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Retrospective Analysis of the Bovine Leukemia Epizootic Situation in Kazakhstan

Serik Kanatbayev [1], Ulbolsyn Kuzhebayeva [2,*], Sayat Baiseitov [3], Maksim Petropavlovskiy [4], Saltanat Mamanova [5], Dauriya Tazhbayeva [2], Izimgali Zhubantayev [1], Yerbulat Baitlessov [1], Aida Daugaliyeva [6] and Berikzhan Kaiypbay [7]

[1]West Kazakhstan Innovative and Technological University, Uralsk, Republic of Kazakhstan
[2]Zhangir Khan West Kazakhstan Agrarian Technical University, Uralsk, Republic of Kazakhstan
[3]Republican Veterinary Laboratory, Astana, Republic of Kazakhstan
[4]Ural Federal Agrarian Scientific Research Center of Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia
[5]Kazakh Scientific Research Veterinary Institute, Almaty, Republic of Kazakhstan
[6]Kazakh Research Institute for Livestock and Fodder Production, Almaty, Republic of Kazakhstan
[7]Kostanay Regional Territorial Inspectorate of the Committee for Veterinary Control and Supervision of the Ministry of Agriculture of the Republic of Kazakhstan, Kostanay, Republic of Kazakhstan
***Corresponding author:** ukuzhebayeva@inbox.ru

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ABSTRACT

The present study is a retrospective analysis of the bovine leukemia epizootic situation in the Republic of Kazakhstan from 2019 to 2023. The study examines trends in the spread of the disease, its geographical distribution, and the effectiveness of existing control measures in Kazakhstan. The study aims to conduct a retrospective analysis of the bovine leukemia epizootic situation in Kazakhstan from 2019 to 2023, identify trends in the spread of the disease, and propose measures for its control and prevention. The work uses data from official veterinary reports and the results of serological blood tests run by local veterinary inspections covering various administrative regions of Kazakhstan. The obtained data show that, despite the preventive measures being implemented, in several regions, such as North and East Kazakhstan, the rate of leukemia infection remains higher than in others. This highlights the need for enhanced measures in high-risk areas. There was also a tendency for the infection rate to fluctuate with peaks in morbidity and subsequent decreases after recreational activities. Despite current preventive measures, bovine leukemia remains a serious problem for the Kazakh livestock industry. The study points to the need to improve the interaction between veterinary services, farm managers, and local governments to optimize disease control strategies. The importance of continuous monitoring and targeted interventions in high-morbidity areas is emphasized. The results provide valuable data for future programs to eradicate leukemia and preserve animal genetic stock and productivity.

Key words: Leukemia, Cattle, Retrospective analysis, Republic of Kazakhstan, Epizootic situation.

INTRODUCTION

Bovine leukemia (BL) is a chronic infectious disease caused by the BL virus (BLV), which leads to the development of malignant neoplasms in lymphoid tissue (Gillet et al. 2007; Aida et al. 2013; Lefkowitz et al. 2018). This disease is a serious problem for animal husbandry, as it affects animal health and significantly reduces animal productivity, leading to economic losses in dairy and meat production (Panei et al. 2013; Buehring et al. 2014; Nekouei et al. 2016; Yang et al. 2016). BLV is transmitted through blood, milk, and other biological fluids, contributing to its widespread livestock distribution (Bartlett et al. 2013; Hsieh et al. 2019; Saushkin et al. 2019).

The Republic of Kazakhstan, with its developed livestock sector, has historically faced difficulties in BLV control. According to the website of the Ministry of Agriculture of the Republic of Kazakhstan, as of 01.05.2024, the number of cattle in the country was 9,698,541, of which 872,740 were kept in agricultural enterprises, 4,159,125 in individual entrepreneur and private farms and 4,666,676 in private households. The total number of breeding cattle in terms of productivity in

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all categories of farms is as follows: 12.4% dairy cattle; 16.4% meat and dairy cattle, and 71% meat cattle (Ministry of Agriculture of the Republic of Kazakhstan 2024).

The issue of leukemia exists in Kazakhstan, and like everywhere in the world, scientists are closely engaged in developing new effective drugs and treatments to control the disease (Ministry of Agriculture of the Republic of Kazakhstan 2012; Borovikov et al. 2024). Leukemia in the country has been studied by many scientists (Piontkovsky 2002; Ispullaev 2009; Sultanov et al. 2022).

According to the previous studies, the breeds most susceptible to BL are Simmental (24.1%), Latvian brown Estonian black-and-white, Lithuanian red (53.2%), and Red steppe (18.5%) (Sakhno et al. 1975). The Kazakh white-headed and native breeds showed a significantly lower percentage of infection (2.1%) (Gizitdinov 1975; Nikolaeva et al. 1975).

The plan of basic measures for the prevention and control of BL for 1992-1995 states that the disease was registered in 274 farms in 14 regions of Kazakhstan (Beimisheva 1995; Bakhtakhunov et al. 2010, 2011). In 1996, BL was registered in 333 farms from 14 regions of Kazakhstan.

According to statistics, in 2000, the average infection rate among livestock was 4.5%, but there is evidence that in some farms, these figures reached up to 65% among dairy livestock (Bakhtakhunov 2011).

The study of the regional epizootiology of BL from 1972 to 2002 reported that the spread of leukemia in Kazakhstan is associated with the import of infected cattle breeds like Latvian brown, Estonian black-and-white, and Latvian red from the Baltic republics (Akhmedsadykov 2009; Mamanova et al. 2015; Sultanov et al. 2015; Bakhtakhunov et al. 2016; Sultanov et al. 2017). Leukemia is hematologically characterized by leukemic, sub-leukemic, or aleukemic clinical course, with the leukemic stage the disease has a lymphoid form, and with the other two, it has reticular and myeloid forms (Borovikov et al. 2010; Erskine et al. 2012; Blagitz et al. 2017; Polat et al. 2017; OIE 2019; Bartlett et al. 2020; Hamada et al. 2020; Daiji et al. 2023; Borovikov et al., 2024).

From 2002 to 2015, according to the data of the Republican and regional laboratories of the Ministry of Agriculture of the Republic of Kazakhstan, 12,826,695 heads of cattle were studied in the agar gel immunodiffusion assay (AGID), which accounted for 16.12% of the total animal population (Bakhtakhunov et al. 2016). The percentage of infection of animals with the leukemia virus in different years was not the same. It was the lowest (1.9%) in 2011 and the highest (11%) in 2005 (Fig. 1).

382,080 infected heads were detected during this period, which averaged 3.0% in Kazakhstan (Rudenko and Piontovsky 2015). The number of animals tested for leukemia was not constant and tended to increase sharply from 2007 to 2011; then, from 2012, the number of animals in question was reduced. A retrospective analysis by region showed that the highest percentage of infection was found in the northern regions of the country (Kostanay, North Kazakhstan, Pavlodar, Akmola); only the Mangystau region, specializing in camel breeding, was free of leukemia (Bakhtakhunov et al. 2016).

