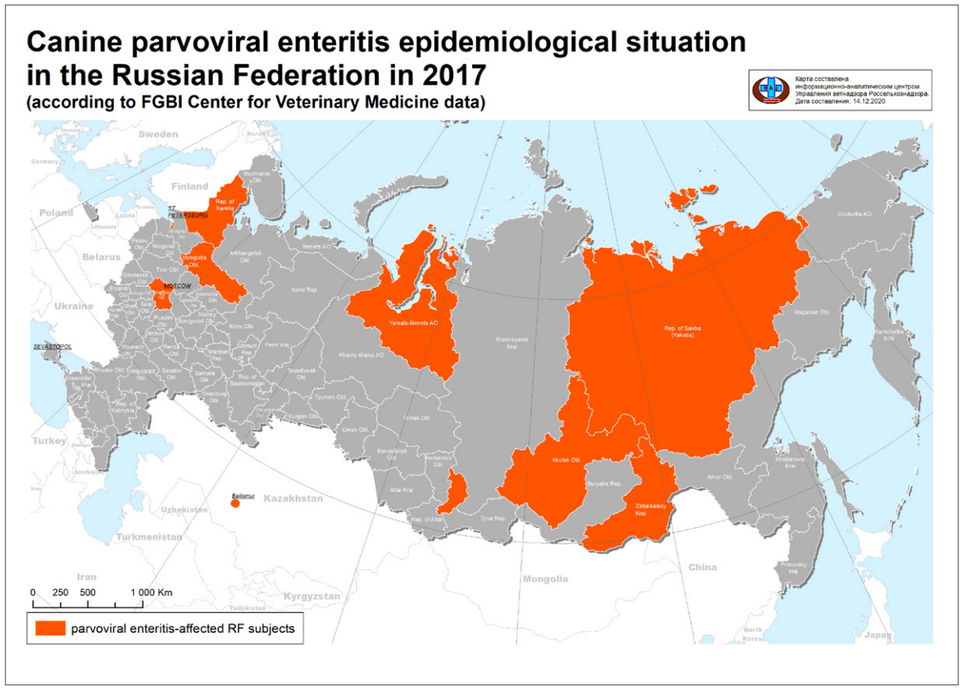

Fig. 2. Distribution of parvovirus enteritis in RF Subjects in 2017

Рис. 2. Распространенность парвовирусного энтерита в субъектах РФ в 2017 г.

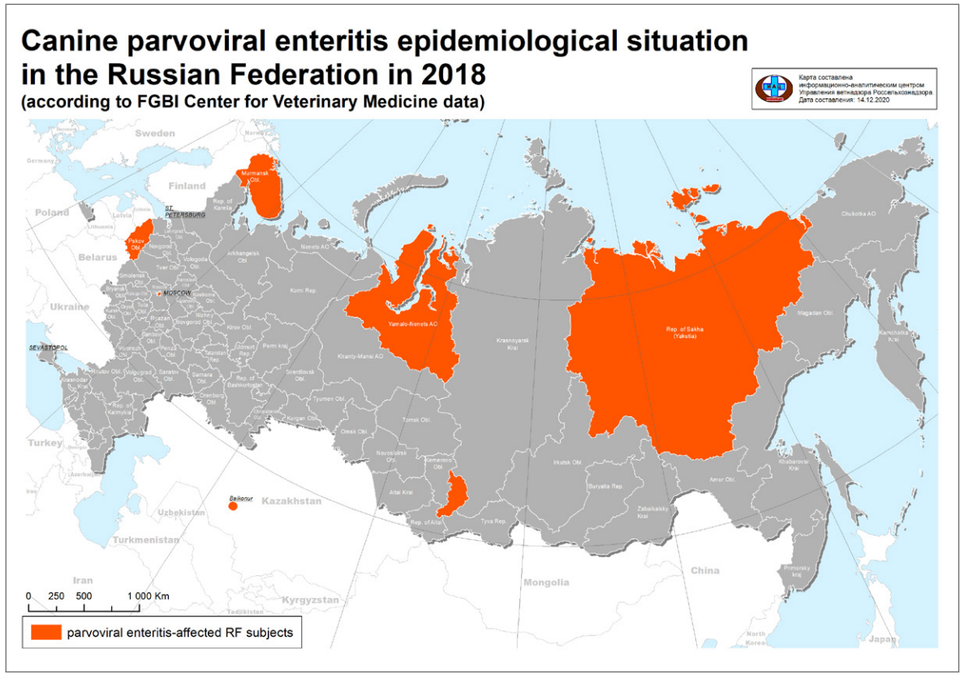

Fig. 3. Distribution of parvovirus enteritis in RF Subjects in 2018

Рис. 3. Распространенность парвовирусного энтерита в субъектах РФ в 2018 г.

