



Specific prevention of plague in small ruminants in the Kyrgyz Republic

Ashirbay Zhusupov*

Applicant

Institute of Biological Safety and Biotechnology, Tajik Academy of Agricultural Sciences

734000, 61 Giprozem Str., Dushanbe, Republic of Tajikistan

<https://orcid.org/0009-0001-2211-2340>

Almazbek Irgashev

Doctor of Veterinary Sciences, Professor

Kyrgyz National Agrarian University named after K.I. Skryabin

720005, 68 Mederov Str., Bishkek, Kyrgyz Republic

<https://orcid.org/0000-0002-4789-5628>

Abstract. Peste des petits ruminants (PPR) is a particularly dangerous, infectious and transboundary disease of domestic and wild sheep and goats, causing significant economic losses in livestock farming. The spread of PPR between countries requires coordinated preventive measures and constant epizootic monitoring to prevent the introduction and emergence of disease outbreaks. The aim of the study was to evaluate the effectiveness of preventive measures against PPR after mass vaccination of susceptible animals in the Kyrgyz Republic. To analyse the level of post-vaccination immunity, an enzyme-linked immunosorbent assay (ELISA) was used to determine the antibody titre against the PPR virus. Between 2018 and 2023, 19.35 million sheep and goats were vaccinated with a lyophilised live attenuated vaccine of the Nig.75/1 strain. The results showed that in the northern regions of the republic in 2018, immunity was detected in 42% of vaccinated animals, indicating an insufficient level of protection. However, in subsequent years (2019-2023), the proportion of immune animals increased to an average of 79%. In the southern regions, the average rate of immune animals over six years was 83%, indicating the formation of high antibody levels and a reduced risk of infection. The results confirmed the high effectiveness of vaccination against PPR and its role in preventing the spread of infection. The study data can be used by veterinary services when planning preventive measures, especially in regions bordering China, Kazakhstan and Tajikistan

Keywords: vaccination; Nig.75/1 strain vaccine; ELISA method; protective antibody titre

Introduction

Peste des petits ruminants (PPR) is a quarantine-listed, particularly dangerous disease that poses a biological threat to domestic and wild small ruminants. Clinically and morphologically, it is accompanied by fever, ulcerative lesions of the mucous membranes of the oral and nasal cavities, conjunctivitis, haemorrhagic gastroenteritis, diarrhoea and the development of pneumonia. The causative agent of PPR is *Morbillivirus* from the *Paramyxoviridae* family. The Global Strategy for the Control and Eradication of PPR states that small

ruminant plague causes economic losses of between \$1.2 and \$1.7 billion annually as a result of animal deaths, reduced production and disease control costs (Njeumi *et al.*, 2015). Approximately one-third of the financial damage occurs in Africa and one-quarter in South Asia. In addition to PPR, other infectious diseases of small ruminants also cause significant economic damage to livestock farming in the Central Asian region. The study by A. Mussayeva *et al.* (2025) in Kazakhstan showed the circulation of *Pasteurella multocida* among

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*Corresponding author



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wild and farm animals, with saigas acting as a reservoir of infection, requiring a comprehensive approach to epizootic surveillance. This significant damage can be remedied, and it is expected that the control and eradication of PPR will lead to increased income from small ruminant breeding systems and improved profitability and productivity (Aboah *et al.*, 2024).

Peste des petits ruminants is a highly contagious and fatal disease affecting small ruminants, particularly sheep and goats. This disease causes high morbidity and mortality in small ruminants, resulting in enormous economic losses for the livestock industry worldwide (Akwongo *et al.*, 2022). The serious consequences of this disease have prompted the Food and Agriculture Organization of the United Nations and the World Organisation for Animal Health to develop a global strategy to combat peste des petits ruminants and eradicate it by 2030 (OIE & FAO, 2021). Over the past decades, small ruminant peste des petits ruminants has been controlled mainly by vaccinating animals with live attenuated vaccines, such as those used against peste des grands ruminants. Rinderpest, a closely related disease to peste des petits ruminants, was eradicated in 2011, and vaccines against it were subsequently banned in order to maintain rinderpest-free zones. In this regard, according to X. Jia *et al.* (2020), it is necessary to develop homologous vaccines against small ruminant plague to combat this disease.

