P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2024.190

Anaerobic Enterotoxaemia and Sheep Bradsot: Clostridiosis

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Article History: 24-475 Received: 26-Apr-24 Revised: 28-May-24 Accepted: 15-Jun-24 Online First: 02-Jul-24

ABSTRACT

This study aimed to isolate and study several pathogenic clostridia in the Republic of Kazakhstan and to statistically analyze disease outbreaks in each of the regions. Thus, in 2021 and 2022, by taking samples from several regions of the country and subjecting them to bacteriological examination using methods of sampling on Kitt-Tarozzi medium, identification of isolated cultures under the microscope, culture on glucose-blood agar, and conducting bioassays on guinea pigs, several key factors were identified. The result was the characterization of the main cultural and morphological properties of bacteria of the genus Clostridium, such as *Cl. perfringens* (types A, B, SVT, and D), *Cl. septicum* 1098, and *Cl. oedematiens* 34. Also, it was found that the Republic of Kazakhstan was favorable in terms of Bradsotome and anaerobic enterotoxaemia outbreaks. In the last 10 years, there have been only 15, mostly isolated, cases of radsotum in sheep. Anaerobic enterotoxaemia is similar, with 44 cases in 10 years. The only exception was Zhambyl oblast, where the number of cases was 34 (1-8 cases per year). Such statistics are attributed to the continuous vaccination of sheep in unfavorable areas and even areas outside the risk zone. The data will provide insights for improving disease control strategies and can serve as a vaccination impact model for other countries' agricultural settings.

Key words: *Clostridium perfringens, Clostridium septicum,* veterinary, Vaccination, Strain

INTRODUCTION

Maintaining the sustainable welfare of sheep farming for infectious diseases is an important challenge for veterinary science and practice (Derkach and Klymenko 2023). One of the leading sheep-breeding countries in the world is Kazakhstan. As of May 1, 2022, there were 27,017,400 heads of small ruminants in the country. The veterinary welfare of sheep breeding should be considered, considering the forecast of infectious diseases, as the genetic makeup of organisms can change under the influence of selection (Tyrunskiy et al. 2023). The creation of a set of targeted programs dealing with prevention as well as the elimination of dangerous diseases caused by an infection in animals, including anaerobic enterotoxaemia and Bradsotosis in sheep, helps solve veterinary problems at the state level.

A severe non-contagious toxic-infectious disease, which is characterized by hemorrhagic enteritis, kidney damage, nervous system damage, and complete intoxication of the body, is an infectious anaerobic enterotoxaemia of sheep (Enterotoxaemia infectious anaerobic). The causative agent of anaerobic enterotoxaemia is *Cl. perfringens*. The most important clostridial diseases are those caused by *Cl. perfringens.* Different species of this microorganism may cause various human and animal diseases. In 55-85% of incidents of malignant edema in animals and of gas gangrene in humans, *Cl. perfringens* type A is isolated in association with other microorganisms or in its pure form. Malignant oedema is of rapid progression, with intoxication and no time for clinical signs to develop. In malignant edema, rapid progression manifests with severe bloating, foaming at the mouth, and hemorrhagic inflammation of the intestinal and gastrointestinal muscles accompanied by gas formation (Khan et al. 2008; Gorelov et al. 2014; Kapustin 2017). Furthermore, bradycardia and hemorrhages into the abdomen and duodenum are observed (Sklyarov and Kapustin 2017; Sklyarov et al. 2017).

An acute infectious disease characterized by general intoxication, hemorrhagic inflammation of the duodenal and abdominal mucosa, as well as degeneration of the parenchymatous organs and rapid cadaveric decomposition, is Bradsotum in sheep. The main pathogen of Bradsotum in sheep is *Clostridium septicum*, which, in some situations, can increase its population in animals'

Cite This Article as: Mussayeva A, Yegorova N, Abutalip A, Aitzhanov B and Suchshikh V, 2024. Anaerobic enterotoxaemia and sheep Bradsot: Clostridiosis. International Journal of Veterinary Science x(x): xxxx. https://doi.org/10.47278/journal.ijvs/2024.190

livers and gastrointestinal tracts. The pathogen's spores remain in feed, livestock buildings, soil, stagnant water, manure, and sheep's small intestines and stomachs for a long time. Bradsot is reported as sporadic or small outbreaks (Kapustin 2017; Sklyarov and Kapustin 2017; Sklyarov et al. 2017).

