

GEOINFORMATION ANALYSIS OF SEASONAL AND SPATIAL DYNAMICS OF ASSOCIATIVE HELMINTHIASIS OF SHEEP IN WEST KAZAKHSTAN REGION

ГЕОИНФОРМАЦИОННЫЙ АНАЛИЗ СЕЗОННОЙ И ПРОСТРАНСТВЕННОЙ ДИНАМИКИ АССОЦИАТИВНОГО ГЕЛЬМИНТИАЗА ОВЕЦ В ЗАПАДНО-КАЗАХСТАНСКОЙ ОБЛАСТИ

N. T. ABEKESHEV, ZH. T. USENOV, R. G. ABDRAKHMANOV, Z. S. AITPAYEVA,
M. A. SVOTINA, ZH. M. VALIYEVA, ZH. K. RYSKALIYEVA, A. S. AITKALIYEV

НАО «Западно-Казахстанский аграрно-технический университет им. Жангир хана»,
г. Уральск, Республика Казахстан, 090009, e-mail: nurzhan_1962@mail.ru, zhadyrarskiyeva98@gmail.com

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This article presents a comprehensive assessment of the seasonal and spatial dynamics of helminth infections in sheep in the West Kazakhstan Region using geographic information systems (GIS). An analysis of the extent of infection (EI) and intensity of infection (II) was conducted by administrative district and animal age group.

It was established that helminth infections are characterized by pronounced seasonality: minimum values of EI and II are observed in the winter, while maximum values occur in the summer-fall season. The highest parasite load was found in sheep older than 3 years, which is associated with prolonged grazing and the accumulation of infection.

Additionally, the contamination of pasture ecosystems (soil, vegetation, and water sources) was studied. It was found that soil is the main reservoir of infective material, especially in arid zones. Vegetation contamination was recorded primarily in steppe regions, whereas the role of water sources is limited to specific seasons.

The results confirm the importance of spatial analysis for identifying epizootically hazardous zones and justifying preventive measures, taking into account the region's natural and climatic conditions.

Key words: associative helminthiasis, sheep, extent of invasion, intensity of invasion, seasonal dynamics, spatial analysis.

В данной статье представлена комплексная оценка сезонной и пространственной динамики гельминтозных инфекций у овец в Западно-Казахстанской области с использованием географических информационных систем (ГИС). Проведен анализ степени инфицирования (СИ) и интенсивности инфицирования (ИИ) по административным районам и возрастным группам животных.

Установлено, что гельминтозные инфекции характеризуются выраженной сезонностью: минимальные значения СИ и ИИ наблюдаются зимой, а максимальные – в летне-осенний период. Наибольшая паразитарная нагрузка была обнаружена у овец старше 3 лет, что связано с длительным выпасом и накоплением инфекции.

Кроме того, было изучено загрязнение пастбищных экосистем (почвы, растительности и источников воды). Установлено, что почва является основным резервуаром инфекционного материала, особенно в засушливых зонах. Загрязнение растительности было зафиксировано преимущественно в степных регионах, тогда как роль источников воды ограничивается определенными сезонами.

Результаты подтверждают важность пространственного анализа для выявления эпизоотически опасных зон и обоснования профилактических мер с учетом природных и климатических условий региона.

Ключевые слова: ассоциативный гельминтоз, овцы, масштабы инвазии, интенсивность инвазии, сезонная динамика, пространственный анализ.

Introduction

Helminth infections in sheep represent one of the most significant problems in pastoral livestock farming, causing reduced productivity and economic losses in various regions of the world. Recent studies show that the development and spread of gastrointestinal nematodes are directly linked to the ecological characteristics of grazing systems and environmental conditions.

Climatic factors, including temperature and humidity, play a key role in shaping the seasonal dynamics of infestation by influencing the survival of free-living stages of parasites in pastures. Changes in climatic conditions also intensify the epizootic activity of helminths and alter the structure of animal infection [1, 2, 3].

The spatial distribution of helminth infections is highly heterogeneous and depends on grazing density, pasture structure, and the ecological conditions of the areas. These patterns are confirmed by recent studies of geospatial modeling of parasitic systems in ruminants [4, 5, 6].

Geographic Information Systems (GIS) are currently widely used in veterinary parasitology to analyze the spatial distribution of infections, identify risk zones, and model epizootic situations [7].

Despite significant advances in the methods of diagnosing and modeling helminth infections [8, 9], the spatiotemporal dynamics of mixed helminth infections in sheep in the West Kazakhstan Region remain understudied.

In this regard, the aim of this study is to conduct a systematic analysis of the seasonal and spatial characteristics of associated helminth infections in sheep in the West Kazakhstan region using GIS mapping methods and an assessment of the contamination of pasture ecosystems.

Materials and methods

The study of associated helminth infections in sheep was conducted in 2025–2026 in the West Kazakhstan Region, covering the Baiterek, Terekta, Syrym, Akzhaik, and Karatobe districts, which represent various natural

and climatic zones (steppe, semi-desert, and desert). These territories were selected due to the pronounced zonal heterogeneity of pasture ecosystems, which has a significant impact on the formation of parasitic systems.