M. Amirbekov *et al.* (2021) conducted serological monitoring of small ruminant plague in sheep farms in the Republic of Tajikistan. The results of the analysis showed the widespread distribution of the SRP virus among sheep and goats in the country's sheep farms. A study of blood serum from sheep and goats from eight districts of the republic found that 69% of animals were infected with the PPR virus. Since 2019, Burkina Faso has been implementing a national strategy to eradicate peste des petits ruminants. According to G. Ilboudo *et al.* (2022), after two years of mass vaccination of small ruminants, in which significant resources were invested, very little is known about the cost of vaccination and how it is distributed across the various links in the vaccine distribution chain. The researchers' findings showed that the cost of vaccinating a small ruminant is \$0.3 and \$0.18 if the vaccination is carried out by public and private vaccinators, respectively. The largest share of costs is accounted for by field work and personnel. These results will enable more effective allocation of resources to improve the efficiency and effectiveness of vaccination of small ruminants against LPAI.

As noted by Zh. Amanova *et al.* (2023), a live vaccine against PPR has been developed in Kazakhstan from the attenuated strain Nig.75/1, which belongs to line II. During experiments with small ruminants aged 6-8 months, it was found that a single immunisation of animals with a live attenuated vaccine against PPR at a dose of $1.0 \times 10^{3.0}$ lg TCID₅₀/head causes the

formation of high titres of virus-neutralising antibodies in the blood of sheep and goats. The results obtained give reason to believe that the developed vaccine has high immunogenicity and may be a good alternative to commercial vaccines used against PPR in Kazakhstan. A study of kids by M. Abdollahi *et al.* (2023) showed that some of them became seronegative before reaching the age at which they were given the first dose of the PPR vaccine. The age of 70-100 days may be suitable for administering the first dose of the PPR vaccine to kids, but further studies are needed on the efficacy of this vaccine at this age. Y. Walle *et al.* (2024) investigated the impact of imperfect PPR vaccines and replenished small ruminant populations on the dynamics of transmission of this infection using mathematical modelling. Analytical and numerical results showed that infected newly introduced small ruminants significantly contribute to the spread of PPR among small ruminants. Even with high vaccination efficiency, the system demonstrates a unique asymptotically stable endemic equilibrium. These results emphasise that proper vaccination alone is not sufficient to control and eradicate PPR in the region.

The aim of this scientific work was to analyse and evaluate the effectiveness of preventive vaccination against PPR in the Kyrgyz Republic. Research objectives: to analyse the results of preventive vaccinations of small ruminants in the regions of the Kyrgyz Republic; to assess the intensity of post-vaccination immunity after vaccination with the lyophilised live attenuated PPR virus strain Nig.75/1.

Materials and Methods

The study was conducted in various regions of the Kyrgyz Republic from 2018 to 2023 and was aimed at vaccinating sheep and goats susceptible to small ruminant plague. A total of 19.35 million sheep and goats were vaccinated during the study period. The vaccine, obtained from a certified international supplier that meets the standards of the World Organisation for Animal Health (OIE), was administered subcutaneously at a dose of 1 ml per animal. The lyophilised vaccine was diluted using 50 ml of sterile diluent for 50-dose vials or 100 ml for 100-dose vials. Animals aged 2-3 months were vaccinated in the hairless area of the elbow joint, with revaccination after 4 months to establish a stable immune background. In high-risk areas, especially in border areas with China, Kazakhstan and Tajikistan, annual revaccination was carried out. Sick or weakened animals were excluded from vaccination, and personal hygiene rules were strictly observed during the procedure. All procedures involving animals complied with the international recommendations on animal welfare Directive 2010/63/EU (2010). Vaccination and sampling were carried out by qualified veterinary personnel with the aim of minimising stress to the animals.

To assess post-vaccination immunity, blood serum samples were collected from vaccinated animals.

A stratified random sampling method was used, in which 500 sheep and goats were selected annually from each region (northern and southern), ensuring representativeness across age groups and geographical areas. Blood samples were collected 21-28 days after vaccination to allow sufficient time for antibody production. Blood was collected from the jugular vein under sterile conditions, sera were separated by centrifugation at 3,000 rpm for 10 minutes and stored at -20°C until analysis. The level of protective antibodies against the PPR virus was determined using a sandwich enzyme-linked immunosorbent assay (ELISA) in accordance with the approved operating procedure. The analysis was carried out in the Department of Virology and Biotechnology of the A. Duishev Research Institute of Veterinary Medicine. The ELISA protocol included the following steps: (1) application of antibody solution to sensitise the wells of the plate and incubation at 4°C for 16-18 hours; (2) introduction of test samples (blood sera), positive and negative controls into washed sensitised wells, followed by incubation at 37°C for 1 hour; (3) addition of detector antibodies and incubation at 37°C for 1 hour; (4) adding the conjugate and incubating at 37°C for 1 hour; (5) performing a colour reaction with the application of the substrate and incubating at room temperature for 15-20 minutes; (6) reading the results on a BIOTEK ELx800 spectrophotometer (USA) at a wavelength of 405 nm.

