IRSTI 68.41.53;68.41.41 https://doi.org/10.26577/eb.2023.v96.i3.07

**N. Abdolla[1,2]*, A.S. Mashzhan[1], S. Kuatbekova[1], S.A. Kan[1,2], A.V. Lushova[1,2], S.M. Mamadaliyev[1]**

[1]Almaty Branch of the National Center for Biotechnology, Kazakhstan, Almaty
[2]M.A. Aitkhozhin Institute of Molecular Biology and Biochemistry, Kazakhstan, Almaty
*e-mail: nurshata@gmail.com

# RISK ASSESSMENT OF SHEEP AND GOAT POX SPREAD IN KAZAKHSTAN

Sheep and goat pox (SGP) disease is a highly contagious and dangerous viral infection, characterized by fever, formation of papular-pustular lesions in the epithelium of the skin and respiratory tract of small ruminants. This disease causes enormous damage to sheep breeding due to the death of animals, forced slaughter, loss of productivity, costs for veterinary and sanitary and quarantine measures. The causative agents are two closely related viruses: sheep pox virus and goat pox virus, belonging to the family Poxviridae, the genus Capripoxvirus. SGP is considered an endemic in Kazakhstan and SGP outbreaks have been registered in a number of regions both in our country and bordering states. The uncontrolled spread of this infection can be associated with colossal economic losses and significant damage of the image of our country as an exporter of lamb. Thus, it is important to monitore the epizootological situation of SGP in the country, control outbreaks of infection, and develop veterinary and sanitary measurements to adequately anticipate of the disease spread. Therefore, the purpose of this study is to perform risk analyses of SGP transmission in Kazakhstan. As a result of the research, the SGP risk factors, epizootological characteristics of this infection in Kazakhstan in the last 10 years, and the districts with high risks regarding the possible occurrence of large outbreaks of SGP were identified and the epizootic visualization map was created. This work provides valuable information on the importance of SGP control and prevention programs in Kazakhstan.

**Key words**: epizootology, sheep pox, goat pox, virus, risk analysis.

Н. Абдолла[1,2]*, А.С. Машжан[1], С. Куатбекова[1],
С.А. Кан[1,2], А.В. Лушова[1,2], С.М. Мамадалиев[1]

[1]«Ұлттық биотехнология орталығы» Алматы қаласындағы филиалы, Қазақстан, Алматы қ.
[2]М.А. Айтхожин атындағы молекулалық биология және биохимия институты, Қазақстан, Алматы қ.
*e-mail: nurshata@gmail.com

## Қазақстанда қой мен ешкі шешек ауруының таралу қаупін талдау

Қой мен ешкі шешегі (ҚЕШ) – өте жұқпалы, қауіпті вирустық инфекциялық ауру, ол ұсақ күйіс қайыратындардың жауарлардың дене қызуының көтерілуімен, тері және өкпе эпителийінде папулезді-пустулярлы ошақтардың пайда болуымен сипатталады. Бұл ауру малдың қырылуы, амалсыз сою, төлдеуінің төмендеуі, ветеринариялық-санитариялық және қауіпсіздік пен карантиндік шараларға жұмсалатын шығындар салдарынан қой шаруашылығына орасан зор зиян келтіреді. Қоздырғыштары – Capripoxvirus туысы Poxviridae тұқымдасына жататын бір-бірімен тығыз байланысты екі вирус қой шешек вирусы және ешкі шешек вирусы болып табылады, ҚЕШ Қазақстанда эндемиялық болып саналады және ҚЕШ ошақтары біздің елдің де, шекаралас мемлекеттердің де бірқатар аймақтарында тіркелген. Бұл инфекцияның бақылаусыз таралуы, біздің еліміздің экономикалық әл-ауқатына орасан зор шығындар әкелуімен қатар, елдің қой етін экспорттаушы ретіндегі халқаралық имиджісінің айтарлықтай бұзылуына әсер етеді. Осылайша, елдегі ҚЕШ эпизоотологиялық жағдайын бақылау, инфекция пайда болуы мүмкін ошақтарын қадағылау, аурудың таралу қаупін болжау үшін ветеринариялық-санитариялық өлшемдерді әзірлеу маңызды. Сондықтан, бұл зерттеудің мақсаты – Қазақстандағы ҚЕШ таралу қаупіне талдау жасау. Жүргізілген зерттеулер нәтижесінде ҚЕШ таралуының қауіп факторлары, Қазақстандағы соңғы 10 жылдағы осы инфекцияның эпизоотологиялық сипаттамасы және ҚЕШ ірі ошақтарының пайда болу қаупі жоғары аймақтар анықталды, сонымен бірге эпизоотиялық визуализация картасы жасалды. Бұл аналитикалық зерттеу жұмысы Қазақстандағы ҚЕШ бақылау және алдын алу бағдарламаларының маңыздылығы туралы құнды ақпарат береді.

**Түйін сөздер:** эпизоотология, қой шешегі, ешкі шешегі, вирус, қауіп талдауы.

Н. Абдолла[1,2]*, А.С. Машжан[1], С. Куатбекова[1],
С.А. Кан[1,2], А.В. Лушова[1,2], С.М. Мамадалиев[1]
[1]Филиал «Национальный центр биотехнологии», Казахстан, г. Алматы
[2]Институт молекулярной биологии и биохимии им. М.А. Айтхожина, Казахстан, г. Алматы
*e-mail: nurshata@gmail.com

**Анализ рисков распространения оспы овец и коз в Казахстане**

Оспа овец и коз (ООК) – высококонтагиозное, особо опасное вирусное заболевание, характеризующееся лихорадкой, образованием папулезно-пустулезных высыпаний на эпителии кожи и дыхательных путей мелких жвачных животных. Это заболевание наносит колоссальный ущерб овцеводству из-за падежа животных, вынужденного убоя, потери продуктивности, затрат на ветеринарно-санитарные и охранно-карантинные мероприятия. Возбудителями являются два близкородственных вируса: вирус оспы овец и вирус оспы коз, принадлежащие к семейству Poxviridae, роду Capripoxvirus. Вспышки ООК были ранее зарегистрированы в ряде регионов Казахстана, что привело к значительным экономическим потерям. В связи с тем, что эта инфекция является эндемичной в Казахстане, важно следить за эпизоотологической ситуацией в стране, контролировать вспышки инфекции и разрабатывать ветеринарно-санитарные мероприятия, позволяющие адекватно прогнозировать распространение болезни. В связи с этим, целью данного исследования является проведение анализа рисков распространения ООК в Казахстане. В результате исследования нами были выявлены факторы риска ООК, эпизоотологическая характеристика ООК в Казахстане за последние 10 лет, определены районы с высоким риском возникновения крупных вспышек ООК и разработана эпизоотическая карта. Эта работа предоставляет информацию, подчеркивающую важность проведения программ контроля и предотвращения распространения ООК в Казахстане.