The epizootological danger of anaerobic enterotoxaemia and sheep Bradsotis is due to the biological feature of the pathogen's ability to form spores resistant to physical, chemical, and biological factors. The high resistance of Clostridium spores in the external environment is the reason for the formation of soil foci of infection (Abd El-Hack et al. 2022). In places where sheep died of clostridiosis or where burials were made where corpses were burned, clostridium spores contaminate the soil, and, as a consequence, a soil focus of infection is formed (Alimolaei and Ezatkhah 2022). Measures to combat clostridiosis, in particular anaerobic enterotoxaemia and Bradsot, consist of mandatory anti-epizootic measures, which include organizational and economic measures, veterinary and sanitary measures, and special veterinary and preventive measures (Labbe et al. 2014; Omer et al. 2020; Alves et al. 2021). A polyvalent vaccine against Bradsot, anaerobic enterotoxaemia, malignant edema, and anaerobic dysentery is used. There is a vaccine against infectious enterotoxemia in sheep, anaerobic dysentery in lambs, and necrotic enteritis in piglets caused by *Clostridium perfringens* types C and D (GOST 28417-89). Animal vaccination is based on the safety principles of associated vaccines against clostridia (Labbe et al. 2014; Ludecke et al. 2020; Omer et al. 2020; Alves et al. 2021; Alimolaei and Ezatkhah 2022).

MATERIALS AND METHODS

During 2009-2020 at the Kazakh Scientific Research Veterinary Institute, in the course of this work, a number of pathogenic clostridia have been isolated and studied: *Clostridium perfringens* type B; *Clostridium perfringens* type B – strain C-3; *Clostridium perfringens* type D strain number 213; *Clostridium perfringens* type D – strain B-12; *Clostridium perfringens* type C – strain BT; *Clostridium perfringens* type C – "Bacon" compared with the reference strain of *Clostridium chauvoei* R-15; *Clostridium chauvoei* strain C-12; *Clostridium chauvoei* strain Kazakh Research Veterinary Institute No. 01A; *Clostridium chauvoei* B-0290; *Clostridium ovis septicum* 1098; *Clostridium novyi* (*Cl. oedematiens* No. 34, *Cl. oedematiens* P-5); *Clostridium septicum* strain P-8. Their cultural, morphological, tinctorial, biochemical, serological, and biological properties were examined.

During the monitoring of anaerobic enterotoxaemia in 2021 and 2022, in the samples taken from the environment, often in the soil, the presence of the causative agent of anaerobic enterotoxaemia, *Clostridium perfringens*, was found and determined as a result of studies. In 2021, 324 samples were taken: 150 samples from the Almaty region (bioassay length 4-8, width manure, fodder, from environment length 4-8, width soil, standing water, grass); 150 samples from the Turkestan region (bioassay manure, fodder, from environment soil, standing water, grass); 24 soil samples from Aktobe, Mangistau, Almaty (far districts), Karaganda, and Akmola regions. As a result of bacteriological studies of 324 samples, using the methods of seeding samples on Kitt-Tarozzi medium, identification of an isolated culture under a microscope, seeding on glucose-blood agar, and conducting the bioassay on guinea pigs, 3 cultures of *Clostridium perfringens* were identified: 2 cultures from the Almaty region, and 1 culture from the Turkestan region.