According to the Kazakh Veterinary Research Institute (KazNIVI), 682 leukemia-affected farms were identified from 2015 to 2019. The infection rate averaged 6.12% from 2015 to 2019; during this period, 166,654 cattle heads were examined, of which 9,622 had antibodies to the virus (5.8% of the studied livestock). During this period, the disease was widespread in North Kazakhstan, Kostanay, West Kazakhstan, and East Kazakhstan regions. One of the main reasons for the spread of leukemia among livestock is the joint keeping of calves and infected animals, delays in culling infected specimens, incomplete coverage of livestock with tests, frequent movement of livestock between farms, and violations of the veterinary and sanitary rules (Turkeev et al. 2019).

Since the independence of Kazakhstan, diagnostic studies of BL have been conducted following established standards. One of these documents is Order No. 747 of the Minister of Agriculture of the Republic of Kazakhstan dated December 22, 2004, "On approval of Veterinary rules for the prevention and elimination of leukemia in cattle", which remains relevant today. Leukemia, as a disease common to many animal species, is included in the list of infectious diseases for which restrictive measures are established, fixed in Order No. 18-03/128 of the Ministry of Agriculture of the Republic of Kazakhstan dated March 28, 2012 (Ministry of Agriculture of the Republic of Kazakhstan 2012).

According to Order No. 7-1/587 of the Minister of Agriculture of the Republic of Kazakhstan dated June 29, 2015 "On approval of Veterinary (veterinary and sanitary) Rules" (Ministry of Agriculture of the Republic of Kazakhstan 2015), veterinary measures in prosperous economic entities are carried out based on an action plan approved by the head of a subdivision of local executive bodies in coordination with the chief state veterinary and sanitary inspector of the relevant administrative-territorial unit. The leukemia diagnosis is carried out using serological, hematological, clinical-hematological, pathoanatomic, and histological research methods and polymerase chain reaction (PCR) (Dolz and Moreno 1999; Baramova et al. 2011; Bai et al. 2019; Derrar et al. 2020; Barshevskaya et al. 2019; Kuczewski et al. 2021; Petropavlovskiy 2022; Nikbakht Brujeni et al. 2023; Pluta et al. 2023, 2024). To detect leukemia in animals on time, successful farms are routinely subjected to diagnostic testing once a year using AGID, starting at the calves' age of 6 months. In case of a positive result of the AGID assay in cattle, the diagnosis is clarified by rerunning the test using the enzyme-linked immunosorbent assay (ELISA). If a positive result of ELISA is detected among cattle, then the leukemia diagnosis is clarified using hematological test methods. Thus, the leukemia diagnosis is carried out in stages using several test methods. If a negative result is obtained using hematological test methods, a note on the results of diagnostic tests is entered into the database for the identification of farm animals, and the animal is examined again after six months. If a positive result is obtained using hematological test methods, this animal is considered to have leukemia.

The chief veterinary and sanitary inspector of the relevant administrative-territorial area, based on the results of an expert opinion (test report), instructs owners to isolate animals with a positive reaction from the rest of the livestock. Within 15 calendar days, such animals must be

sent to specialized slaughter facilities within the territory for sanitary slaughter.

Despite numerous preventive measures and herd rehabilitation programs, the infection continues to threaten farms and regions where large farms are concentrated. Retrospective studies are important to analyze the dynamics of the spread of infection, assess the epizootic situation, and develop more effective strategies to control the disease.

The objectives of this study are to conduct a retrospective analysis of the BL epizootic situation in Kazakhstan from 2019 to 2023, identify trends in the spread of the disease, and propose measures for its control and prevention.

MATERIALS AND METHODS

Study design

We conducted the study in the spring of 2024. The main research method was a retrospective analysis. A retrospective analysis of the epizootic situation for BL makes it possible to assess how successfully existing measures for preventing and eliminating the disease are applied and to identify trends that indicate the emergence of new foci of infection. A retrospective analysis involves studying the dynamics of the disease in recent years in Kazakhstan to develop effective recommendations for further reducing the incidence and improving the general condition of livestock.

Materials

The cattle numbers were taken from the website of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (https://stat.gov.kz/ru/).

The epizootological material was collected according to the documentation and official veterinary reports of local executive bodies, protocols of serological blood serum tests for leukemia, and information from regional veterinary inspections of the Committee for Veterinary Control and Supervision of the Ministry of Agriculture of the Republic of Kazakhstan.

Methods

In addition to the general retrospective analysis method, we used statistical methods to analyze quantitative and qualitative indicators, including the number of positive cases among animals, to identify trends and infection foci.

This study was based on secondary data. We used qualitative content analysis of scientific literature. We selected the scientific literature for analysis using the PRISMA (preferred reporting elements for systematic reviews and meta-analyses) data selection algorithm. The research algorithm consisted of the following stages. In the first stage, we selected literature that contained the keywords "leukemia in Kazakhstan", "livestock diseases in Kazakhstan", "BL", and "statistics on BL in Kazakhstan". The criterion for selecting the source was the indexability of the journal in Scopus, Web of Science, and Google Scholar. A study was selected for analysis if the author had at least five publications on the topic in question for at least the last 10 years and if veterinary research accounted for at least 40% of all other studies by the author. After analyzing the abstracts and conclusions, we selected the 50 most relevant papers.

RESULTS

To clarify the whole picture, let us look at the number of cattle in Kazakhstan from 2019 to 2023 (Fig. 2). Fig. 2 shows the dynamics of the number of cattle in Kazakhstan from 2019 to 2023. At the beginning of 2023, statistics recorded 8.4 million heads in various farms, households, and agricultural enterprises. In Kazakhstan, the number of cattle increased by 12% from 2019 to 2023. More than half of the cattle were kept on individual farmsteads. The region with the most dairy cattle is Turkestan, while the number of meat cattle is highest in West Kazakhstan. Over the past 5 years, there has been a stable trend in the annual increase in the number of cattle, which indicates the development of the livestock industry in Kazakhstan.

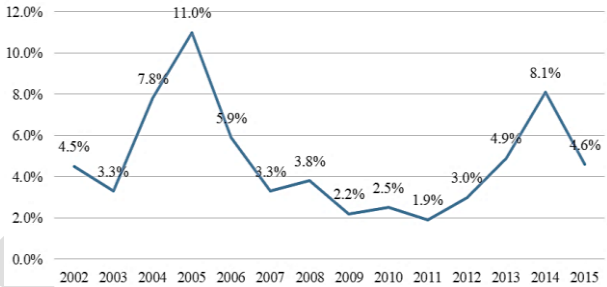

Fig. 1: Percentage of leukemia incidence according to the data of the Republican and regional laboratories of the Ministry of Agriculture of the Republic of Kazakhstan.