Fig. 4. Distribution of parvovirus enteritis in RF Subjects in 2019

Рис. 4. Распространенность парвовирусного энтерита в субъектах РФ в 2019 г.

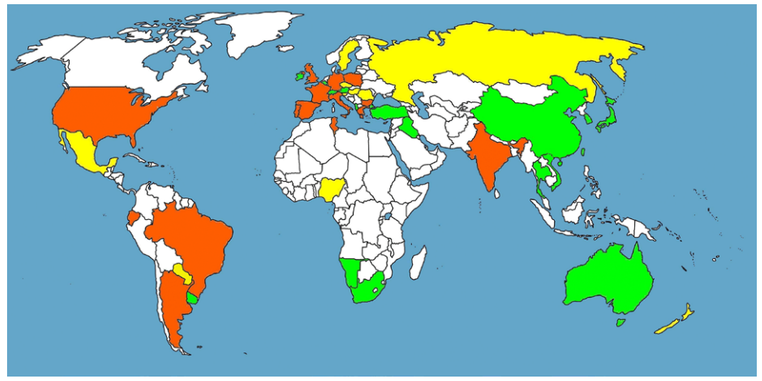

Fig. 5. Global geographic distribution of three CPV-2 variants.
Orange areas – presence of three virus variants; green areas – presence of two out of three virus variants; yellow areas – presence of one out of three virus variants [4] (https://www.microbiologyresearch.org/content/journal/jgv/10.1099/jgv.0.000540)

Рис. 5. Географическое распределение в мире трех вариантов CPV-2.
Оранжевый – наличие трех вариантов вируса; зеленый – наличие двух из трех вариантов вируса; желтый – наличие одного из трех вариантов вируса [4] (https://www.microbiologyresearch.org/content/journal/jgv/10.1099/jgv.0.000540)

therefore the issue of efficacy of the presently used vaccines remains open.

According to the literature data on the epidemic situation regarding canine parvovirus infection in the world, CPV-2 (CPV-2a, CPV-2b, CPV-2c) variants have been registered in 42 countries on five continents (Fig. 5).

At present the CPV-2a, CPV-2b and CPV-2c types are unevenly distributed in the world. The co-circulating virus variants are recorded in Continental European countries. Thus, CPV-2a and CPV-2b prevail in France and Belgium, types CPV-2a and CPV-2c – in Italy, type CPV-2a – in Eastern Europe, type CPV-2c – on the Iberian Peninsula, all these three variants of the virus are common in Germany. The circulation of CPV-2b/2c and CPV-2a/2c is recorded in North and South America. The CPV-2a and CPV-2b types prevail in Asia, Great Britain, Australia and Japan. All three types of CPV-2 co-circulate in the north of Africa, while CPV-2a and CPV-2b are more common in the south [4, 10].

Our early studies showed that parvovirus infection rates in dogs were higher in spring and autumn. Perhaps this is due to the increase in the number of stray animals during this period. Another equally important factor is the high resistance of the virus to physical and chemical treatment, as well as the possibility of its preservation in the external environment for up to several months [1, 9, 11].

Analysis of the parvovirus morbidity dynamics in dogs in the Central Federal District of the Russian Federation in 2017–2019 revealed the largest number of diseased animals in the spring and autumn periods (Fig. 6). An increase in the number of dogs with parvovirus enteritis was noted from April to June and from October to December in 2018 and 2019. Figure 6 shows that the peak of animal morbidity in 2019 was registered in late autumn and the first winter month. It has been established that over the past three years the number of reported cases of canine parvovirus enteritis in this region has increased.