In 2022, 687 samples were taken (170 samples from Kyzylorda, 160 samples from Turkestan, 160 samples from Zhambyl, 110 samples from Almaty, 45 samples from Karaganda, 27 samples from the Western Kazakhstan region, and 15 samples from Aktobe region). As a result of bacteriological studies, using the methods of seeding samples on Kitt-Tarozzi medium, identification of an isolated culture under a microscope, seeding on glucose-blood agar, and conducting the bioassay on guinea pigs, 3 cultures of *Clostridium perfringens* were identified: 1 culture from Almaty region, and 2 cultures from Zhambyl region. Thus, as a result of monitoring studies for 2021-2022, out of 1011 samples studied, 6 epizootic cultures were isolated from the soil of the Zhambyl, Almaty, and Turkestan regions, which is a potential source for infecting animals.

According to statistical data for the last 10 years (2012-2021), 44 cases of anaerobic enterotoxaemia were registered, of which 34 were in the Zhambyl region. The remaining 10 cases of the disease were distributed among the vaccinated regions (3 cases in Almaty, 2 cases in Kyzylorda, 2 cases in Mangistau, 2 cases in the Aktobe region, and 1 case in East Kazakhstan in 2021). Aktobe and East Kazakhstan region until 2021 referred to the safe regions without vaccination.

RESULTS AND DISCUSSION

In stained smears, *Clostridium perfringens* type D appears as a short, thick bacillus with slightly rounded or cupped ends. It is polymorphic, often taking the form of cocci. On blood agar, the colonies initially resemble dewdrops and later turn greyish. Forms large, oval, central, or subterminal spores. A serological group is established using type D *Clostridium perfringens* serum. When cultured in dense media, delicate, flaky colonies grow in the deep layer of nutrient agar, with intense gassing resulting in the rupture of the agar column. The causative agents of malignant oedema in animals and Bradsot in sheep *Cl. septicum* is mobile, which was established by seeding on semisolid agar in which colonies grew in the form of intertwined, like twisted threads. *Clostridium septicum*, the causative agent of malignant oedema in animals and Bradsot in sheep, ferments salicin and does not ferment sucrose when sown on Hiss medium with various carbohydrates, which distinguishes it from *Clostridium chauvoei*. *Clostridium septicum* (*Vibrio septique*) is the main of the group of causative agents (*Cl. oedematiens*, *Cl. berfringens*, *Cl. hystoliticus*, and the non-pathogenic anaerobe *B. sporogenes*) of gas oedema in animals. It causes malignant oedema in animals and Bradsot in sheep. It is often found in decaying materials, such as soil, hay, and straw (Brook 1995; Kapustin et al. 2013; Kapustin 2017; Knapp et al. 2020; Ludecke et al. 2020; Abd El-Hack et al. 2022; Hussain et al. 2022).

Table 1 provides comparative biological characteristics of clostridium cultures: cultural, tinctorial, morphological, and biochemical. *Clostridium perfringens* strain B.12 was isolated from the mesenteric lymph node of 2-year-old sheep from experimental farm n.a., Mynbaev, Karasai district of Almaty region. When sown on Kitt-Tarozzi medium and cultured at 37 ℃, the growth of clostridia is accompanied by a uniform turbidity of the medium, abundant gas formation, emitting the characteristic smell of rot. Samples from such tubes were taken for smear preparation, stained by Gram stain, and examined under a microscope at objective 7, magnification 100, under immersion. The strain is pathogenic for laboratory animals, lambs, and sheep. For further differentiation, the culture of *Clostridium perfringens* was seeded on Zeisler's glucose-blood agar, where haemolysis of blood erythrocytes occurs under the influence of the growing culture. The final diagnosis was made by bioassay. The pathogen of anaerobic enterotoxaemia is pathogenic for all kinds of laboratory animals. It causes the death of guinea pigs by intramuscular injection at a dose of $2.5*10^7$ microbial bodies. White mice die within 2h to 10h after intravenous injection of a 6h to 18h culture at a dose of 0.3ml to 0.5ml; guinea pigs die within 24h to 72h after intramuscular injection at a dose of 1ml to 2ml. A pure culture of *Clostridium perfringens* was isolated from the organs of the dead guinea pigs. The number of cases of anaerobic enterotoxaemia is shown in Table 2.