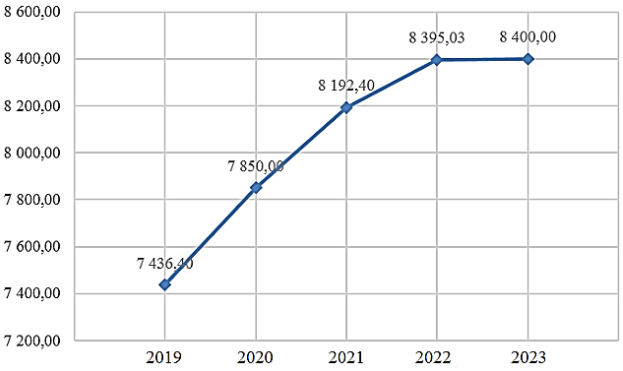

Fig. 2: The number of cattle in Kazakhstan from 2019 to 2023 (thousand heads).

From 2019 to 2023, 225,516 heads were subjected to monitoring studies for BL in Kazakhstan using AGID (about 0.6% of the total number of livestock over 5 years) (Fig. 3).

According to the veterinary reporting data in Fig. 3, a tense BL epizootic situation was observed in Kazakhstan. In total, 225,516 heads of cattle were monitored for leukemia using AGID over the past 5 years. Of these, 10,153 samples, or 4.5%, showed a positive result. The highest number of tests was performed in 2020, with a total of 119,313 tests, accounting for 52% of the tests over 5 years. Based on statistical data, the volume of monitoring studies was increased depending on budget funds; in 2019, 2021, and 2022, the volume of studies ranged from 21,969

to 24,580 samples. In 2023, this figure was 32,350 samples, which is 72.8% lower than in 2020. On average, it is 31.6% higher than in other years.

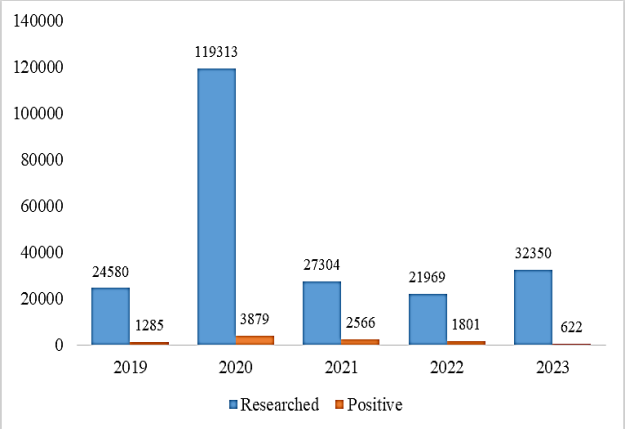

Fig. 3: Scope of monitoring studies for BL in 2019-2023, heads.

The number of samples that showed a positive result in 2019 was 5.2% (Fig. 4). In 2020, there was a decrease to 3.3%; in 2021, there was a sharp increase to 9.4%, which is the highest result in 5 years of monitoring studies. In subsequent years, this indicator decreased again by 1.2% in 2022 and then decreased to 1.9% in 2023.

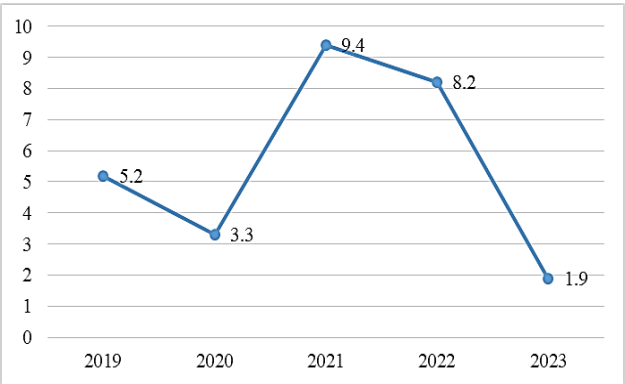

Fig. 4: Indicator of detection of positive (%) results for leukemia in the studied samples for 2019-2023.

According to the data in Table 1, the number of animals studied varied by region and year. The largest number of animals was studied in the Jambyl (12,695 heads) and Pavlodar (12,888 heads) regions according to data for 2020. In 2021 and 2022, animal leukemia tests were not run in the Atyrau, West Kazakhstan, and Turkestan regions and in 2023, in the Mangystau region. The percentage of positive cases also varies between regions. The highest percentage of infected animals was observed in the Kostanay, East Kazakhstan, and North Kazakhstan regions, where in some years, the share of positively responding animals exceeded 10%. The highest infection rate was observed in 2021 in the Kostanay region (29.69%) and in 2022 in the Jambyl region (37.4%). It is worth noting a decrease in the infection rate over the past 2 years, compared with previous years. There is a pattern of uneven spread of BL in Kazakhstan, which indicates that in some areas, more intensive measures are required to control and prevent the disease.

Fig. 5 shows the geographical distribution of the average rate of infection of cattle with leukemia in the country over the past 5 years. According to Fig. 5, in the North Kazakhstan (12.99%) and Kostanay (12.33%) regions, the average infection rate for 5 years was higher than in other regions. The following areas were leukemia free: Mangystau, Kyzylorda, Turkestan, Ulytau, and Jetisu. It is also worth noting the East Kazakhstan region, where the infection rate was 9.31%. This region was second only to the North Kazakhstan and Kostanay regions. In other regions, the infection rate ranged from 0.07 to 5.11%, indicating a wide variation in the detection rate of BL in Kazakhstan.

DISCUSSION

Despite the comprehensive preventive measures against leukemia, the problem remains urgent (Borovikov et al. 2024; Mukanov and Mukantayev 2024). The procedure for BL veterinary measures is regulated by Order No. 7-1/587 of the Minister of Agriculture of the Republic of Kazakhstan dated June 29, 2015 "On approval of Veterinary (veterinary and sanitary) rules". The North Kazakhstan, Kostanay, and East Kazakhstan regions have much higher epizootological indicators than other regions, where the detection rate is much lower and is characterized by resistance to the virus among livestock. Leukemia poses a serious threat to the gene pool of highly productive cattle breeds (Tharwat et al. 2024). For prevention, veterinary measures in prosperous economic entities are carried out based on an action plan approved by the head of the subdivision of local executive bodies in coordination with the chief state veterinary and sanitary inspector of the relevant administrative-territorial unit (Vaslavskiy 2022; Hilmiati et al. 2024). Successful business entities are routinely subjected to a diagnostic examination once a year based on AGID to detect leukemia in animals on time, starting at the age of 6 months. An economic entity where negative results are obtained during annual routine examinations using AGID, ELISA, and hematological methods receives a good BL status. No more than 10% of the total number of animals in an economic entity can receive positive results using the hematological method (Thabet et al. 2024). In economic entities engaged in the import and export of breeding young animals, a double serological examination of animals is carried out: the first time at the age of 6 months and the second time before the breeding sale. Animals imported for breeding are tested for leukemia using AGID, ELISA, or PCR in the exporting country or the supplier farm no earlier than 30 calendar days before sale and in the importing country or the buyer's farm during the quarantine period. Tests are carried out in all regions, including planned work on government orders and paid tests, for example, in case of export (Abdullayev et al. 2024). Routine leukemia tests do not cover 100% of the population, which may limit disease detection.