The study subjects were sheep of various age groups: lambs under 1 year old, animals aged 1–3 years, and those over 3 years old. The sample was selected based on the principles of representativeness and coverage of the main categories of the flock, in accordance with generally accepted approaches in veterinary parasitology [10, 11].

The study materials consisted of animal feces, soil samples, pasture vegetation, and water from natural and temporary water bodies. Sampling was conducted during different seasons of the year to identify seasonal trends in infestation.

Helminthological studies were performed using classical methods: ovoscopy and flotation methods to detect helminth eggs, quantitative methods to assess the intensity of infestation (eggs/g of feces), and laboratory analysis of environmental samples for the presence of invasive stages of parasites [12].

Helminths were identified based on morphological characteristics using identification guides and diagnostic keys. The primary focus was on gastrointestinal strongyles and cestodes of the genus *Moniezia*, which are widespread in sheep grazing systems [13].

Contamination of environmental samples was quantified as follows: in soil, by the number of helminth eggs (eggs/g); in water, by the number of eggs (eggs/L); and in vegetation, by the presence or absence of contamination. Geographic Information Systems (GIS) were used to analyze the spatial distribution and seasonal dynamics of the infestation. Mapping was performed in QGIS using visualization methods in which the extent of infestation was represented by color gradation, and the intensity by the size of symbols. The use of GIS technologies allows for the identification of spatial patterns of parasite distribution and is widely applied in epizootiological studies. Statistical data analysis included the calculation of mean values (M) and standard deviations ($\pm m$), as well as a comparative analysis of indicators depending on the season, age of the animals, and natural and climatic conditions [14].

Results

The findings indicate that helminth infections in sheep in the West Kazakhstan Region are influenced by a combination of natural, climatic, and economic factors and are characterized by marked seasonal and spatial variability. To visually analyze the seasonal dynamics of associated helminth infections in sheep, a GIS map was created showing the spatial distribution of the extent of infection (EI) and the intensity of infection (II) across districts of the West Kazakhstan Region during different seasons of the year. Color gradation was used to represent the level of infestation extensivity, while the size of the symbols characterized the intensity of infestation (Figure 1).

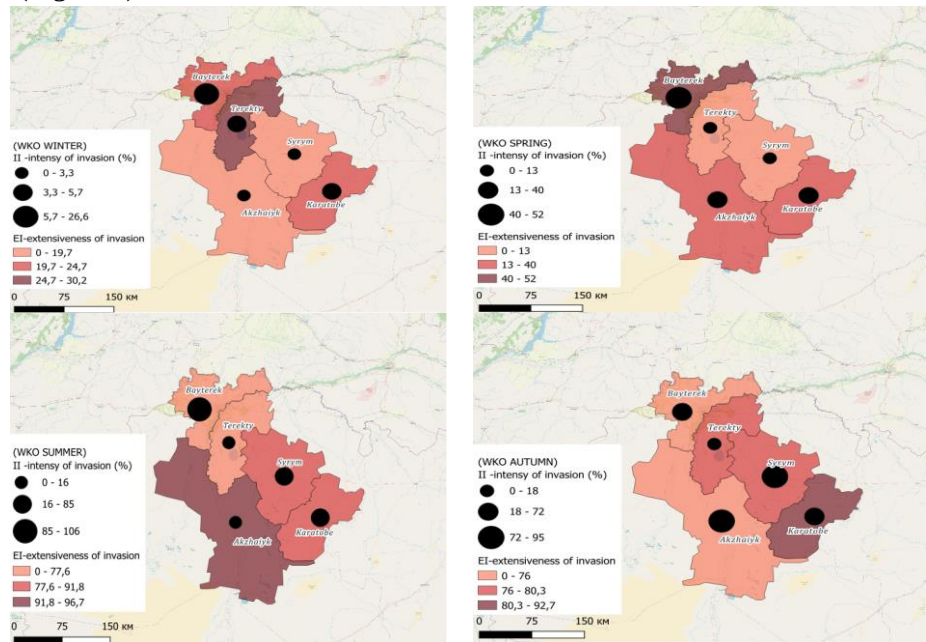


Figure 1. GIS visualization of the seasonal dynamics of the prevalence (EI) and intensity (II) of associated helminth infections in sheep in the West Kazakhstan Region

Analysis of the data presented in Figure 1 showed that during the winter period, the lowest rates of infestation were recorded in all districts of the region. In the spring, an increase in the extent and intensity of infestation was observed, associated with the activation of the parasites' life cycle and the start of grazing. The highest values of the indicators were recorded during the summer, indicating the peak of the epizootic process. Particularly high values of infestation intensity were observed in the Baiterek and Karatobe districts,

indicating the significant role of local grazing conditions in the formation of infection foci. Similar trends have been described in studies on the dynamics of strongylosis in ruminants.