**Ключевые слова**: эпизоотология, оспа овец, оспа коз, вирус, анализ риска.

## Introduction

Sheep and goat pox (SGP) is one of the most economically significant diseases of small ruminants (SRs). SGP is a highly contagious viral disease, characterized by fever, the formation of papular-pustular lesions in the epithelium of the skin and mucous membranes, and lung damage [1]. Large outbreaks of this infection usually have a cyclical nature (recurring in the same area in 3-5 years) [1]. Asian and African countries are considered endemic.

SGP are caused by two viruses, the sheep pox virus (SPPV) and the goat pox virus (GTPV), which are combined into a single supraspecific complex, capripox virus of small ruminants. These two viruses are genetically separable, but it is not possible to differentiate them serologically even using a neutralization reaction [2]. Both capripoxviruses can be present in both goat and sheep populations. Like all poxviruses, SPPV and GTPV are large (200–450 nm in diameter) dsDNA viruses surrounded by several layers of lipid–protein envelopes [3]. Like all poxviruses, capripoxviruses encode a variety of proteins that help them evade the host's immune response. Like all poxviruses, they encode analogs of mammalian cytokines, but unlike most other poxviruses, their genome also encodes proteins that inhibit antigen presentation on molecules of the major histocompatibility complex (MHC) [4]. Such adaptive mechanisms allow capripoxviruses to persist in animal organisms for a long time.

The main ways of infection are aerogenic (through the air), contact and alimentary (through food). In addition, blood-sucking stable flies (Stomoxys calcitrans) have been implicated in infections through mechanical transmission of capripoxviruses [5].

Clinical manifestations of the disease: eyelids swell, discharges begin to flow from the eyes and nose (first serous-mucous, then serous-purulent). Breathing in animals becomes difficult and sniffling, hyperthermia is observed (up to 40-41°C). A smallpox rash begins to appear on the head, lips, around the eyes, on the fore and hind limbs, on the scrotum and foreskin in males, as well as on the skin of the udder and the mucous membrane of the shameful lips of females. The disease spreads in the form of epizootics. After 2-4 weeks in the herd, if measures are not taken in a timely manner, most animals in the herd will be infected. Mortality in smallpox outbreaks in regions endemic for the disease from the disease itself is low (up to 2-5%), although it can reach 100% in non-endemic areas, as well as among imported livestock [2]. Mortality among young animals is much higher than adult animals.

The initial stage of SGP must be differentiated from fungal scab, tick-borne scabies and papular non-contagious eczema, as well as contagious pustular dermatitis of sheep (ecthyma). For this, virological, immunological and molecular biological methods are used. serological methods allow assessing the effectiveness of livestock vaccination, as well as assessing the level of antibody prevalence in herds that have not been vaccinated against the virus [6, 7]. For the detection of capripoxviruses in MRS herds, both by classical PCR and by real-time PCR, the following loci are used: GPCR (G-protein-coupled chemokine receptor gene), RPO30 (viral RNA polymerase gene), P32 (P32 envelope protein gene ). Real-time PCR methods are an order of magnitude more sensitive than viral DNA detection methods based on regular PCR [8].

The chosen topic of the research is crucial as the SGP is endemic in Kazakhstan, for 186 outbreaks of this infection were recorded in the country during the period from 1961 to 2000 [9]. Over the past 10 years, outbreaks have been recorded in Kyzylorda (2013), Turkistan (2013 and 2015), East Kazakhstan (2015), West Kazakhstan (2015, 2019), Mangystau (2019) and Atyrau (2019) [10]. Previously, the disease was also recorded in other regions, for example, in Pavlodar region (2010). These outbreaks led to large economic losses in the country.

Vaccination is the most promosing method to prevent spreading of SGP. In our country, where more than 80% of the SRs livestock are concentrated in private backyards and small enterprises, the total vaccination of SRs is therefore a rather difficult task, which, moreover, is associated with significant economic costs. At the same time, large-scale monitoring of SGP has not been carried out over the past 10 years, which was one of the reasons for the outbreak of this infection in western Kazakhstan in 2019. Since this infection is endemic in Kazakhstan, it is important to monitore the epizootological situation regularly in the country, control outbreaks of infection, and develop veterinary and sanitary measures to adequately anticipate of the disease spread. Therefore, the purpose of this study is to perform risk analyses of SGP transmission in Kazakhstan.

## Methods and materials

*Epidemiological methods.* All calculations of epidemiological parameters were carried out using the EpiInfo v. 7.2.2.2 (CDC).

*Analysis of epizootological aspects.* the epizootological description of SGP in the world and in Kazakhstan was studied on the basis of electronic information sources.

*Cartographic analysis and GIS*. The creation of a GIS database and the determination of the geographical coordinates of farms and collection points was carried out using GPS navigators of Android mobile devices, as well as the database of GeoHack (https://geohack.toolforge.org) and GoogleMaps (https://www.google .com/maps).

*Risk Analysis.* For risk analysis and forecasting chosen the method of analogy and modeling and we used an additional add-in in Microsoft Excel – Decision Tools Suite 6.0 Professional from Palisade.

*Calculation of the sample size for SGP monitoring.* The minimum (critical) sample size for conducting an annual monitoring study in relation to common sheep and goats is determined by the formula [11]:

$$\text{Sample size (n)} = N^* [Z^2 * p * (1\text{-}p)/e^2] / [N - 1 + Z^2 * p * (1\text{-}p)/e^2] \quad (1)$$

Where:

*N* – is the population size;

*Z* – is the critical value of the normal distribution at the required confidence level;

*p* – is the expected level of prevalence, %;

*e* – is the permissible error.