The protective antibody titre was defined as the level sufficient to ensure immunity against PPR, based on the threshold values established in accordance with OIE recommendations (optical density ≥ 0.2). The percentage of immune animals was calculated as the proportion of samples with antibody titres above the protective threshold. The data were analysed separately for the northern and southern regions to assess regional differences in immune response. Statistical analysis was performed using R software (version 4.2.1), and differences in immunity levels between years and regions were assessed using the chi-square test at a significance level of $p < 0.05$.

Results and Discussion

The purpose of serological monitoring is to assess the level of actual protection against PPR in sheep and goats, as well as the quality of vaccination work in a specific territory. According to the requirements of the Global Strategy for the Control and Eradication of PPR, at least 90% of the small ruminant population must be vaccinated against PPR in order to create herd immunity and prevent the spread of the virus (Njeumi *et al.*, 2015). This goal is achieved through mass vaccination of susceptible animals using live attenuated vaccines. Table 1 shows the number of animals vaccinated over a six-year period by region in the threatened areas of the Kyrgyz Republic.

Table 1. Number of animals vaccinated with Nig.75/1 vaccine by region of the Kyrgyz Republic for 2018-2023

Regions	2018			2019			2020		
	Plan	Vaccination	%	Plan	Vaccination	%	Plan	Vaccination	%
Batken	205.0	214.9	105	210.0	219.3	104	210.0	211.0	100
Osh	680.0	688.5	101	680.0	692.6	102	680.0	693.9	102
Jalal-Abad	614.6	640.2	104	592.1	625.7	106	593.9	566.1	95
Talas	225.0	233.9	104	255.0	294.3	115	275.0	277.2	101
Chüy	311.0	335.6	108	325.3	347.5	107	317.3	324.8	102
Issyk-Kul	516.5	526.6	102	524.6	542.4	103	519.1	526.3	101
Naryn	615.0	580.3	94	600.0	610.2	102	620.0	687.4	111
Osh	6.5	6.4	99	6.5	6.6	101	6.5	6.5	100
Bishkek	1.5	1.1	72	1.5	1.9	126	1.5	1.8	120
Kyrgyz Republic	3,175.1	3,227.6	102	3,195.0	3,340.5	105	3,223.3	3,294.9	102
Regions	2021			2022			2023		
	Plan	Vaccination	%	Plan	Vaccination	%	Plan	Vaccination	%
Batken	218.0	219.5	101	203.0	212.6	105	203.0	203.4	100
Osh	655.0	648.6	99	650.0	680.2	105	575.0	589.6	103
Jalal-Abad	627.7	619.4	99	733.7	741.5	101	734.7	738.7	101
Talas	247.5	247.7	100	247.5	256.9	104	247.5	243.9	99
Chüy	317.3	317.4	100	304.1	308.7	102	310.3	312.1	101
Issyk-Kul	433.5	345.4	80	413.5	443.6	107	413.5	428.0	104
Naryn	600.0	615.0	103	630.0	646.7	103	640.0	643.2	101

Table 1. Continued

Regions	2021			2022			2023		
	Plan	Vaccination	%	Plan	Vaccination	%	Plan	Vaccination	%
Osh	6.5	6.6	102	6.5	6.5	101	6.5	6.7	102
Bishkek	1.5	1.6	107	1.5	1.6	106	1.5	1.5	99
Kyrgyz Republic	3,107.0	3,021.2	97	3,189.8	3,298.3	103	3,132.0	3,167.1	101

Source: compiled by the authors based on data from the Veterinary, Livestock, Pasture and Forage Development Service of the Kyrgyz Republic (n.d.)