Parvovirus enteritis in dogs was recorded in the Northwestern Federal District throughout year 2017. The number of diseased animals increased from March to December, the peak morbidity was recorded in the period

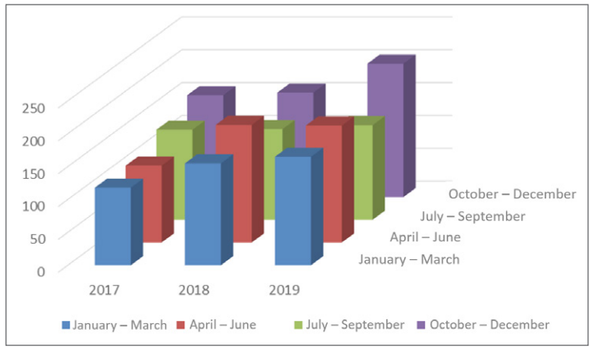

Fig. 6. Morbidity dynamics of canine parvovirus enteritis in the Central Federal District in 2017–2019

Рис. 6. Динамика заболеваемости собак парвовирусным энтеритом в Центральном федеральном округе в 2017–2019 гг.

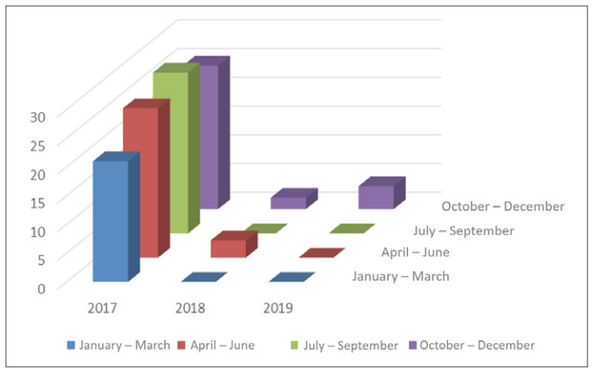

Fig. 7. Morbidity dynamics of canine parvovirus enteritis in the Northwestern Federal District in 2017–2019

Рис. 7. Динамика заболеваемости собак парвовирусным энтеритом в Северо-Западном федеральном округе в 2017–2019 гг.

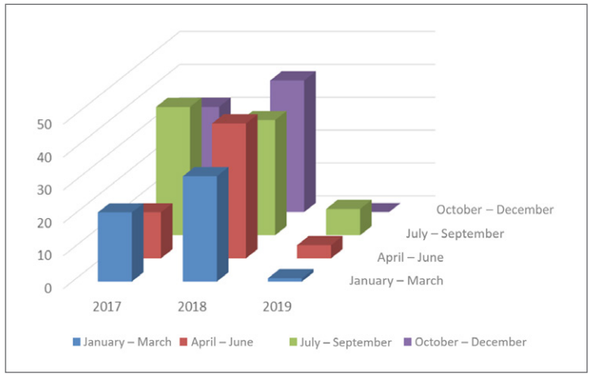

Fig. 8. Morbidity dynamics of canine parvovirus enteritis in the Urals Federal District in 2017–2019

Рис. 8. Динамика заболеваемости собак парвовирусным энтеритом в Уральском федеральном округе в 2017–2019 гг.

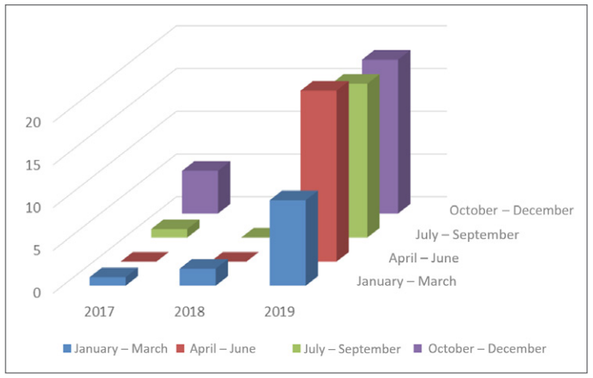

Fig. 9. Morbidity dynamics of canine parvovirus enteritis in the Siberian Federal District in 2017–2019

Рис. 9. Динамика заболеваемости собак парвовирусным энтеритом в Сибирском федеральном округе в 2017–2019 гг.