## Results and discussion

*Analysis of the epizootological process of SGP in the world.* SGP is widespread in Africa and Asia [12]. According to the World Organization for Animal Health (WOAH), SGP are notifiable diseases due to the rapid spread of the infection and the significant economic damage it can cause [13]. As for nearby states, outbreaks of sheep and goat pox were detected from 2018 to 2020 on the territory of the Russian Federation, and in 2018 in the Xijiang Uygur Autonomous Region of China, bordering on the Republic of Kazakhstan [14], in 2022 in Tajikistan [15]. Kyrgyzstan officially denies the fact of outbreaks of sheep and goat pox on its territory, but there are clear indications that numerous outbreaks of infection of unclear etiology of SRs that occurred in the republic in 2013 were nothing more than SGP [16]. In general, data on official outbreaks of SGP over the past 10 years are presented in Figure 1.

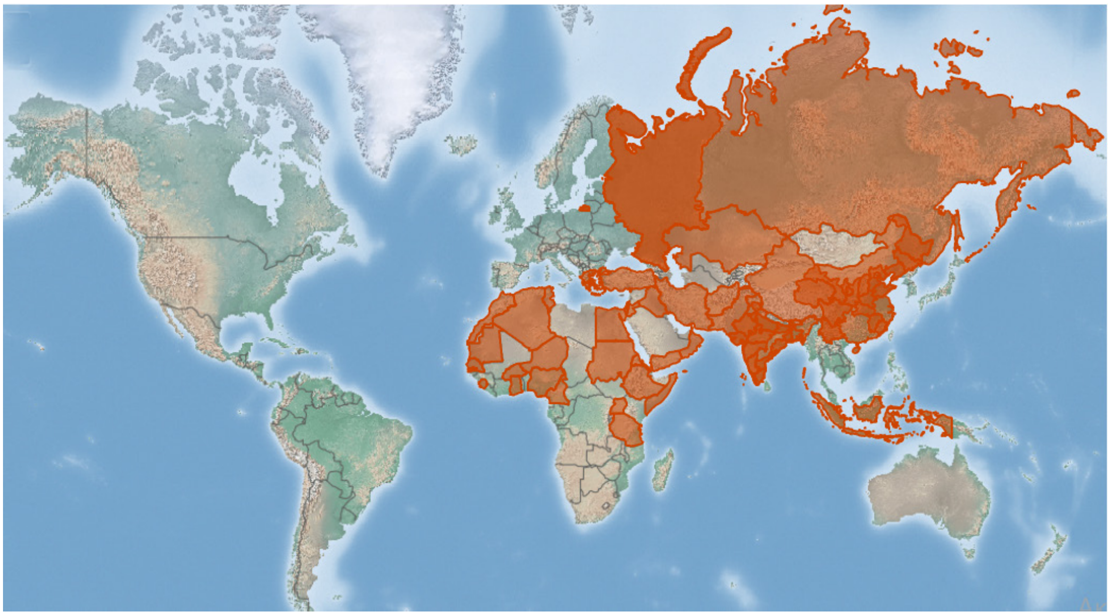


**Figure 1 –** The spread of SGP for the period 2011 – 2022yy. Red indicates the regions and states in which the disease was detected by the WOAH [17]

*Analysis of the epizootological process of SGP in Kazakhstan.* Outbreaks of sheep pox have occurred in our country for the past five years. In April 2019, an outbreak of sheep pox occurred in the rural district of Kyzyl Ozen, Tupkaragai district of the Mangystau region (about 50 animals died). A quarantine was declared. On June 14, 2021, by the decision of the administration of the Tupkaragai district, quarantine was lifted from the territory of this district from the rural district of Kyzyl Ozen. The outbreak also took place from July 19 to August 12, 2019 in the village of Suyunduk, Suyunduk rural district, Kurmangazy district, Atyrau region [10]. A quarantine was declared on August 12, 2019, by the decision of the administration of the Suyunduk rural district of the Kurmangazy district of the Atyrau region, in connection with the implementation of a complex of veterinary and quarantine measures to eliminate the sheep pox disease, quarantine was officially lifted from this territory. Before the outbreaks, neither Mangystau nor Atyrau regions vaccinated livestock against SPPV and GTPV, but after 2019, annual immunization of animals against this infection was carried out in both regions. There is also evidence that in the same 2019, an outbreak of sheep pox occurred in the 'Birlik' breeding farm in the Zhangalin district of the West Kazakhstan region [9].

To clarify the reliable epizootic situation of SGP, in 2021, the Kazakh National Agrarian Research University, as part of the program, conducted research in Mangystau, Atyrau, Turkistan, Zhambyl, West Kazakhstan, East Kazakhstan region (since 2022 Abay and East Kazakhstan) and North Kazakhstan region. In seven regins of the Republic of Kazakhstan, 72 epizootic units (EU) were studied. As a result of the study, 7 disadvantaged regions for this infection were identified. These are Mangystau region (Mangistau district, 1 EU., Tupkaragai district, 1 EU., Munailin district, 1 EU), Atyrau region (Kurmangazin district, 2 EU), Turkestan region (Baidibek district, 1EU), Zhambyl region (Shu district, 1 EU), West Kazakhstan region (Akzhaiyk, Koztal district, 2 EU), East Kazakhstan region (Zaisan district, 1 EU), North Kazakhstan region (Akzhar district, 1 EU).

*Analysis of the risk of infection spread across the territory of Kazakhstan.* The presence or absence of foci of infection in the past (at least within the last ten years) and whether animals are immunized against this infection are extremely important parameters in risk assessment in relation to the prediction of SGP. Table 1 presents data on the total number of SGP-susceptible livestock and on the plan for immunizing animals by region against this infection for 2022. A map showing both of these parameters is shown in Figure 2.

**Table 1** – Livestock vaccination plan for SGP in 2022 year.

| Oblasts | total number of SRs (*thousand*) | Vaccination plan *(thousand)* | Immunized percentage |
|---|---|---|---|
| Abay | 1444,2 | 0 | 0,0% |
| Akmola | 751,6 | 0 | 0,0% |
| Aktobe | 1 533,5 | 0 | 0,0% |
| Almaty | 2981,9 | 2315,6 | (77,7%) |
| Atyrau | 723,6 | 569,5 | (78,7%) |
| East Kazakhstan | 773,6 | 0 | 0,0% |
| Karaganda | 992,0 | 0 | 0,0% |
| Kostanay | 526,2 | 0 | 0,0% |
| Kyzylorda | 895,8 | 496,7 | (55,4%) |
| Mangystau | 357,0 | 200,9 | (56,3%) |
| North Kazakhstan | 624,7 | 0 | 0,0% |
| Pavlodar | 818,9 | 0 | 0,0% |
| Turkistan | 6044,2 | 4817,4 | (79,7%) |
| Ulytau | 449,0 | 0 | 0,0% |
| West Kazakhstan | 1 545,1 | 1053,2 | (68,2%) |
| Zhambyl | 3 917,0 | 3860,4 | (98,6%) |
| zhetysu | 2121,9 | 1502,3 | (70,8%) |
| **Total in Kazakhstan:** | **28 023,7** | **14816,0** | |