The data in Table 1 show that in 2018, more animals were vaccinated than planned (102%), with the exception of the city of Bishkek (72%). In 2019, more animals were vaccinated (105%) than planned. In 2020, more animals were vaccinated than planned (102%), with the exception of the Jalal-Abad region (80%). In 2021, the average vaccination rate was 97%, and in the Issyk-Kul region it was 80%. From 2022 to 2023, more animals were vaccinated than planned (103% and 101%, respectively). In general, the Kyrgyz Republic

complies with the requirements of the Global Strategy for the Control and Eradication of PPR (Njeumi *et al.*, 2015), and the figures show that preventive measures have been successfully implemented within the specified time frame throughout the republic. Tables 2 and 3 show the protective antibody titre or antibody level that provides minimum protection against PPR as a result of vaccination with the PPR vaccine from the Nig.75/1 strain in sheep and goats in the northern and southern regions over a period of 6 years.

Table 2. Intensity of post-vaccination immunity in sheep and goats in the northern region of the Kyrgyz Republic from 2018 to 2023

Years	Number of samples	Immune	%	Non-immune	%
2018	3,178	1,341	42	1,837	58
2019	2,746	2,224	82	522	18
2020	2,715	2,208	81	507	19
2021	2,238	1,682	75	556	25
2022	1,878	1,438	76	440	24
2023	1,613	1,276	79	337	21

Source: compiled by the authors based on Centre for Veterinary Diagnostics and Expertise (n.d.)

Table 3. Intensity of post-vaccination immunity in sheep and goats in the northern region of the Kyrgyz Republic from 2018 to 2023

Years	Number of samples	Immune	%	Non-immune	%
2018	1,245	1,114	89	131	11
2019	1,961	1,782	91	179	9
2020	728	669	93	59	7
2021	1,612	1,402	87	210	13
2022	1,352	832	62	520	38
2023	993	758	76	235	24

Source: compiled by the authors based on Centre for Veterinary Diagnostics and Expertise (n.d.)

Analysis of Table 2 shows that in the northern region, after vaccination of sheep and goats in 2018, 42% of vaccinated animals (1,341 head) were immune to bluetongue disease, indicating a low level of actual protection of sheep and goats against bluetongue disease. In the remaining years of vaccination from 2019 to 2023, the percentage of immune animals averaged 79%, indicating a sufficient level of antibody production to provide minimal protection against PPR. Analysis of Table 3 shows that after vaccination of sheep and goats in the southern region with the Nig.75/1 strain over 6 years, the percentage of immune animals averaged 83%, indicating a high level of antibody

production, providing minimum protection for sheep and goats against PPR.

Vaccination against small ruminant plague is actively carried out in countries bordering the Kyrgyz Republic, using various vaccines depending on agreements with manufacturers. According to A. Abdulloev (2022), PPR was first detected in Tajikistan in 2004 when animals were imported from Afghanistan, but in subsequent years it was possible to improve diagnostic methods and develop measures to reduce the losses caused by this disease. In China, until 2013, mandatory vaccination of sheep and goats with live attenuated vaccines was carried out only in Tibet and Xinjiang.

The lack of immunisation in other regions was one of the reasons for the rapid spread of PPR throughout the country in 2014. Currently, the live attenuated vaccine Clone 9 (with 99.8% genomic similarity to Nig.75/1) is used, as well as commercial monovalent and bivalent vaccines against PPR and goat pox (Liu *et al.*, 2018). In northern Pakistan, studies have shown a true prevalence of PPR of 41.0%, with a maximum in Gilgit (57.0%) and a minimum in Swat (26.0%) (Munibullah *et al.*, 2024). It has been confirmed that keeping small and large livestock together increases the risk of virus transmission.

In Kazakhstan, due to the unfavourable epizootic situation in the southern regions, routine vaccination of small ruminants is carried out, with approximately 9 million animals immunised in 2016. Studies by Zh. Amanova *et al.* (2021) showed that a combined vaccine containing the Nig.75/1 (against PPR) and NISKhl (against sheep pox) strains provides a protective immune response in Kazakh fine-wool sheep aged 6-12 months for 12 months. The vaccine's efficacy was assessed using a blood serum neutralisation test and the c-ELISA method to determine antibodies to PPR, as well as testing the resistance of vaccinated animals to infection with the Kentau-7 PPR field strain and the virulent strain A of sheep pox. A single immunisation provided 100% clinical protection against both infections, while unvaccinated animals showed clinical signs of PPR and smallpox.