According to Table 2, in 4 regions of the Republic of Kazakhstan that are unsafe with vaccination (Almaty, Turkestan, Kyzylorda, and Mangistau), 1-3 cases were registered over the past 10 years. In the Zhambyl region, 34 cases of the disease were registered over 10 years (1-8 cases/year). Since 2022, the Aktobe region and East Kazakhstan region belong to regions that are being vaccinated against anabolic enterotoxaemia. Thus, there are 9 vaccinated regions (together with those created): Kyzylorda, Mangystau, Almaty, Turkestan, Zhambyl, the Zhetisu region, Aktobe, East Kazakhstan, and the Abay region. The region of negligible risk includes 8 safe regions

Table 1: Main cultural and morphological properties of bacteria in the genus *Clostridium*

Properties of the bacteria strain	Characteristics of the *Cl. perfringens* species strain (types A, B, CBT, and D)	Characteristics of the *Cl. septicum* 1098 species strain	Characteristics of the *Cl. oedematiens* 34 species strain
The size of the microbe	Length – 4-8, width – 1.5	Length – 4-8, width – 2-10, width Length – 4-8, width – 0.8-1.1	
The shape of bacilli	Isolated, thick, sometimes short bacilli with rounded ends	Isolated bacilli, often as filaments	
Shape and location of spores	Oval; centrally, terminally, sub-terminally	Oval; centrally, terminally, sub-terminally	Oval; centrally, terminally, sub-terminally
Resistance to boiling (minutes)	80-90	2-15	Up to 60
Gram staining	+	+	+
Mobility	-	+	+
Growth forms on liquid medium under Vaseline oil (MPLB)	Gas formation, turbidity of the medium	Gas formation, turbidity of the medium	Gas formation, turbidity of the medium
In the brain medium	No blackening.	No blackening.	No blackening.
Milk	Clotting is active	Clotting is slow, the clot is loose, spongy, immersed in the whey	Clotting is slow, small flakes
Clotted whey	Slightly and slowly liquefying	Does not liquefy	Does not liquefy
Gelatine	Liquefies on day 3-5	Liquefies after 48 hours	Liquefies after 2-4 hours
Form of colonies on blood agar	Round, juicy, greyish, oval, green, with a zone of haemolysis	Delicate lace plaque, twisted threads, curls, with a zone of haemolysis	Rough, convex in the centre, fringed with a zone of haemolysis
Shape of colonies in the column (deep layer of agar) (nutrient agar)	Disc-shaped, lenticular, sometimes shaggy	Flaky, round with branched sprouts	Fluffy colony, with a centre and thin threads

Table 2: Number of cases of anaerobic enterotoxaemia

Areas	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Almaty	1	-	-	-	-	-	-	-	-	2	3
Aktobe	-	-	-	1	-	-	-	1	-	-	2
Akmola	-	-	-	-	-	-	-	-	-	-	-
Atyrau	-	-	-	-	-	-	-	-	-	-	-
Mangistau	-	1	-	-	-	-	1	-	-	-	2
Kyzylorda	-	-	-	2	-	-	-	-	-	-	2
Turkestan	-	-	-	-	-	-	-	-	-	-	-
Zhambyl	8	3	4	4	-	5	1	7	-	2	34
East Kazakhstan Region (EKR)	-	-	-	-	-	-	-	-	-	1	1
Pavlodar	-	-	-	-	-	-	-	-	-	-	-
Northern Kazakhstan Region (NKR)	-	-	-	-	-	-	-	-	-	-	-
Karaganda	-	-	-	-	-	-	-	-	-	-	-
Western Kazakhstan Region (WKR)	-	-	-	-	-	-	-	-	-	-	-
Kostanay	-	-	-	-	-	-	-	-	-	-	-
TOTAL	9	4	4	7	-	5	2	8	-	5	44

of Kazakhstan, where for the last 10 years the disease has not been registered and animal vaccination has not been carried out (Akmola, Atyrau, WKR, NKR, Karaganda, Ulytau, Kostanai, and Pavlodar). Low-risk regions are 8 unsafe regions of Kazakhstan, where single cases of animal disease were registered and vaccination was conducted (Kyzylorda, Turkestan, Mangistau, Almaty, Zhetisu, East Kazakhstan, the Abay region, and the Aktobe region). The region, which is an unsafe zone for vaccination, should be attributed to the medium-risk region. There is no high-risk region in the republic.