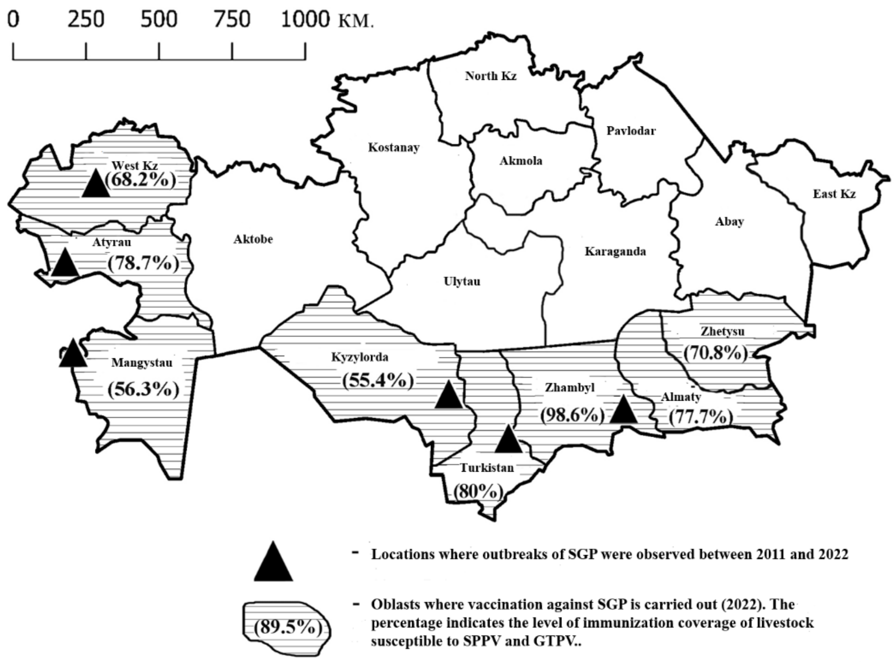



**Figure 2** – Locations of outbreaks of SGP in the territory of Kazakhstan over the past 10 years and vaccination data (a plan for 2022)

The greater the density of susceptible SRs in a given area, the greater the risk of SGP epizootics and infection spread. The highest density of sheep and goats is in the south of our country, namely in the Turkistan, Zhambyl, Almaty and Zhetysu oblasts (Figure 3). However, it should be noted that sheep are raised throughout the territory of the Republic of Kazakhstan, and the density of sheep and goats even in the desert and semi-desert regions of the country is quite sufficient for an outbreak of this infection. At the same time, in regions of the country with a low density of SRs, it becomes possible to quickly localize outbreaks and prevent the spread of infection to adjacent territories.

The total number of susceptible livestock is also an important epidemiological indicator, as it can indicate the potential risk of economic loss associated with a given infection. The largest number of sheep and goats in the country is concentrated on the territory of the Turkistan oblast; followed by Zhambyl, Almaty and Zhetysu oblasts, which together account for more than half of the country's total number of SRs (Figure 4).

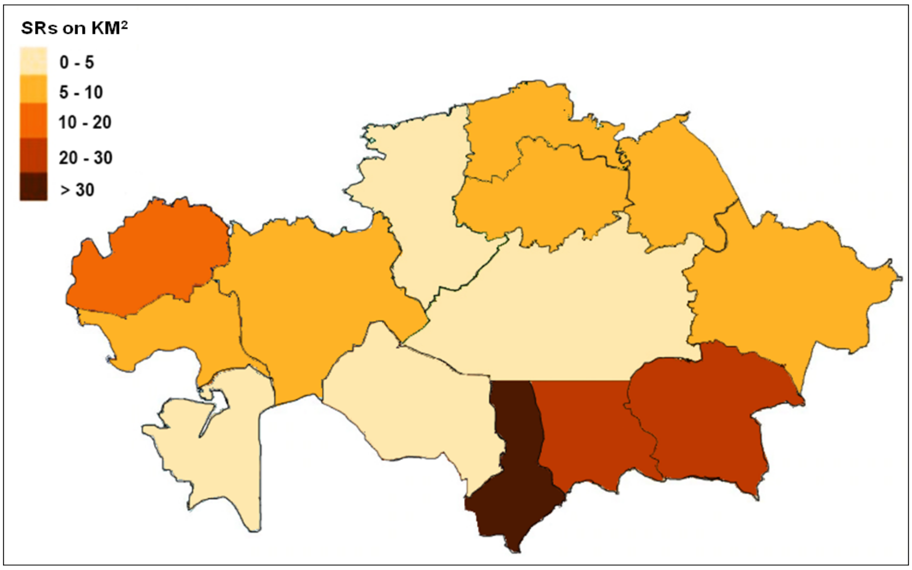



**Figure 3** – The density of SRs in the Republic of Kazakhstan by region (data as of 08/01/2022) [18]

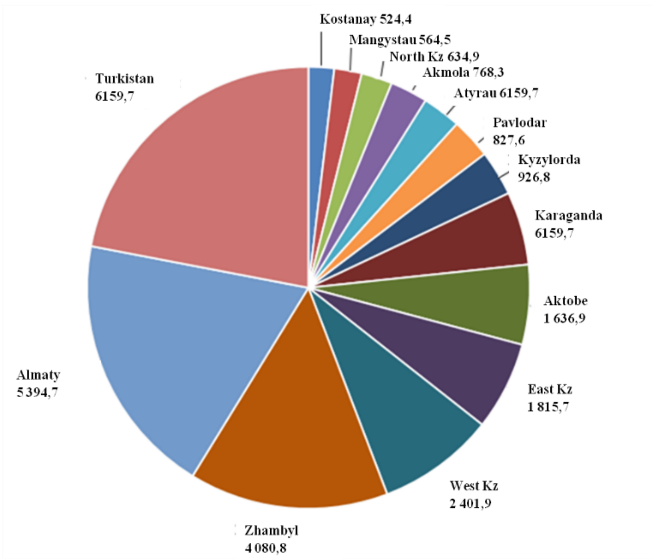



**Figure 4 –** Number of goats and sheep in the Republic of Kazakhstan (thousand) (01.06.2022) [18]

Thanks to the State Program for supporting domestic animal husbandry, favorable conditions have developed for increasing the number of livestock in the country. Over the past two years, there has been a sharp increase in the number of literally all types of livestock and poultry. Forecasts can be short-term, medium-term and long-term. The medium-term forecast is compiled for a year and serves as the basis for planning veterinary-sanitary and preventive measures.