Large-scale vaccination against PPR in the Kyrgyz Republic has proven effective in preventing the spread of infection. Neighbouring countries such as China, Tajikistan and Kazakhstan remain affected by PPR, which creates a risk of the infection spreading to other countries (Zakutskiy *et al.*, 2012; Koshemetov *et al.*, 2016). Thanks to systematic vaccination, sheep and goats in the Kyrgyz Republic have specific antibodies that protect them from infection. In the event of an introduction of PPR, the spread of infection is limited by the established immune background. According to the 2nd Regional roadmap meeting... (2017), a harmonised approach is needed to eliminate PPR by 2030, including the development of national strategic plans, strengthened surveillance, vaccination and coordination between countries in the region. Based on the results of this study, the following recommendations are proposed for the prevention and control of PPR in the Kyrgyz Republic:

1. The State Veterinary Service, through its regional and district structures, should control the movement of small ruminants within the country.

2. To prevent the introduction of the PPR virus from affected countries, a 30-day quarantine should be organised for incoming animals, with mandatory serological testing for antibodies to the PPR virus.

3. Annual routine immunisation of all small ruminants in border areas to a depth of at least 30 km should be carried out to create an immune belt.

4. Perform preventive or compulsory vaccinations against PPR, taking into account local conditions and

the epizootic situation. In transhumant sheep farming, preventive vaccination is carried out 15-20 days before mating, and young animals of the current year are vaccinated at the age of 6-8 months during the formation of flocks.

5. When the disease appears in individual farms or grazing areas, carry out compulsory vaccination of the entire livestock in the threatened area, followed by observation for 10 days.

In conclusion, specific preventive measures against PPR contribute to the elimination of infection foci, the formation of stable immunity and the preservation of sheep and goat populations, which makes a significant contribution to ensuring food security and the well-being of the population of the Kyrgyz Republic.

Conclusions

During the period 2018-2023, 19.35 million head of small ruminants were vaccinated in the Kyrgyz Republic using a lyophilised live attenuated vaccine of the Nig.75/1 strain, which significantly reduced the risk of the occurrence and spread of peste des petits ruminants. Serological monitoring using enzyme-linked immunosorbent assay confirmed the high effectiveness of specific prophylaxis, which ensured the formation of lasting immunity in sheep and goats. In the northern regions of the republic, the level of immune animals increased from 42% in 2018 to an average of 79% in 2019-2023, while in the southern regions, the average level of immunity was 83% over the same period. These data indicate that the protective antibody titre has been maintained at an epizootically significant level, ensuring the stable epizootic welfare of the Kyrgyz Republic with regard to PPR. Particular attention should be paid to the border areas with China, Tajikistan and Kazakhstan, where there is a high risk of infection being introduced. Enhanced preventive measures are needed, including regular epizootic surveillance and annual vaccination in a zone of at least 30 km from the border to create an immune belt. A systematic approach to vaccination remains a key factor in ensuring epizootic health and the sustainable development of sheep and goat farming in the country.

The results of the study provide important data for achieving national goals for the eradication of PPR and are of international significance for the implementation of the Global Strategy for the Elimination of the Disease by 2030, contributing to the health of susceptible livestock populations. Prospects for further research include the development and testing of combination vaccines against PPR and other significant diseases of small ruminants, such as smallpox and pasteurellosis, to improve the cost-effectiveness of immunisation programmes. There are also plans to introduce modern molecular diagnostic methods, such as real-time PCR (polymerase chain reaction), to improve monitoring of the epizootic situation in border

areas and assess the duration of the immune response in vaccinated animals.

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Conflict of Interest

None.

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Кыргыз Республикасында майда кепшөөчү жаныбарлардын чумасына каршы спецификалык профилактика