Modern diagnostic methods combined with improved cattle leukemia rehabilitation programs and close cooperation between veterinarians, farm managers, and researchers offer the opportunity to eliminate the disease (Glazunov et al. 2022; Chaudhary et al. 2024). This makes it possible to compensate for economic losses (Kamalieva et al. 2020), preserve and increase the gene pool of breeding

Table 1: Results of monitoring studies using AGID to BL in 2019-2023

No.	Region	2019			2020			2021			2022			2023		
		Heads examined	Reacted positively, heads	% of responding animals	Heads examined	Reacted positively, heads	% of responding animals	Heads examined	Reacted positively, heads	% of responding animals	Heads examined	Reacted positively, heads	% of responding animals	Heads examined	Reacted positively, heads	% of responding animals
1	Akmola	2,174	83	3.8	7,717	94	1.2	2,162	37	1.71	1,513	5	0.33	1,413	1	0.07
3	Aktobe	3,641	18	0.5	8,771	0	0.0	4,553	0	0.0	4,186	0	0	2,914	0	0
4	Atyrau	310	0	0.0	3,058	126	4.1	0	0	0.0	0	0	0	912	1	0.11
5	City of Almaty	2,176	0	0.0	17,766	144	0.8	3,914	34	0.87	2,738	0	0	3,293	0	0
6	Jetisu	2,449	0	0.0	4,609	0	0.0	920	0	0.00	805	0	0	755	0	0
7	East Kazakhstan	1,617	212	13.1	9,075	979	10.8	2,233	207	9.27	1,960	67	3.42	996	13	1.31
8	Abai	800	0	0.0	6,190	45	0.7	2,600	32	1.23	1,580	91	5.76	4,069	32	0.79
9	Jambyl	1,387	0	0.0	12,695	98	0.8	585	0	0.0	1,337	500	37.4	1,377	0	0
10	West Kazakhstan	1,655	79	4.8	8,555	303	3.5	0	0	0.0	0	0	0	332	17	5.12
11	Karaganda	177	0	0.0	4,606	7	0.2	0	0	0.0	0	0	0	348	0	0
12	Kyzylorda	263	0	0.0	1,459	0	0.0	0	0	0.0	0	0	0	1,256	0	0
13	Kostanay	3,221	539	16.7	6,490	117	1.8	4,773	1,417	29.69	3,882	474	12.2	3,961	206	5.2
14	Mangystau	30	0	0.0	31	0	0.0	0	0	0.0	0	0	0	0	0	0
15	Pavlodar	750	15	2.0	12,888	609	4.7	2,114	262	12.39	1,568	175	11.2	4,017	29	0.72
16	North Kazakhstan	2,384	339	14.2	9,713	1,357	14.0	3,450	577	16.72	2,400	489	20.4	5,797	323	5.57
17	Turkestan	1,546	0	0.0	5,690	0	0.0	0	0	0.0	0	0	0	910	0	0
TOTAL		24,580	1,285	5.2	119,313	3,879	3.3	27,304	2,566	9.4	21,969	1,801	8.2	32,350	622	1.9

cattle, improve production performance, raise healthy animals, and meet people's needs for natural dairy products, maintaining their health and quality of life (Zhaksalykov et al. 2024).

To eradicate BL, prevent relapses, and contain the spread of the infection in Kazakhstan, it is necessary to do the following:

- carry out routine diagnostic tests for leukemia using AGID and ELISA for the entire livestock from 4-6 months of age and PCR from 2 weeks. Special attention should be paid to regions with a high level of infection, such as North and East Kazakhstan (Gnezdilova et al. 2022; Tarik and Muhsen 2024);
- ensure the isolation of animals with a positive leukemia test result and their timely culling for sanitary slaughter in specialized slaughterhouses (Sofiane 2020);
- strictly control the movement of cattle between farms and regions, especially when selling breeding young animals, with mandatory diagnostic tests before transportation (Kumar et al. 2022);
- organize regular training for veterinary specialists and farmers on the prevention and control of leukemia, including compliance with hygiene standards and biological safety measures (Oviedo-Pastrana et al. 2024);
- implement strict biological safety measures in farms, such as the use of disinfectants, the treatment of equipment and animal care products, and the use of personal protective equipment for workers (Zhanabayev et al. 2022);
- use genetic markers of leukemia resistance to select and breed specimens resistant to the virus, which will help reduce the incidence in the long term (Beishova et al. 2024).

Conclusion

Our retrospective analysis of the BL epizootic situation in Kazakhstan for 2019-2023 demonstrated key theoretical and practical aspects of the issue.

From the theoretical point of view, the study confirmed the complexity of the epidemiological situation due to geographical, genetic, and organizational factors. We established that in the North Kazakhstan, Kostanay, and East Kazakhstan regions, the infection rate is significantly higher, while the Mangystau and Kyzylorda regions remain disease-free. The main reasons for the persistence of infection include the joint keeping of healthy and infected animals, delayed culling, and insufficient coverage of the entire livestock by diagnostic tests.

The practical significance of the work includes recommendations to strengthen control over the spread of livestock leukemia. The priority measures are to conduct routine diagnostic tests in all regions, paying special attention to areas with a high level of infection. The results confirm the need for complex diagnostic methods, including AGID, ELISA, and PCR, for the entire livestock. It is necessary to isolate infected animals on time and send them for sanitary slaughter. The control of livestock movement between countries, regions, and farms, especially in the breeding cattle trade, also plays a key role.

It is also recommended to conduct educational programs for veterinarians and farmers on the prevention, biological safety, and economic consequences of BL. The introduction of genetic research to select virus-resistant breeds will reduce the incidence in the long term.