In the bacteriology laboratory of Kazakh Research Veterinary Institute, a culture of *Cl. septicum* was isolated from delivered pathological material from a 6-month-old lamb that was deceased from Bradsot, from a private owner of the experimental farm n.a. Mynbaev, Karasai district, Almaty region. Bacteriological examination was carried out by seeding the pathological material into nutrient media: meat peptone broth, nutrient agar, meat peptone liver broth, and culture in the thermostat at 37 ℃. In liver broth with liver pieces and Vaseline oil, as well as in semi-liquid agar, the culture grew abundantly, causing uniform turbidity of the medium and gas formation. After 48 hours, the microbes had settled to the bottom of the test tube, and the broth was clear. Prints from the liver and a smear of microbes deposited at the bottom of the test tube were Gram-stained, and Gram-positive microbes with rounded ends arranged in chains shaped as long threads were observed under a microscope. The microbe did not form capsules. The spores were oval, central, subterminal, or free-lying.

In order to identify the isolated culture, an inoculation on cerebrospinal medium and coagulated serum were made. After 18 to 20 hours after seeding, it was observed that the medium and serum had not changed. In a deep layer of gelatine and sugar agar, the culture grew as cotton flakes or snowflakes. Some colonies had a dense centre. The tested anaerobes, when sown on blood agar with glucose, grew as tender colonies with sprouts and caused haemolysis. Some colonies were surrounded by a visible zone of haemolysis, light yellow-coloured.

Cl. septicum culture is pathogenic for all laboratory animals, especially guinea pigs. To study biological properties, 3 guinea pigs weighing 350 to 450 g were used, which were infected under the skin with a daily culture of *Cl. septicum* at a dose of 0.25 to 0.5 ml. Clinical signs of the disease appeared after 8 to 12 hours. The abdominal bloating was observed, hair was easily removed from the injection site, and reddish fluid was observed on the skin. The animals died after 18h to 20h. At the autopsy of guinea pig corpses, oedema, haemorrhagia of subcutaneous tissue, and bloating of the intestines were observed. *Cl. septicum* coagulates milk, does not alter coagulated serum, and does not blacken on brain medium. It decomposes glucose, lactose, fructose, maltose, mannose, and salicin, resulting in the formation of gas and acid. It does not ferment sucrose, glycerol, or mannitol. The absence of sucrose fermentation is used in the differentiation of *Cl. chauvoei*.

The epizootic situation on the Bradsot of sheep has been studied. The epizootic situation for Bradsot in sheep in the Republic of Kazakhstan is assessed as safe. According to the statistical data of the Veterinary Control and Supervision Committee of the Ministry of Agriculture of the Republic of Kazakhstan for the past 10 years, there have been registered rare single cases of Bradsot in sheep (Musaeva et al. 2022). From Table 3, it follows that for 10 years, a total of 15 cases of Bradsot were registered. Among these, 14 cases occurred in sheep, and 1 case was spotted deer in the Borabay district of Bugy-Burabay r/d of Akmola region, with the antler production centre. In 10 years, sporadic cases of the disease were registered. The highest number of outbreaks of sheep Bradsot were observed in 2013 and 2021 (4 cases each) and in 2014 (3 cases). In 2015, 2016, 2019, and 2022, no cases of sheep Bradsot were observed in the territory of the Republic.