A parameter that can be tracked over a sufficiently long period is the total number of sheep and goats in the country. Due to the high correlation of this indicator with the frequency of outbreaks of sheep pox and goat pox, it can be used to extrapolate data for risk assessment in the medium term.Goats and sheep are no exception (data on changes in the number of SRs for the entire period of independence of the Republic of Kazakhstan are presented in Figure 5. This circumstance significantly increases the risk of new foci of infection in the country.

*Analysis of the risks of importation and predicting outbreaks of SGP.* To analyze the risks of introduction and spread of sheep pox, as well as to assess the level of potential economic damage that may be associated with the spread of the causative agent of this disease. The method of analogy and modeling was chosen for this risk analysis. This approach makes it possible, based on the available data concerning the characteristics of the infection process, the main factors of infection spread, and the laboratory analysis data obtained during monitoring, which characterize the current SGP situation in the country, to carry out relatively technically simple risk calculations without resorting the complex multifactorial mathematical models.

In the approach of risk analysis, the following risk factors have been taken into account: 1) the history of outbreaks of SGP in a given area; 2) the density and total number of susceptible animals to virus in the regions; 3) the way of transmission of the pathogen; 4) the availability of preventive methods to minimize the risks associated with the spread of infection (availability of vaccines), the degree of implementation of these in practice (accessibility for households), and the availability of treatment methods; 5) the genotype of the pathogen, mediating the degree of symptomatic manifestations, the level of lethality, and the level of infectivity; 6) the actual state of the sheep pox epizootological process in a given region (country), including the average level of antibody seroprevalence in herds; 7) the risk of introducing infection from regions or states endemic for the disease and assessing the potential rate of infection spread by assessing the geographical features of the regions; 8) opportunities to eradicate the disease from endemic areas; the presence or absence of legislative acts to control or eradicate the infection.

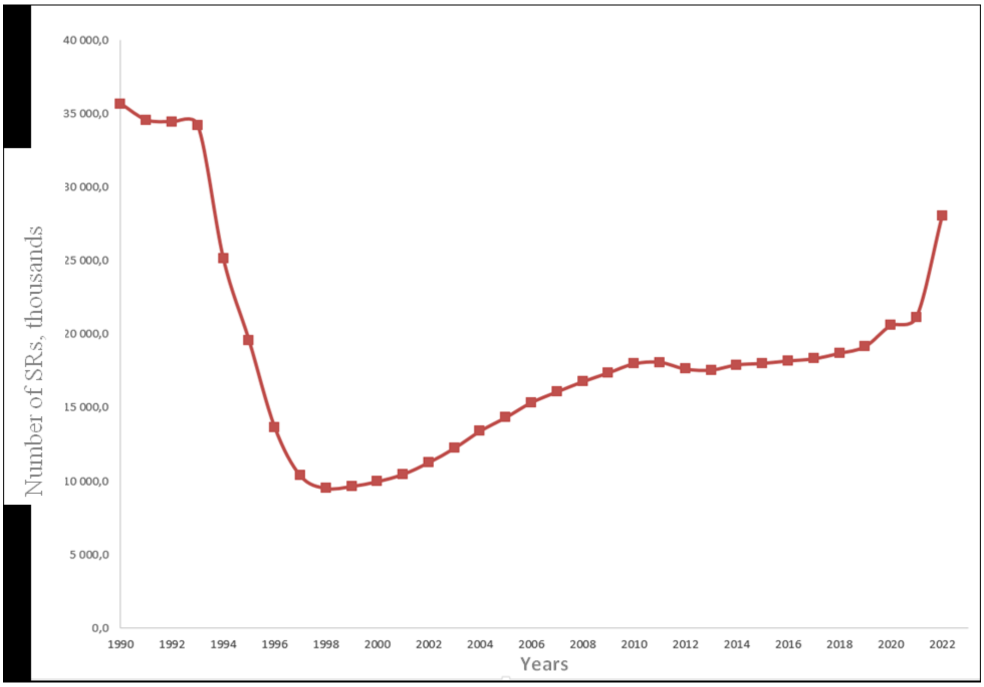



**Figure 5** – Change in the number of SRs in Kazakhstan [18]

For each risk factor, the corresponding scores were assigned from 0 to 5, the scoring was carried out by regions of the Republic of Kazakhstan. Conditional scores for each of the main risk factors for outbreaks of SRs and the spread of the infectious agent to non-endemic areas are presented in Table 2. It was decided to consider the "Vaccination" parameter as the most important factor determining the overall risk of outbreaks of infection – whether animals are vaccinated in a given region of the country according to the state program and how effectively this vaccination is carried out (the breadth of coverage of the population of the region by vaccination and the actual effectiveness of vaccination on the ground). The fact is that even in areas with the smallest number of SRs in the country, the number and density of goats and sheep are sufficient for the rapid spread of infection. This confirmed by outbreaks of SGP that occurred in 2019 in Atyrau and Mangystau regions. Thus, it is in the regions of the country where mass vaccination of livestock against SGP is not carried out that the most economically significant outbreaks of infection can be expected in the near future (West Kazahkstan and Aktobe regions are of particular danger). Therefore, vaccination should be considered when planning public events.

Summing up these scores, the regions of the Republic of Kazakhstan were ranked according to the level of risk of new outbreaks of SGP in the country in the medium term:

11 and < points – low risk level;

12-14 points – moderate risk;

15-17 points – medium risk;

18 and > points – high risk.

Based on all processed data, a risk map of the main foci of SGP diseases, which may be present in the territory of Kazakhstan, was created. The map is shown in Figure 6.