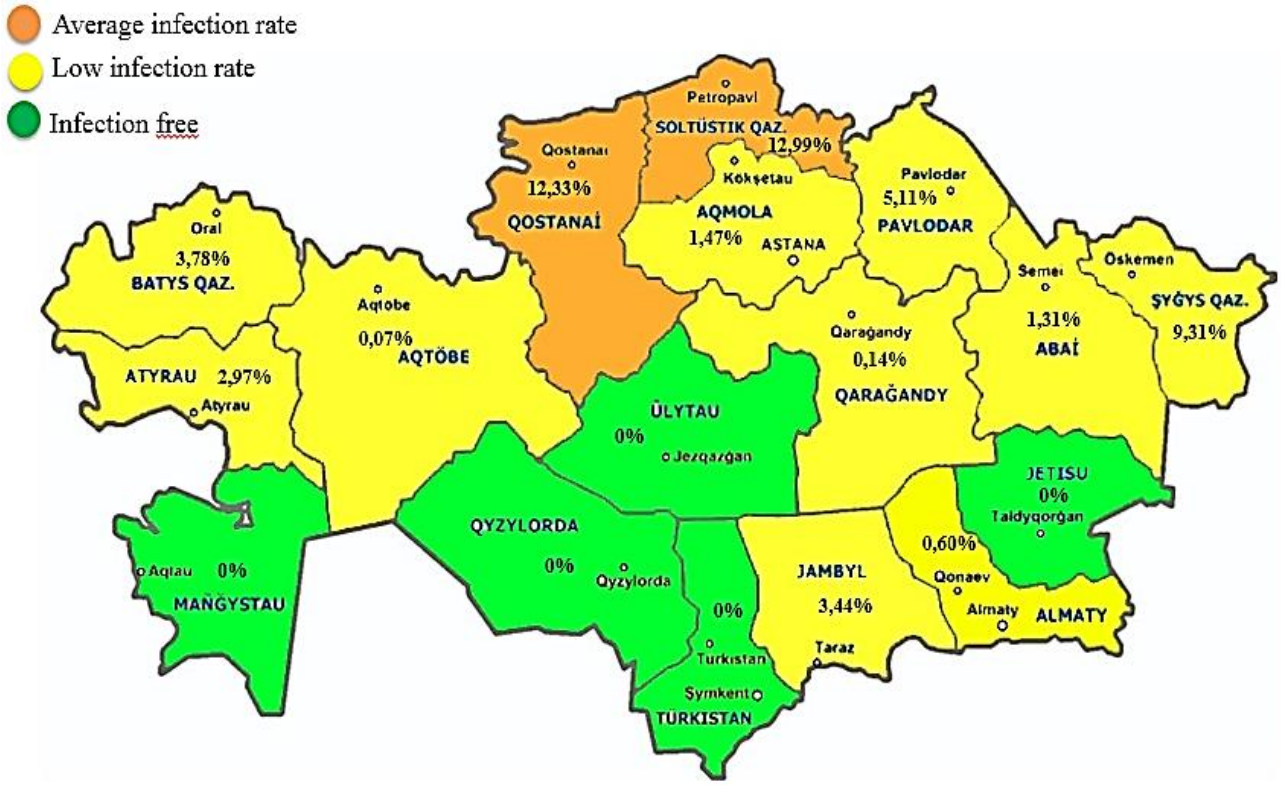

Fig. 5: Geographical distribution of BL infection, by region in 2019-2023.

Thus, our results emphasize the importance of an integrated approach and intersectoral cooperation for successful BL control, contributing to the sustainable development of animal husbandry in Kazakhstan.

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Author's Contribution: Serik Gaynievich Kanatbayev developed the concept and design of this study and participated in writing the article. Ulbolsyn Zhangaziyevna Kuzhebayeva performed the analysis and interpretation of the data and participated in writing the article. Sayat Tulebaevich Baiseitov performed the retrospective processing and participated in writing the article. Maksim Valerievich Petropavlovskiy developed the concept and design of the study, performed the interpretation of the data, and participated in writing the article. Saltanat Bekbosynovna Mamanova performed retrospective processing and participated in writing the article. Dauriya Talapovna Tazhbayeva performed statistical data processing. Izimgali Nurimovich Zhubantayev performed the analysis and interpretation of the data and participated in writing the article. Yerbulat Upievich Baitlessov collected the statistical data. All the authors have read and approved the final version of the manuscript. Aida Tlekovna Daugalieva participated in the data collection. Berikzhan Balapanovich Kaiypbay participated in the data collection.

Data Availability: All the data is available in the article.

Ethics Statement: In this study no live animals were used, thus requires no Ethical approval.

Generative AI statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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REFERENCES

Abdullayev IS, Akhmadeev RG, Avanesian DN and Vaslavskaya IY, 2024. Formation of a strategy for the development of animal husbandry at the regional level (Using the example of maral breeding in the Altai Republic). Siberian Journal of Life Sciences and Agriculture 16(4): 454–474. https://doi.org/10.12731/2658-6649-2024-16-4-1261

Aida Y, Murakami H, Takahashi M and Takeshima SN, 2013. Mechanisms of pathogenesis induced by bovine leukemia virus as a model for human T-cell leukemia virus. Frontiers

in Microbiology 4: 328. http://dx.doi.org/10.3389/fmicb.2013.00328

Akhmedsadykov NN, 2009. Leikoz krupnogo rogatogo skota [Bovine leukemia]. Veterinariya RK 6: 63-67.

Bai L, Yokoyama K, Watanuki S, Ishizaki H, Takeshima SN and Aida Y, 2019. Development of a new recombinant p24 ELISA system for diagnosis of bovine leukemia virus in serum and milk. Archives of Virology 164(1): 201-211. https://doi.org/10.1007/s00705-018-4058-5

Bakhtakhunov YK, 2011. Dinamika rasprostraneniya leikoza krupnogo rogatogo skota v Kazakhstane [Dynamics of the spread of bovine leukemia in Kazakhstan]. Sb. nauch. tr. KazNIVI 57: 98-100.

Bakhtakhunov YK, Baramova SA and Aitlesova RB, 2010. Rasprostranenie i infitsirovannost skota virusom leikoza. In: Kenenbaev SB (ed), Nauchnoe Obespechenie Razvitiya Agropromyshlennogo Kompleksa Stran Tamozhennogo Soyuza: Materialy Mezhdunarodnoy Nauchno-Prakticheskoy Konferentsii [Distribution and Infection of Cattle with the Leukemia Virus. Scientific Support for the Development of the Agro-Industrial Complex of the Countries of the Customs Union: Proceedings of a Research and Practice Conference]. AO "KazAgroInnovatsiya", Astana, Republic of Kazakhstan, pp: 83-88.

Bakhtakhunov YK, Baramova SA and Aitlesova RB, 2011. Leikoz krupnogo rogatogo skota i mery borby s nim [Bovine leukemia and measures to control it]. Vestnik s.-kh. nauki Kazakhstana 12: 52-55.

Bakhtakhunov YK, Mamanova SB, Bizhanov AB and Karabasova AS, 2016. Epizooticheskaya situatsiya po leikozu krupnogo rogatogo skota v Respublike Kazakhstan [Epizootic situation of bovine leukemia in the Republic of Kazakhstan]. In: Aktual'nyye Problemy Sovremennoy Veterinarnoy Nauki i Praktiki: Materialy Mezhdunarodnoy Nauchno-Prakticheskoy Konferentsii, Posvyashchennoy 70-letiyu Krasnodarskogo NIVI [Actual Problems of Modern Veterinary Science and Practice: Proceedings of the International Scientific and Practical Conference Dedicated to the 70th Anniversary of the Krasnodar Veterinary Research Institute]. OOO "Izdatel'skiy Dom - Yug", Krasnodar, Russia, pp: 276-279.