Based on the results of the study of the epizootological situation of sheep Bradsot, the territory of the republic was zoned into two zones: a zone of stable well-being, where sheep Bradsot have not been registered for more than 10 years (8 regions), and a low-risk zone characterized by relative safety regarding the sheep Bradsot, with occasional registration of sporadic cases that do not spread (6 regions). There is no zone of medium or high degree of occurrence and spread of sheep Bradsot in the Republic of Kazakhstan. Animals are vaccinated in areas of low risk, which include the southern and south-eastern regions of Kazakhstan (Almaty, the Zhetisu region, Zhambyl, and Turkestan). In areas of unsafe regions, the annual vaccination of small

Table 3: Epizootological characteristics of the territory of the Republic of Kazakhstan on sheep Bradsot for 2012-2021

Name of regions	Years									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Akmola	-	1	-	-	-	-	-	-	-	-
Almaty	-	1	1	-	-	-	-	-	-	2
Atyrau	-	-	-	-	-	-	-	-	-	-
Aktobe	-	-	-	-	-	-	-	-	-	-
East Kazakhstan	-	-	1	-	-	-	-	-	-	-
Zhambyl	1	-	-	-	-	-	-	-	1	2
West Kazakhstan	-	-	1	-	-	1	1	-	-	-
Karaganda	-	-	-	-	-	-	-	-	-	-
Kostanay	-	1	-	-	-	-	-	-	-	-
Kyzylorda	-	-	-	-	-	-	-	-	-	-
North Kazakhstan	-	-	-	-	-	-	-	-	-	-
Mangistau	-	-	-	-	-	-	-	-	-	-
Pavlodar	-	-	-	-	-	-	-	-	-	-
Turkestanskaya	-	1	-	-	-	-	-	-	-	-
Total	1	4	3	-	-	1	1	-	1	4
Total for the republic for 10 years	15 cases of Bradsot									

ruminants in March against Bradsot is conducted in accordance with the approved vaccination plan, 20 days before putting animals on pasture. Areas of stable well-being on the Bradsot of sheep include the northern, eastern, western and central regions of Kazakhstan. Vaccination of sheep against Bradsot is not conducted in the territory of safe areas, except for Kyzylorda and Mangistau regions. Repeatability of Bradsot is established in Almaty and Zhambyl regions, where annual vaccination of sheep is carried out. During the bacteriological examination of 1005 samples of material collected in 2021-2022 from environmental objects (soil, feed, manure, grass, and water from non-flowing water bodies), 5 cultures of the sheep Bradsot pathogen *Clostridium septicum* were identified. The Bradsot pathogen was found in soil samples from Almaty region, Zhambyl region, and Turkestan region.

Anju et al. (2021) proved that the most important clostridium species for sheep are *C. perfringens, C. botulinum, C. tetani, C. sordellii, C. septicum,* and *C. oedematiens*. The main bioparticularity of pathogenic clostridia is their ability to create highly active toxins. Each of these clostridium species is widely distributed in nature, particularly in humus-rich soil, with *C. perfringens* being the most prevalent due to its limited number of toxin types. Similar characteristics can be observed in studies of anaerobic enterotoxaemia and Bradsotosis in sheep. At the same time, Moustafa et al. (2022) indicated that the causative agent of Bradsotum was *C. septicum*, a motile bacilliform bacterium with oval spores consisting of single cells or in pairs. It presents as elongated filaments in serous membrane smears. In long-term cultures, stains are Gram-negative with the formation of central or subterminal spores of rounded shape without capsules.

Jiang et al. (2020), in their experiments, noted that Bradsotum is recorded as sporadic incidents or small outbreaks. In the natural environment, sheep are vulnerable, irrespective of sex and age. The disease can be observed all year round, but spring and autumn are the most dangerous, and in summer only in the year of drought. Sources of spread of the pathogen are dead animals that have fallen as a result of the disease, standing water, pasture land, and hay from areas infected with bradsite that have become infected through contact with the pathogen. A Bradsot outbreak affects about 30 to 35% of sheep, and fatalities occur in 90 to 100% of cases. This study complements the previously provided results, enabling a more precise understanding of the distribution and impact of Bradsotum in sheep.