**Table 2** – Scores for assessing the risks of outbreaks of SGP for certain oblasts of Kazakhstan

| Oblasts | Outbreaks | SRs density | Numbers of SRs | Vaccination | Factual data | The risk of infection | Sum |
|---|---|---|---|---|---|---|---|
| Akmola+.Nur-sultan | 0 | 2 | 2 | 5 | 1 | 2 | 12 |
| Aktobe | 3 | 2 | 3 | 5 | 1 | 5 | 19 |
| Almaty+ Almaty | 1 | 4 | 5 | 1 | 1 | 5 | 17 |
| Atyrau | 5 | 2 | 2 | 1 | 1 | 5 | 16 |
| West Kazakhsatn | 5 | 3 | 3 | 1 | 1 | 5 | 18 |
| Zhambyl | 1 | 4 | 4 | 1 | 1 | 4 | 15 |
| Karaganda | 1 | 1 | 3 | 5 | 1 | 0 | 11 |
| Kostanay | 0 | 1 | 2 | 5 | 1 | 4 | 13 |
| Kyzylorda | 2 | 1 | 2 | 5 | 1 | 3 | 14 |
| Mangystau | 4 | 1 | 2 | 3 | 1 | 3 | 14 |
| Pavlodar | 1 | 2 | 2 | 5 | 1 | 3 | 14 |
| North Kazakhstan | 0 | 2 | 2 | 5 | 1 | 4 | 14 |
| Turkistan+Symkent | 2 | 5 | 5 | 1 | 1 | 3 | 17 |
| East Kazakhstan | 2 | 2 | 3 | 5 | 1 | 4 | 17 |

The high risk areas were the West Kazakhstan (due to the extremely high risk of maintaining latent foci of infection) and Aktobe oblasts (mainly because in the region there is no vaccination of SRs against SGP, despite a sufficiently high number of susceptible livestock in the region and the proximity of the regions of Kazakhstan and the Russian Federation, where outbreaks of sheep pox were recorded most recently). Turkistan, Zhambyl, Almaty, and Zhetysu Oblasts require careful attention from regulatory authorities due to the very high density of SRs, optimal conditions for the spread of infection, and the presence of borders with states where the disease considered endemic. Abay and East Kazakhstan oblasts remain at medium risk of outbreaks due to the lack of livestock vaccination programs against sheep pox, the relatively large number of SRs, and the borders with China's Xinjiang Uyghur District. Atyrau and Mangystau oblasts are also at risk, where had recently been recorded outbreaks of SGP. In the Kyzylorda oblast, the most risky area is the vicinity of Kyzyl-Orda, which is a kind of crossroads for the movement of livestock. At times, the density of livestock susceptible to SGP, which reaches critical values, and the observed rotation of herds contributes to the introduction of infection from regions of the country endemic to the disease. In addition, outbreaks of SGP have previously recorded in the oblast.

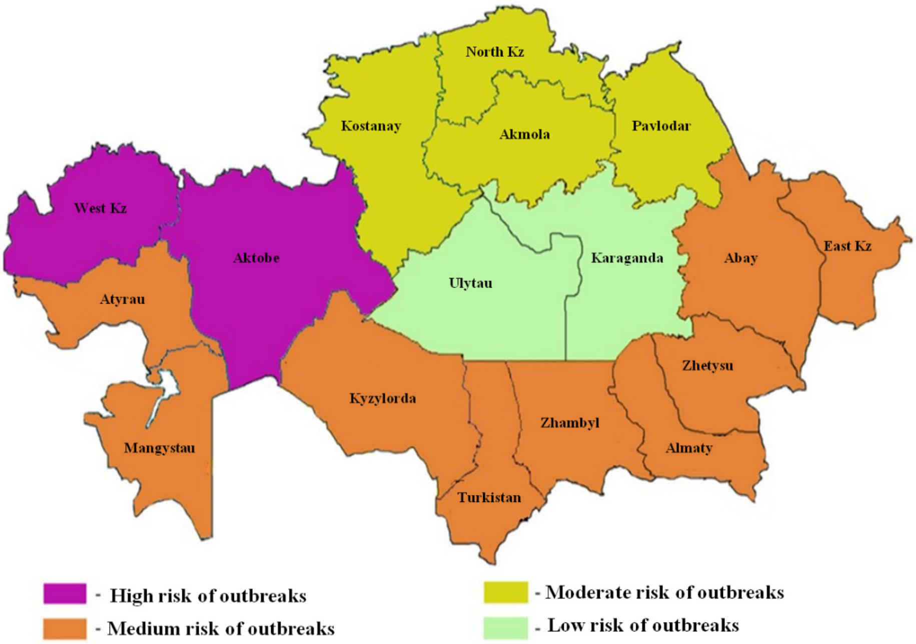


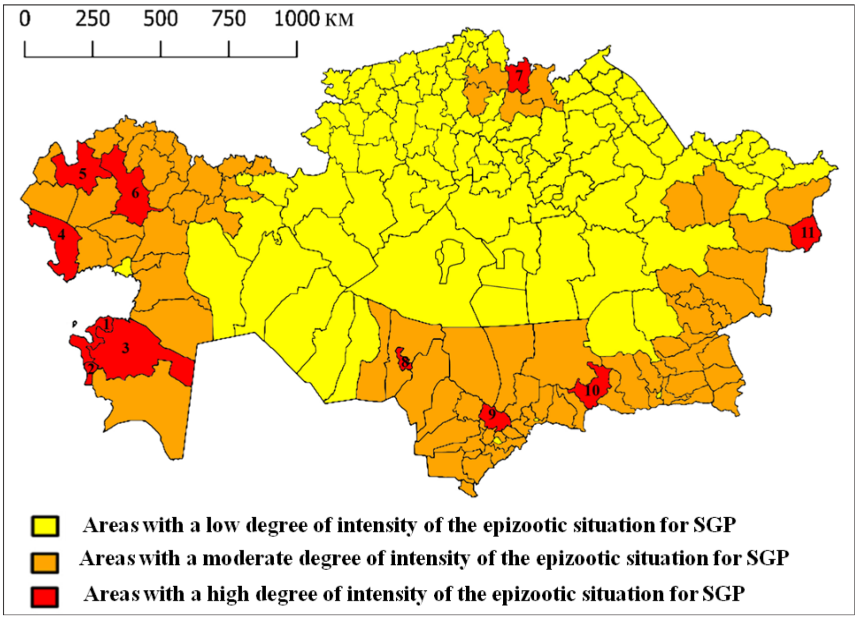

**Figure 6** – Map of risks in relation to the occurrence of large outbreaks of SGP in the territory of Kazakhstan (as of 01.09.2022)

Also in the research work, target indicators for the effectiveness of the implementation of veterinary measures have been determined, as it is possible to control the effect of measures to prevent the introduction of SGP into the republic and the spread of infection to non-endemic territories:

- The percentage of vaccinated animals among those selected for monitoring;
- The percentage of SRs covered by the vaccination plan in the regions;
- Level of seroprevalence of antibodies to capripoxviruses in vaccinated animals;
- Level of seroprevalence of antibodies to capripoxviruses in unvaccinated animals;
- The percentage of herds, whose samples were detected by PCR-positive animals, or animals with signs of SGP with confirmation of virus carriage by the method of neutralization reaction or electron microscopy;
- Number of new outbreaks of SGP by region.