Baramova SA, Bakhtakhunov YK and Mamanova SB, 2011. Rekomendatsii po Laboratornoi Diagnostike i Organizatsii Profilakticheskikh Ozdorovitelnykh Meropriyatii pri LKRS [Recommendations for Laboratory Diagnostics and Organization of Preventive Health Measures for Bovine Leukemia]. Almaty, Republic of Kazakhstan, pp: 20.

Barshevskaya LV, Sotnikov DV, Zherdev AV, Khassenov BB, Baltin KK, Eskendirova SZ, Mukanov KK, Mukantayev KK and Dzantiev BB, 2019. Triple immunochromatographic system for simultaneous serodiagnosis of bovine brucellosis, tuberculosis, and leukemia. Biosensors 9(4): 115. https://doi.org/10.3390/bios9040115

Bartlett PC, Norby B, Byrem TM, Parmelee A, Ledergerber JT and Erskine RJ, 2013. Bovine leukemia virus and cow longevity in Michigan dairy herds. Journal of Dairy Science 96: 1591-1597. https://doi.org/10.3168/jds.2012-5930

Bartlett PC, Ruggiero VJ, Hutchinson HC, Droscha CJ, Norby B, Sporer KRB and Taxis TM, 2020. Current developments in the epidemiology and control of enzootic bovine leukosis as caused by bovine leukemia virus. Pathogens 9(12): 1058. https://doi.org/10.3390/pathogens9121058

Beimisheva GM, 1995. Epizooticheskii protsess pri leikoze krupnogo rogatogo skota [The epizootic process in bovine leukemia]: Author's abstract of a Cand. Vet. Sci. dissertation. Kazakh Research Veterinary Institute of the Kazakh Academy of Agricultural Sciences, Almaty, Republic of Kazakhstan, pp: 11.

Beishova I, Nametov A, Shamshidin A, Belaya A, Ulyanova T, Kovalchuk A, Tegza I, Traisov B, Yuldashbaev Y, Akhmetaliyeva A, Abylqazinova A and Beishov R, 2024. Effectiveness of the use of genetic markers of meat productivity in the Kazakh White-Headed breed identified using genome-wide association study. Online Journal of Biological Sciences 24(3): 624–632. https://doi.org/10.3844/ojbsci.2024.624.632

Blagitz MG, Souza FN, Batista CF, Azevedo LFF, Sanchez EMR, Diniz SA, Silva MX, Haddad JP and Della Libera AMMP, 2017. Immunological implications of bovine leukemia virus infection. Research in Veterinary Science 114: 109-116. https://doi.org/10.1016/j.rvsc.2017.03.012

Borovikov S, Tursunov K, Adish Z, Tokhtarova L and Mukantayev K, 2024. Effects of combined cytotoxic T-lymphocyte antigen 4 and programmed death 1 ligand-receptor blockade on interferon-gamma production in bovine leukemia virus-infected cattle. Veterinary World 17(8): 1672–1679. https://doi.org/10.14202/vetworld.2024.1672-1679

Borovikov SN, Kiyan VS, Baramova ShA, Bachtahunov YC and Zhusambaeva SI, 2010. Optimizatsiya uslovii kultivirovaniya kletochnoi linii FLK dlya narabotki virusa leikoza krupnogo rogatogo skota [Optimization of cultivation conditions of the FLK cell line for the production of bovine leukemia virus]. Vestnik nauki KazATU im. S. Seifullina 1(56): 219-223.

Buehring GC, Shen HM, Jensen HM, Choi KY, Sun DJ and Nuovo G, 2014. Bovine leukemia virus DNA in human breast tissue. Emerging Infectious Diseases 20: 772-782. https://doi.org/10.3201/eid2005.131298

Chaudhary M, Farooq U, Idris M, Lashari MH, Qasim S, Afzal MA, Khan MA and Ali A, 2024. First report on clinical feasibility of dried blood spot technique for hemoglobin estimation in Cholistani cattle. Advancements in Life Sciences 11(3): 663–668.

Daiji Y, Maezawa M, Ishikawa K, Chambers JK, Uchida K and Inokuma H, 2023. Enzootic bovine leukosis caused by bovine leukemia virus classified as Group C based on viral whole genome sequencing in a 23-month-old Holstein-Friesian heifer. The Journal of Veterinary Medical Science 85(12): 1291-1295. https://doi.org/10.1292/jvms.23-0354

Derrar S, Ayad MA, Meliani S, Houari H, Said SM and Safer I, 2020. Comparison between cytology and histopathology to evaluate endometritis in dairy cows. International Journal of Ecosystems and Ecology Science 10(2): 265–270. https://doi.org/10.31407/ijees10.204

Dolz G and Moreno E, 1999. Comparison of agar gel immunodiffusion test, enzyme-linked immunosorbent assay, and western blotting for the detection of BLV antibodies. Zentralbl Veterinarmed B 46(8): 551-559. https://doi.org/10.1111/j.1439-0450.1999.tb01248.x

Erskine RJ, Bartlett PC, Byrem TM, Render CL, Febvay C and Houseman JT, 2012. Association between bovine leukemia virus, production, and population age in Michigan dairy herds. Journal of Dairy Science 95(2): 727-734. https://doi.org/10.3168/jds.2011-4760

Gillet N, Florins A, Boxus M, Burteau C, Nigro A, Vandermeers F, Balon H, Bouzar AB, Defoiche J, Burny A, Reichert M, Kettmann R and Willems L, 2007. Mechanisms of leukemogenesis induced by bovine leukemia virus: Prospects for novel anti-retroviral therapies in human. Retrovirology 4: 18. http://dx.doi.org/10.1186/1742-4690-4-18

Gizitdinov NN, 1975. Itogi nauchno-issledovatelskoi raboty laboratorii virusologii [Results of the research work of the virology laboratory]. In: Infektsionnye, Parazitarnye i Nezaraznye Bolezni Selskokhozyaistvennykh Zhivotnykh v Kazakhstane [Infectious, Parasitic and Non-Infectious Diseases of Farm Animals in Kazakhstan]. Qaynar, Astana, Kazakh SSR, pp: 37-39.