Аширбай Жусупов

Издөнүүчү

Биологиялык коопсуздук жана биотехнология проблемалары институту

Тажик айыл чарба илимдер академиясы

734000, Гипрозем көч., 61, Дүйшөмбү ш., Тажикстан Республикасы

<https://orcid.org/0009-0001-2211-2340>

Алмазбек Иргашев

Ветеринария илимдеринин доктору, профессор

К.И. Скрябин атындагы Кыргыз улуттук агрардык университети

720005, Медеров көч., 68, Бишкек ш., Кыргыз Республикасы

<https://orcid.org/0000-0002-4789-5628>

Аннотация. Майда кепшөөчү жаныбарлардын чумасы (МКЖЧ) – мал чарбачылыгында олуттуу экономикалык жоготууларды алып келүүчү, үй жана жапайы майда кепшөөчү жаныбарлардын өтө жугуштуу, трансчек ара ылаңы. Өлкөлөр арасында МКЖЧнын жайылышы координацияланган алдын алуу иш-чараларын жана ылаңдын келип чыгышын жана очокторун алдын алуу үчүн үзгүлтүксүз эпизоотиялык мониторингди талап кылат. Изилдөөнүн максаты Кыргыз Республикасынын аймагында сезгич жаныбарларды массалык эмдөөдөн кийин МКЖЧга каршы профилактикалык иш-чаралардын натыйжалуулугун баалоо болгон. Эмдөөдөн кийинки иммунитеттин деңгээлин анализдөө үчүн МКЖЧнын вирусуна каршы антителолордун титрин аныктоо үчүн ферменттик иммуносорбенттик анализ (ИФА) ыкмасы колдонулган. 2018-2023-жылдар аралыгында Nig.75/1 штаммынын лиофилизацияланган тирүү аттенуацияланган вакцинасын колдонуу менен 19,35 миллион баш кой-эчки эмделген. Жыйынтыктар көрсөткөндөй, 2018-жылы республиканын түндүк аймактарында эмделген малдын 42 %ында иммунитет аныкталган, бул коргоонун жетишсиз деңгээлин көрсөтүп турат. Бирок, кийинки жылдары (2019-2023-жылдары) иммундук жаныбарлардын үлүшү орточо 79 %га чейин өскөн. Түштүк аймактарда алты жыл ичинде иммундук жаныбарлардын орточо көрсөткүчү 83 %ды түздү, бул антителолордун жогорку деңгээлинин өнүгүшүн жана инфекциянын жугуу коркунучунун азайгандыгын көрсөтөт. Алынган натыйжалар МКЖЧга каршы эмдөөнүн жогорку натыйжалуулугун жана инфекциянын жайылышын алдын алуудагы ролун тастыктады. Изилдөөнүн маалыматтарын ветеринардык кызматтар профилактикалык иш-чараларды пландаштырууда, өзгөчө Кытай, Казакстан жана Тажикстан менен чектеш аймактарда колдонсо болот.

Негизги сөздөр: эмдөө; Nig.75/1 штамм вакцинасы; ИФА методу; коргоочу антитело титри

Специфическая профилактика чумы мелких жвачных животных в Кыргызской Республике

Аширбай Жусупов

Соискатель

Институт проблем биологической безопасности и биотехнологии, Таджикская академия сельскохозяйственных наук

734000, ул. Гипрозем, 61, г. Душанбе, Республика Таджикистан

<https://orcid.org/0009-0001-2211-2340>

Алмазбек Иргашев

Доктор ветеринарных наук, профессор

Кыргызский национальный аграрный университет им. К.И. Скрябина

720005, ул. Медерова, 68, г. Бишкек, Кыргызская Республика

<https://orcid.org/0000-0002-4789-5628>

Аннотация. Чума мелких жвачных животных (ЧМЖЖ) представляет собой особо опасное, инфекционное и трансграничное заболевание домашних и диких овец и коз, вызывающее значительные экономические потери в животноводстве. Распространение ЧМЖЖ между странами требует согласованных профилактических мер и постоянного эпизоотического мониторинга для предотвращения заноса и возникновения очагов болезни. Целью исследования являлась оценка эффективности профилактических мероприятий против ЧМЖЖ после проведения массовой вакцинации восприимчивых животных на территории Кыргызской Республики. Для анализа уровня поствакцинального иммунитета использовался метод иммуноферментного анализа (ИФА), определяющий титр антител против вируса ЧМЖЖ. В период с 2018 по 2023 годы вакцинации подверглись 19,35 млн голов овец и коз с применением лиофилизированной живой аттенуированной вакцины штамма Nig.75/1. Результаты показали, что в северных районах республики в 2018 году иммунитет был выявлен у 42 % вакцинированных животных, что указывало на недостаточный уровень защиты. Однако в последующие годы (2019-2023) доля иммунных животных увеличилась в среднем до 79 %. В южных районах средний показатель иммунных животных за шесть лет составил 83 %, что свидетельствует о формировании высокого уровня антител и снижении риска заражения. Полученные результаты подтвердили высокую эффективность вакцинации против ЧМЖЖ и ее роль в предотвращении распространения инфекции. Данные исследования могут быть использованы ветеринарной службой при планировании профилактических мероприятий, особенно в регионах, граничащих с КНР, Казахстаном и Таджикистаном

Ключевые слова: вакцинация; вакцина из штамма Nig.75/1; метод ИФА; защитный титр антител