*Zoning and regionalization of the territory of Kazakhstan.* Based on the above information, an epizootic visualization map has developed with indicators of the epizootic process of SGP in the Republic of Kazakhstan for 2019–2022. It included the data from the visual inspection of livestock during monitoring, the data on outbreaks of infection that occurred in given areas, the density of SRs, climatic characteristics, and the presence of borders with regions of other countries where the infection is common. The zoning map of the territory of the Republic of Kazakhstan shown in Figure 7.

The isolates of both SPPV and GTPV were isolated in the country, and their genetic characterization was carried out, including whole genome sequencing of isolates of these viruses [7]. Taking into account the results of the risk analysis, as well as actual evidence of the circulation of SPPV and GTPV throughout the country, a regionalization map of the territory of the Republic of Kazakhstan was developed in relation to the recommended measures for the control of SGP in the country (Figure 8).




*Designations: the numbers indicate areas with a high degree of intensity of the epizootic situation for SGP. In the Mangystau oblast: 1 – Tupkaragai district, 2 – Aktau, 3 – Mangystau district; in the Atyrau oblast: 4 – Kurmangazy district; in West Kazakhstan oblast: 5 – Kaztalov district, 6 – Akzhar district; in North Kazakhstan oblast: 7 – Akzhar district; in the Kyzylorda oblast: 8 – Kyzylorda; in the Turkistan oblast: 9 – Baidibek district; in Zhambyl oblast: 10 – Shu district; in East Kazakhstan oblast: 11 – Zaisan district.*

**Figure 7** – Epizootic visualization map with indicators of SGP epizootic process in Kazakhstan

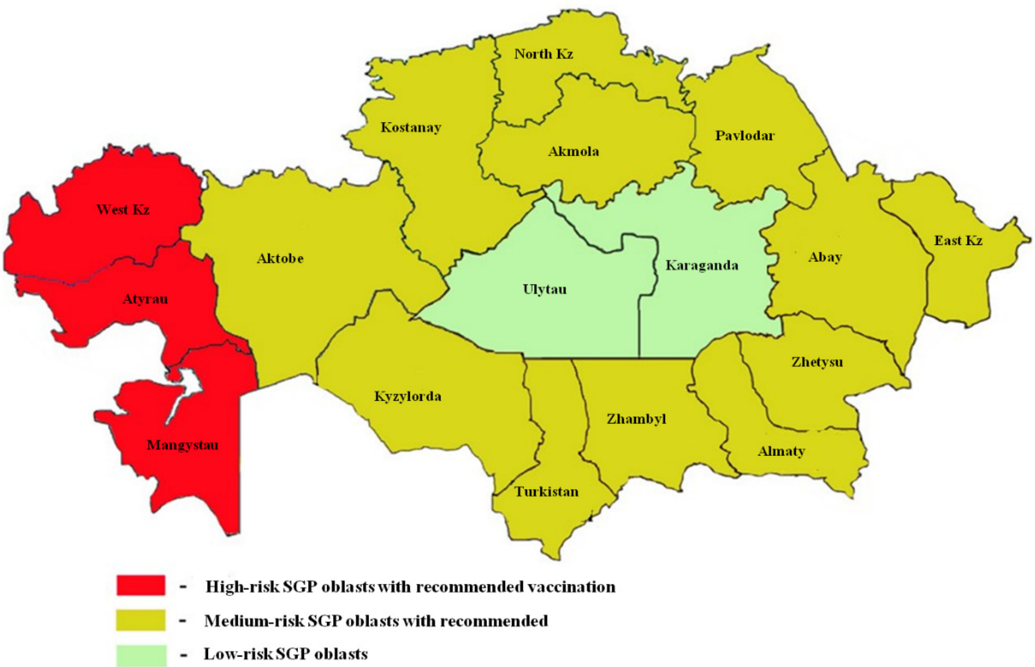



**Figure 8 –** Regionalization of the territory of Kazakhstan in relation to measures to minimize the risks of outbreaks and the spread of SGP

In order to prevent the occurrence of outbreaks of SGP and ensure the effective implementation of preventive measures, it will be recommaned that the territory of the Republic of Kazakhstan conditionally divided into 3 zones:

- Zone 1 – unfavorable for SGP, where the infection can be spread in a latent form (West Kazakhstan, Mangystau and Atyrau Oblasts);
- Zone 2 – favorable for SGP, with a risk of occurrence and spread of infection (North Kazakhstan, East Kazakhstan, Aktobe, Kyzylorda, Turkestan, Zhambyl, Almaty, Zhetysu, Abay, Akmola, Pavlodar, Kostanay oblasts);
- Zone 3 – favorable for SGP, with a low risk of infection, without vaccination (Ulytau and Karaganda oblast).

In the 1st and 2nd zones, it is recommended to vaccinate SRs against SGP with a wide coverage of livestock (more than 70%), introduce mandatory livestock monitoring and strengthen veterinary and sanitary measures. In these areas, it is also recommended to conduct annual monitoring using both serological and molecular biological methods of analysis to identify the facts of the circulation of viruses that cause SGP in this area. In the 1st zone, it is additionally recommended to strengthen control by veterinary services regarding the identification of animals with signs that can be attributed to manifestations of this infection. In the 3rd zone, it is recommended to carefully check for the presence of clinical symptoms of SGP of animals delivered to this zone from the other two zones or from other states. Total vaccination is optional.

*Sample size determination for SGP monitoring*. As of 06/01/2022, according to the official data of the Bureau of Statistics in the Republic of Kazakhstan [18], the country contains 28023.699 thousand heads of sheep and goats. Since no large-scale monitoring of SGP has been carried out in the country before, the level of antibody seroprevalence should be taken equal to 50% (according to [11]). For epidemiological studies, the confidence interval in the vast majority of cases is assumed to be 95%, so this value is recommended for calculations; therefore, the Z value for this confidence interval is 1.96 [1, 11]. The allowable error is usually assumed to be 5% in calculations [19]. Thus, for groups of five to thirty animals, the minimum required number of animals is estimated to be 400 per year. As a rule, the number of animals exceeding the critical sample size by at least 10% is involved in monitoring, since some proportion of the samples may not be suitable for analysis (for example, serum may be hemolyzed, and blood clotted).