Glazunov Y, Kabitskaya Y, Glazunova L, Donnik I, Boyko E and Vinogradova Y, 2022. Participation of Dermacentor

reticulatus imago in the reservation of bovine leukemia virus. Online Journal of Biological Sciences 22(4): 456–462. https://doi.org/10.3844/ojbsci.2022.456.462

Gnezdilova LA, Panin AN, Pozyabin SV, Selina MV and Borunova SM, 2022. Diagnosis and prevention of infectious animal diseases based on monitoring, molecular diagnostics, and genomics. International Journal of Ecosystems and Ecology Science 12(3): 459–470. https://doi.org/10.31407/ijees12.358

Hamada R, Metwally S, Polat M, Borjigin L, Ali AO, Abdel-Hady AAA, Mohamed AEA, Wada S and Aida Y, 2020. Detection and molecular characterization of bovine leukemia virus in Egyptian dairy cattle. Frontiers in Veterinary Science 7: 608. https://doi.org/10.3389/fvets.2020.00608

Hilmiati N, Ilham N, Nulik J, Rohaeni ES, DeRosari B, Basuki T, Hau DK, Ngongo Y, Lase JA, Fitrawaty F, Surya SC and Oomarniyah N, 2024. Smallholder cattle development in Indonesia: Learning from the past for an outcome-oriented development model. International Journal of Design and Nature and Ecodynamics 19(1): 169–184. https://doi.org/10.18280/ijdne.190119

Hsieh JC, Li CY, Hsu WL and Chuang ST, 2019. Molecular epidemiological and serological studies of bovine leukemia virus in Taiwan dairy cattle. Frontiers in Veterinary Science 6: 427-429. https://doi.org/10.3389/fvets.2019.00427

Ispullaev AI, 2009. Virus leikoza krupnogo rogatogo skota: Struktura, kharakteristika i perspektivy ego genotipirovaniya [Bovine leukemia virus: Structure, characteristics and prospects for its genotyping]. Veterinariya Kazakhstana 2: 47-49.

Kamalieva Y, Mingaleev D, Ravilov R and Zhanabayev A, 2020. Incidence of non-specific tuberculin reactions in cattle in the Republic of Tatarstan in comparison with bovine tuberculosis epizootic situation. BIO Web of Conferences 27: 00104. https://doi.org/10.1051/bioconf/20202700104

Kuczewski A, Orsel K, Barkema HW, Mason S, Erskine R and van der Meer F, 2021. Invited review: Bovine leukemia virus-Transmission, control, and eradication. Journal of Dairy Science 104(6): 6358-6375. https://doi.org/10.3168/jds.2020-18925

Kumar G, Kumar Y, Kumar G and Tahlan AK, 2022. Sero-characterization of intestinal and extra-intestinal Escherichia coli (E. coli) isolates from different geographical locations in India. Research Journal of Pharmacy and Technology 15(11): 5239–5244. https://doi.org/10.52711/0974-360X.2022.00882

Lefkowitz EJ, Dempsey DM, Hendrickson RC, Orton RJ, Siddell SG and Smith DB, 2018. Virus taxonomy: The database of the International Committee on Taxonomy of Viruses (ICTV). Nucleic Acids Research 46(D1): 708-717. https://doi.org/10.1093/nar/gkx932

Mamanova SB, Kutumbetov LB, Bakhtakhunov YK, Smaznova IA, Zayakin VV, Akhmedov RB and Nam IYa, 2015. Razrabotka programmy likvidatsii leikoza krupnogo rogatogo skota v zhivotnovodcheskikh khozyaistvakh Rossii, Kazakhstana i Kirgizii na osnove biotekhnologicheskikh podkhodov [Development of a program for the elimination of bovine leukemia in livestock farms in Russia, Kazakhstan and Kyrgyzstan based on biotechnological approaches]. In: Nam IYa (ed), Innovatsionnye Agrobiotekhnologii v Zhivotnovodstve i Veterinarnoi Meditsine: Materialy I Evraziiskoi Nauchno-Prakticheskoy Konferentsii [Innovative Agrobiotechnologies in Animal Husbandry and Veterinary Medicine: Proceedings of the 1st Eurasian Research and Practice Conference]. Bryansk State University named after Academician I.G. Petrovsky, Bryansk, Russia, pp: 63-68.

Ministry of Agriculture of the Republic of Kazakhstan, 2012. Prikaz Ministra sel'skogo khozyaystva Respubliki Kazakhstan ot 28 marta 2012 goda No. 18-03/128 “Ob utverzhdenii perechney zaraznykh bolezney zhivotnykh, pri kotorykh ustanavlivayutsya ogranichitel'nyye meropriyatiya ili karantin” [Order of the Minister of Agriculture of the Republic of Kazakhstan of March 28, 2012, No. 18-03/128 “On approval of lists of contagious diseases of animals, in which restrictive measures or quarantine are established”]. Retrieved from. https://adilet.zan.kz/rus/docs/V1200007583

Ministry of Agriculture of the Republic of Kazakhstan, 2015. Prikaz Ministra selskogo khozyaistva Respubliki Kazakhstan ot 29 iyunya 2015 goda No. 7-1/587 "Ob utverzhdenii veterinarnykh (veterinarno-sanitarnykh) pravil" [Order of the Minister of Agriculture of the Republic of Kazakhstan of June 29, 2015, No. 7-1/587 "On approval of veterinary (veterinary and sanitary) rules"]. Retrieved from https://adilet.zan.kz/rus/docs/V1500011940

Ministry of Agriculture of the Republic of Kazakhstan, 2024. Osnovnye pokazateli razvitiya zhivotnovodstva v Respubliki Kazakhstan na yanvar-aprel 2024 goda [Key indicators of livestock development in the Republic of Kazakhstan for January-April 2024]. Retrieved from https://www.gov.kz/memleket/entities/moa/documents/details/662583?directionId=1359&lang=ru

Mukanov K, Mukantayev K and Tursunov K, 2024. Role of programmed cell death receptor-1 and cytotoxic T lymphocyte-associated antigen 4 in bovine leukemia virus infection. International Journal of Veterinary Science 13(3): 369–377. https://doi.org/10.47278/journal.ijvs/2023.108

Nekouei O, VanLeeuwen J, Stryhn H, Kelton D and Keefe G, 2016. Lifetime effects of infection with bovine leukemia virus on longevity and milk production of dairy cows. Preventive Veterinary Medicine 133: 1-9. https://doi.org/10.1016/j.prevetmed.2016.09.011

Nikbakht Brujeni G, Houshmand P and Soufizadeh P, 2023. Bovine leukemia virus: A perspective insight into the infection and immunity. Iranian Journal of Veterinary Research 24(4): 290-300. https://doi.org/10.22099/ijvr.2023.48236.7023

Nikolaeva BF, Savitskaya RS and Sakhno VA, 1975. Vliyanie stelnosti na techenie leikoza u korov [The influence of calving on the leukemia process in cows]. Sbornik nauchnych trudov. KazNIVI 16: 208-210.

OIE, 2019. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. World Health Organization for Animal Health, Paris, France, pp: 1113-1124.

Oviedo-Pastrana M, Doria-Ramos M, Mattar S, Oviedo-Socarras T and Vallejo-Timarán D, 2024. Seroprevalence of bovine leukemia virus and association with bovine infectious abortion in Creole breeds from tropical grazing herds in the Colombian Caribbean. Veterinary World 17(8): 1715–1721. https://doi.org/10.14202/vetworld.2024.1715-1721

Panei CJ, Takeshima SN, Omori T, Nunoya T, Davis WC, Ishizaki H, Matoba K and Aida Y, 2013. Estimation of bovine leukemia virus (BLV) proviral load harbored by lymphocyte subpopulations in BLV-infected cattle at the subclinical stage of enzootic bovine leucosis using BLV-CoCoMo-qPCR. BMC Veterinary Research 9: 95. https://doi.org/10.1186/1746-6148-9-95

Petropavlovskiy MV, 2022. Molekulyarno-geneticheskie i immunobiologicheskie svoistva vozbuditelya leikoza krupnogo rogatogo skota v zavisimosti ot geograficheskikh variatsii [Molecular and genetic and immunobiological properties of the causative agent of bovine leukemia depending on geographical variations]: Author's abstract of a Dr. Vet. Sci. dissertation. Ural Federal Agrarian Research Center of the Ural Branch of the Russian Academy of Sciences, Ekaterinburg, Russia, pp: 43.