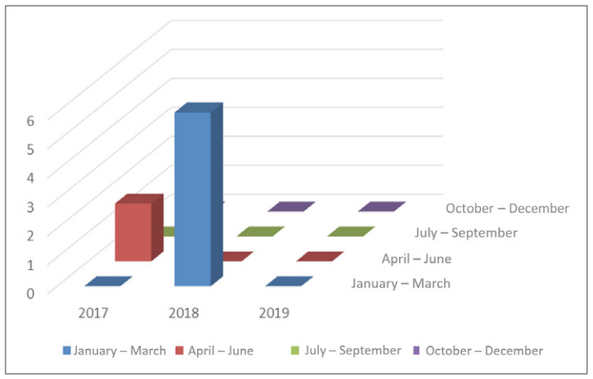

Fig. 10. Morbidity dynamics of canine parvovirus enteritis in the Far Eastern Federal District in 2017–2019

Рис. 10. Динамика заболеваемости собак парвовирусным энтеритом в Дальневосточном федеральном округе в 2017–2019 гг.

of July – September. However, in 2018–2019 there was a decrease in the number of cases of canine parvovirus infection, and single cases were recorded in spring and late autumn (Fig. 7).

Figure 8 shows that the number of dogs with parvovirus enteritis increased from July to December in the Ural Federal District in 2017. The morbidity rate in dogs was high throughout the year 2018, with a peak in spring and autumn. In 2019 single disease cases were reported from April to September.

Single cases of canine parvovirus enteritis occurred in the Siberian Federal District in 2017–2018; and in 2019 the disease was recorded throughout the year, the number of diseased animals increased from March to December (Fig. 9).

Analysis of the parvovirus morbidity dynamics in dogs in the Far Eastern Federal District in 2017 revealed the largest number of diseased animals in the period of April – June, and the peak of morbidity was recorded in January – March 2018. In 2019 canine parvovirus infection was not reported. The analysis showed that for the three years there was a decrease in the number of registered cases of canine parvovirus enteritis in the Far Eastern Federal District (Fig. 10).

The data analysis for Baikonur city over the past three years suggests increase in registered cases of canine parvovirus enteritis. The seasonality of disease cases is clearly demonstrated in Figure 11 showing that its peak was in late autumn 2017 and in summer-autumn 2018. However, an increase in the number of canine parvovirus infection cases was noted in the spring – summer period 2019.

Thus, the analysis of the epidemic situation of canine parvovirus enteritis in some Subjects of the Russian Federation in 2017–2019 shows that the disease was recorded all year round but the frequency of reported cases depended on the season. Canine parvovirus infection occurred more often in spring, late autumn and early winter. This may be associated with significant daily temperature fluctuations and climatic differences during these seasons in some federal districts of the country and, probably, with the decreased level of animals' body resistance thus increasing the risk of infection.

Despite extensive vaccination, the main reasons for the wide spread of the virus remain either interference due to maternal antibodies in vaccinated puppies (the so-called 'window of susceptibility') or low level of immune protection efficacy in adult dogs. Another reason is that the circulating CPV-2 field strains have completely replaced the original type of the virus used for production of most commercial vaccines, which may fail to provide effective cross-protection.

CONCLUSION

The analysis of the scientific study results showed that canine parvovirus type 2 is globally widespread and circulates in the Russian Federation. The estimated data on the epidemic situation with regard to canine parvovirus enteritis over the past three years in some Subjects of Russia indicate a correlation between seasonality and frequency of reported disease cases.

It should be noted that it is necessary to monitor the circulation and spread of parvovirus in order to study the genetic and antigenic properties of newly detected isolates for the timely renewal of vaccine strains used for development of specific prevention means.

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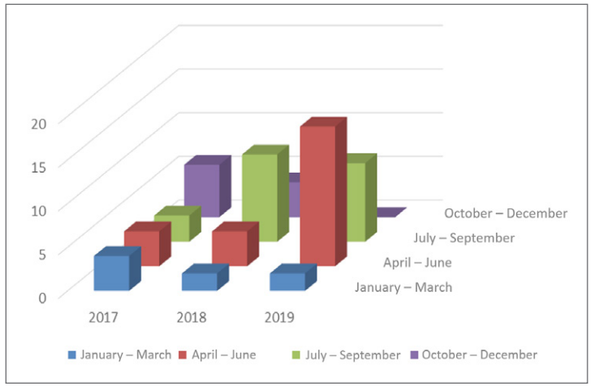

Fig. 11. Morbidity dynamics of canine parvovirus enteritis in Baikonur city in 2017–2019

Рис. 11. Динамика заболеваемости собак парвовирусным энтеритом в г. Байконуре в 2017–2019 гг.

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