A specified number of samples taken for monitoring purposes should be distributed among collection points (sampling should be carried out at a minimum of ten different locations, or epidemiological units (EU)). It is desirable that several districts of each of the areas covered by the monitoring program be involved in the monitoring. Within a given location (or EA), the selection of animals for monitoring purposes should be random (unless all animals show symptoms attributable to SGP). It is important that the animals selected for monitoring include animals of both sexes and different age groups. If animals are seen with symptoms similar to those of SGP, they should be additionally selected for laboratory analysis (semi-targeted sampling aimed at detecting signs of virus circulation in herds as efficiently as possible).

**Conclusion**

According to the conducted research, the epizootological characteristics of the country's territory for the last 10 years on SGP have been determined. Based on the results, an analysis of the epizootic situation and an analysis of the risks of SGP spread, zoning and regionalization of the territory of the Republic of Kazakhstan according to the degree of tension of the epizootic situation of this diseases were carried out, as wells as the sample size for SGP monitoring was determined. These data will help to increase the effectiveness of veterinary-sanitary measurements for the prevention and control of the spread of infection, and fully determine the current situation regarding to SGP, as well as to reduce or prevent the risk of new outbreaks of SGP in Kazakhstan.

**Acknowledgments**

The work was carried out within the framework of the BR10764899 program "To study the epizootic characteristics of the country's territory for especially dangerous diseases and develop veterinary and sanitary measures to improve their effectiveness", funded by the Ministry of Agriculture of the Republic of Kazakhstan.

**Conflict of interest**

The authors of the article confirm that there is no financial or any other support for the study, or a conflict of interest.

## References

1. Hamdi J., Munyanduki H., Omari Tadlaoui K., El Harrak M., Fassi Fihri O. Capripoxvirus Infections in Ruminants: A Review // Microorganisms. – 2021. – Vol. 9, No.5. – P. 902.

2. Sheep pox and goat pox. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Chapter 3.7.12. 2018. – P. 1513-1524.

3. Babiuk S., Bowden T.R., Boyle D.B., Wallace D.B., Kitching R.P. Capripoxviruses: an emerging worldwide threat to sheep, goats and cattle // Transboundary and emerging diseases. – 2008. – Vol.55. – P. 263–272.

4. Yewdell J.W., Hill A.B. Viral interference with antigen presentation // Nature immunology. – 2002. – Vol. 3, No. 11. – P.: 1019–1025.

5. Kitching R.P., Taylor W.P. Transmission of capripoxvirus // Research in Veterinary Science. – 1985. – Vol. 39. – P. 196-199.

6. Tuppurainen E., Venter E.H., Shisler J.L., Gari G., Mekonnen G.A., Juleff N., Lyons N.A., De Clercq K., Upton C., Bowden T.R., Babiuk S., Babiuk L.A. Review: Capripoxvirus Diseases: Current Status and Opportunities for Control. Transbound Emerg Dis. 2017; 64(3): 729–745.

7. Tulman E.R., Afonso C.L., Lu Z., Zsak L., Sur J.H., Sandybaev N.T., Kerembekova U.Z., Zaitsev V.L., Kutish G.F., Rock D.L. The genomes of sheeppox and goatpox viruses // Journal of Virology. – 2002. – Vol. 76. – P. 6054–6061.

8. Lamien Ch.E., Goff Ch.L., Silber R., Wallace D.B., Gulyaz V., Tuppurainen E., Madani H., Caufour P., Adami T., Harrak M.E., Luckins A.G., Albina E., Diallo A. Use of the Capripoxvirus homologue of Vaccinia virus 30 kDa RNA polymerase subunit (RPO30) gene as a novel diagnostic and genotyping target: Development of a classical PCR method to differentiate Goat poxvirus from Sheep poxvirus // Veterinary Microbiology. – 2011. – Vol.149. – P. 30–39.

9. Jepizooticheskaja situacija v Respublike Kazahstan [Epizootic situation in the Republic of Kazakhstan]. https://rel.kz/epizooticheskaya-situatsiya-v-respublike-kazahstan/.

10. Amanova Z., Zhugunissov K., Barakbayev K., Kondybaeva Z., Sametova Z., Shayakhmetov Y., Kaissenov D., Dzhekebekov K., Zhunushov A., Abduraimov Y., Zakarya K., Bulatov Y. Duration of protective immunity in sheep vaccinated with a combined vaccine against peste des petits ruminants and sheep pox // Vaccines (Basel). – 2021. – Vol. 9, No.8. – P. 912.

11. Charan J., Kantharia N.D. How to calculate sample size in animal studies? // Journal of Pharmacology and Pharmacotherapeutics. – 2013. – Vol.4, No.4. – P. 303-306.

12. Zewdie G., Derese G., Getachew B., Belay H., Akalu M. Review of sheep and goat pox disease: Current updates on epidemiology, diagnosis, prevention and control measures in Ethiopia // Animal diseases. – 2021. –Vol. 1, No.1. – P. 28.

13. World Organization for Animal Health. https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_sheep_pox_goat_pox.pdf.

14. Akimova T.P. Epizooticheskaya situatsiya po ospe ovets i koz v mire [Epizootic situation of sheep pox and goat pox in the world] // Veterinarnaya mikrobiologiya, virusologiya, epizootologiya. – 2019. – Vol. 3. – P. 3-9

15. Atovullozoda R.A. Epizooticheskaya situatsiya po ospe ovets i ospe koz v Tadzhikistane v 2000–2021 gg [Epizootic situation of sheep pox and goat pox in Tajikistan in 2000–2021] // Veterinariya segodnya. – 2022. – Vol. 11, No.1. – P. 61–69.

16. Nurgaziyev R.Z. Genodiagnostika ospy ovets v Kyrgyzskoy Respubliki [ Genodiagnostics of sheep pox in the Kyrgyz Republic] // Veterinarnaya meditsina. – 2015. – N.5, Vol.127. – P. 132-135

17. Sheep and goat pox – CABI: https://www.cabi.org/isc/datasheet/81537

18. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (Kaz.Stat.). https://stat.gov.kz/official/industry/14/statistic/7

19. Sheep pox and goat pox. OIE Terrestrial manual 2018. Ch. 3.7.12. 1513-1524.