Piontkovsky VI, Mustafin MK and Khasenov ES, 2002. Leikoz krupnogo rogatogo skota, puti profilaktiki i ozdorovleniya [Bovine leukemia, ways of prevention and recovery]. Vestnik nauki Kostanai 1: 148-154.

Pluta A, Rola-Łuszczak M, Hoffmann FG, Donnik I, Petropavlovskiy M and Kuźmak J, 2024. Genetic variability of bovine leukemia virus: Evidence of dual infection, recombination and quasi-species. Pathogens 13(2): 178. http://dx.doi.org/10.3390/pathogens13020178

Pluta A, Taxis TM, van der Meer F, Shrestha S, Qualley D, Coussens P, Rola-Łuszczak M, Ryło A, Sakhawat A, Mamanova S and Kuźmak J, 2023. An immunoinformatics study reveals a new BoLA-DR-restricted CD4+ T cell epitopes on the Gag protein of bovine leukemia virus. Scientific Reports 13(1): 22356. https://doi.org/10.1038/s41598-023-48899-4

Polat M, Takeshima SN and Aida Y, 2017. Epidemiology and genetic diversity of bovine leukemia virus. Virology Journal 14(1): 209. https://doi.org/10.1186/s12985-017-0876-4

Rudenko EO and Piontkovsky VI, 2015. Epizooticheskaya situatsiya po leikozu krupnogo rogatogo skota, sovershenstvovanie profilaktiki i mery borby s nim v Respublike Kazakhstan i Kostanaiskoi oblasti [Epizootic situation on bovine leukemia, improvement of prevention and control measures in the Republic of Kazakhstan and Kostanay region]. 3i: Intellect, Idea, Innovation - Intellekt, Ideya, Innovatsiya 1: 88-96.

Sakhno VA, Akhmediyarov A, Savitskaya RS and Akhantaev T, 1975. Rezultaty izucheniya epizootologii leikoza krupnogo rogatogo skota v Kazakhstane [Results of the study of the epizootology of bovine leukemia in Kazakhstan]. Sbornik nauchnych trudov KazNIVI 16: 211-213.

Saushkin NY, Samsonova JV, Osipov AP and Kondakov SE, 2019. Strip-dried blood sampling: Applicability for bovine leukemia virus detection with ELISA and real-time PCR. Journal of Virological Methods 263: 101-104. https://doi.org/10.1016/j.jviromet.2018.11.004

Sultanov A, Rola-Łuszczak M, Mamanova S, Ryło A, Osiński Z, Saduakassova MA, Bashenova E and Kuźmak J, 2022. Molecular characterization of bovine leukemia virus with the evidence of a new genotype circulating in cattle from Kazakhstan. Pathogens 11(2): 180. https://doi.org/10.3390/pathogens11020180

Sultanov AA, Kutumbetov LB and Mamanova SB, 2017. Strategiya Borby s Leikozom Krupnogo Rogatogo Skota v Respublike Kazakhstan. Rekomendatsiya [Strategy for Bovine Leukemia Control in the Republic of Kazakhstan. Guidelines]. MSKh RK TOO KazNIVI, Almaty, Republic of Kazakhstan, pp: 1-8.

Sultanov AA, Kutumbetov LB, Bakhtakhunov YK and Mamanova SB, 2015. Meropriyatiya po Profilaktike i Pzdorovleniyu ot Leikoza Krupnogo Rogatogo Skota v Khozyaistvuyushchikh Subektakh Respubliki Kazakhstan. Rekomendatsiya [Measures for the Prevention and Treatment of Bovine Leukemia in Economic Entities of the Republic of Kazakhstan. Guidelines]. MSKh RK TOO KazNIVI, Almaty, Republic of Kazakhstan, pp: 1-30.

Tarik AS and Muhsen RK, 2024. Clinical, hematological and some biochemical alterations of Rotavirus group A in newborn buffalo calves. Advancements in Life Sciences 11(3): 600–606. https://doi.org/10.62949/als.v11i3.2051

Thabet NF, Kandil OM and Farah KM, 2024. Impact of Theileria equi infection on Arabian stallion fertility: Serological and hormonal perspectives. International Journal of Veterinary Science 13(6): 1002–1008. https://doi.org/10.47278/journal.ijvs/2024.196

Tharwat M, Marzok M and Alkheraif AA, 2024. Bovine leukosis: Classification, clinical findings, clinical pathology, diagnosis, necropsy, and control measures. International Journal of Agriculture and Biosciences 13(4): 553–559. https://doi.org/10.47278/ijab/2024.148

Turkeev MK, Mamanova SB, Daugalieva AT, Turgenbayev KA and Kalisynov BS, 2019. Epizootologiya i mery borby s leikozom krupnogo rogatogo skota v Respublike Kazakhstan [Epizootology and measures to control bovine leukemia in the Republic of Kazakhstan]. Sbornik nauchnych trudov KazNIVI 65: 150-157.

Vaslavskiy YI, 2022. Public-Private Partnership: High-Impact alliance for sustainability targets. MGIMO Review of International Relations 15(5): 27–63. https://doi.org/10.24833/2071-8160-2022-5-86-27-63. EDN QQSPJV.

Yang Y, Fan W, Mao Y, Yang Z, Lu G, Zhang R, Zhang H, Szeto C and Wang C, 2016. Bovine leukemia virus infection in cattle of China: Association with reduced milk production and increased somatic cell score. Journal of Dairy Science 99(5): 3688-3697. https://doi.org/10.3168/jds.2015-10580

Zhaksalykov RA, Bayazitova KN, Polyak AI, Kassymbekova LN, Mustafina R and Zabolotnykh MV, 2024. Veterinary and sanitary assessment of milk quality in black-and-white cows fed with extruded compound feeds in North Kazakhstan. Advancements in Life Sciences 11(4): 893–898. https://doi.org/10.62949/als.v11i4.3375

Zhanabayev AA, Nurgaliev BY, Kereyev AK, Paritova AY, Ussenbayev AY, Bayantasova SM, Seitkamzina D, Zhumagalieva GK and Yelemessova B, 2022. Parasite fauna and infection of sheep with parasitosis. Online Journal of Biological Sciences 22(4): 404–414. https://doi.org/10.3844/ojbsci.2022.404.414