Morandi et al. (2022) explained that the initiators of anaerobic enterotoxaemia are rather large, thickened, immobile bacilli with clipped or slightly rounded ends. Filamentous or cocci-form forms of the bacteria can be found on protein- and carbohydrate-rich media. Gram-positive bacteria are found in young cultures of microorganisms, while gram-negative bacteria are found in older ones. The bacteria form a capsule inside sheep under growth conditions on media containing blood serum. The spores are sub-thermally or centrally located in the external environment. In a growth situation on Kitt-Tarozzi medium containing glucose, strong gas formation and culture growth can be seen, which are accompanied by a measured turbidity. Three stable variations of *Cl. perfringens* colonies can be distinguished: rough, slimy, and smooth. At the beginning of growth, the colonies may look like small dewdrops on the agar surface, but afterwards they are no longer transparent and take on a whitish or greyish colouration. This is also confirmed in the studies cited above.

Marks et al. (2011), referring to the epizootological situation of Bradsot and anaerobic enterotoxaemia in Germany, pointed out that the number of diseases and adverse sites for clostridia have been decreasing rapidly during the last decade. The incidence of anaerobic enterotoxaemia has fallen by 87.9% in 10 years compared with 2012, *emphysema carbunculosis* by almost 95%, and malignant oedema by around 70%. This is coupled with the situation worldwide and in Kazakhstan in particular.

Forming statistics on Kazakhstan's neighbour, Uzbekistan researchers Redding et al. (2021) gave their data. The number of secondary adverse factors detected for these diseases decreased by 2022 compared to 2012. Thus, the number of adverse events for anaerobic enterotoxaemia in sheep decreased by almost 25 times during the period under study and for malignant oedema by 8 times. As for brucellosis, the detection of infection varies considerably, but in the last few years, it has been equally marked by sporadic cases. This shows that everywhere the situation tends to improve and gives an insight into the world situation regarding Bradsotis and anaerobic enterotoxaemia.

Giles and Roberts (2022) said that it is important to note that data from official sources does not fully reflect the real situation related to the incidence of *Clostridium difficile* disease in animals. This is because reporting by farmers to the State Veterinary Service in situations where it can be proven that bradsite initiators and anaerobic enterotoxaemia are present in the samples taken, can lead to high economic losses and limited interventions. As a consequence, owners prefer to have diagnostics carried out in a large number of commercial diagnostic centres, or else to avoid the death of animals. These observations are very important when generating disease statistics in the Republic of Kazakhstan.

Conclusion

Studies have found that the epizootic situation of sheep Bradsot in Kazakhstan was assessed as favourable. An insignificant percentage of soil contamination with pathogen spores (0.49%) in the southern and south-eastern regions belonging to low-risk levels was established. Based on the study of the epizootic situation of Bradsot, statistical data, and repeatability records of Bradsot outbreaks, a forecast about the threat of outbreaks of single cases in the southern and south-eastern regions of the country can be made. A favourable forecast is determined by the quality of prophylactic measures taken and the coverage of sheep vaccination on unsafe farms.

Thus, the patterns of the epizootic process in anaerobic enterotoxaemia and Bradsot are influenced by the trends and features of the disease: the increase in the number of outbreaks, the dependence of the disease on certain natural or economic conditions; the structure of anaerobic enterotoxaemia and Bradsot outbreaks in sheep and its compliance with the percentage of small cattle livestock; the ratio of outbreaks among animals of different ages; characteristics of disease outbreaks; stationarity of the

disease; the ratio of outbreaks among sheep kept in public and private use (farms, household plots); the ratio of outbreaks of anaerobic enterotoxaemia and Bradsot among vaccinated and unvaccinated animals. The generalization of the data obtained makes it possible to establish the frequency and pattern of the spread of infections. It should be noted that a favorable prognosis depends on the immunogenicity of the vaccines used, which form stable immunity for 6 months, the bactericidal and sporicidal activity of the disinfectants used, the availability of a full-fledged material and technical base, and the effectiveness of the veterinary and sanitary measures taken.

Author's Contribution

AM: supervision, conceptualization, project administration; NY: resources, project administration; AA: visualization, methodology; BA and VS: validation, formal analysis. AM, NY, AA, BA and VS: writing – review & editing, writing – original draft.

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