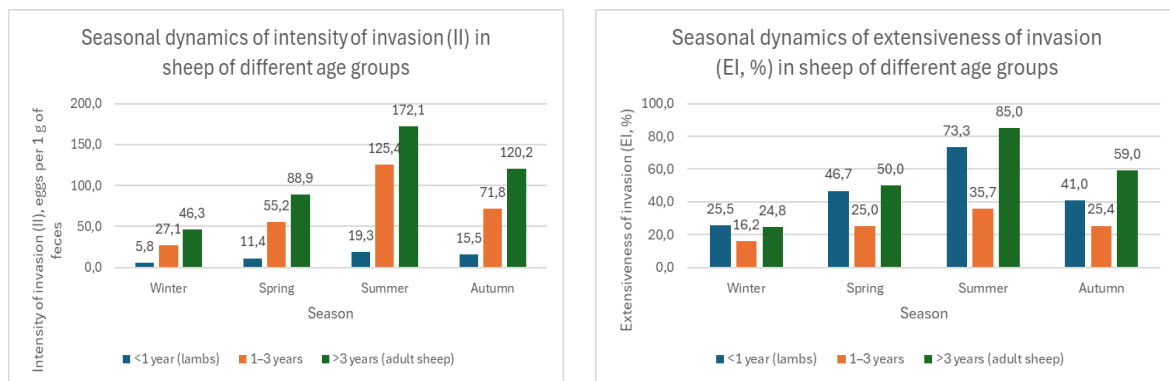


Figure 2. Seasonal trends in the extent of infestation (EI, %) in sheep of various age groups

Age analysis revealed that the highest values of infestation extent are recorded in sheep older than 3 years during the spring, summer, and fall periods, which is associated with the cumulative effect of prolonged contact with a contaminated environment (Figure 2). Lambs under 1 year of age are characterized by high susceptibility, manifested by relatively high infestation extent despite low infestation intensity. This relationship indicates early infection and functional immaturity of the immune system.

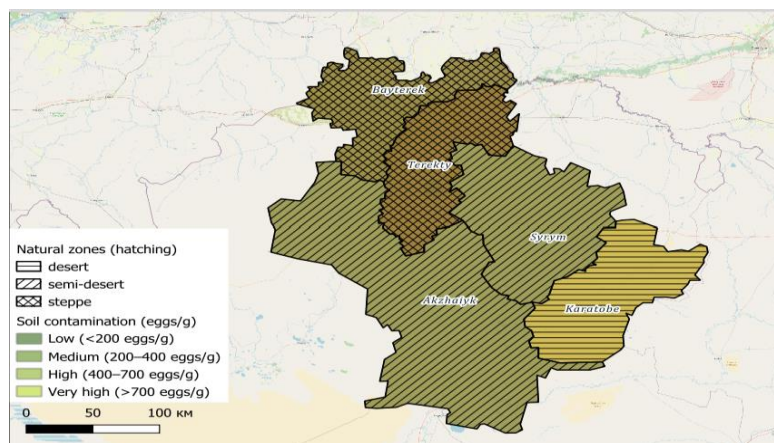


Figure 3. Soil contamination with helminths in the pasture ecosystems of the West Kazakhstan Region

The map shows the distribution of soil contamination levels with helminth eggs (eggs/g) in various natural zones of the region. It has been established that the highest levels (>700 eggs/g) are recorded in the Karatobe District, which belongs to the desert zone. In semi-arid districts (Syrym, Akzhaiyk), high and moderate contamination levels (200–700 eggs/g) are observed, whereas in steppe districts (Baiterek, Terekta), moderate values (200–400 eggs/g) predominate (Figure 3). The observed spatial differentiation is due to both natural and climatic conditions and the specific patterns of pasture use, including the concentration of livestock near water sources. The data presented in Figure 2 demonstrate that the highest levels of soil contamination are observed in desert and semi-desert regions. This is associated with the uneven distribution of grazing pressure and the concentration of animals near water sources.

The data in the table indicate a marked regional variation in the level of soil contamination with helminth eggs. The highest level of contamination (>700 eggs/g) and, consequently, a very high epizootic risk were observed in the Karatobe District, which is located in a desert zone. In semi-arid districts (Syrym, Akzhaiyk), high and moderately high contamination rates (300–700 eggs/g) were recorded, accompanied by an elevated epizootic risk. These territories are characterized by the formation of mixed infestations involving strongyles and members of the genus *Moniezia* (Table 1).

Table 1. Soil contamination with helminths by region

District	Natural zone	Soil contamination (eggs/g)	Epizootological risk	Dominant helminths
Bayterek	Steppe	Medium (200–400)	Medium	Gastrointestinal strongylates
Terekty	Steppe	Medium (200–400)	Medium	Gastrointestinal strongylates
Karatobe	Desert	Very high (>700)	Very high	Gastrointestinal strongylates
Syrym	Semi-desert	High (400–700)	High	Strongylates + <i>Moniezia</i>
Akzhaiyk	Semi-desert	Medium-high (300–500)	Medium-high	Strongylates + <i>Moniezia</i>

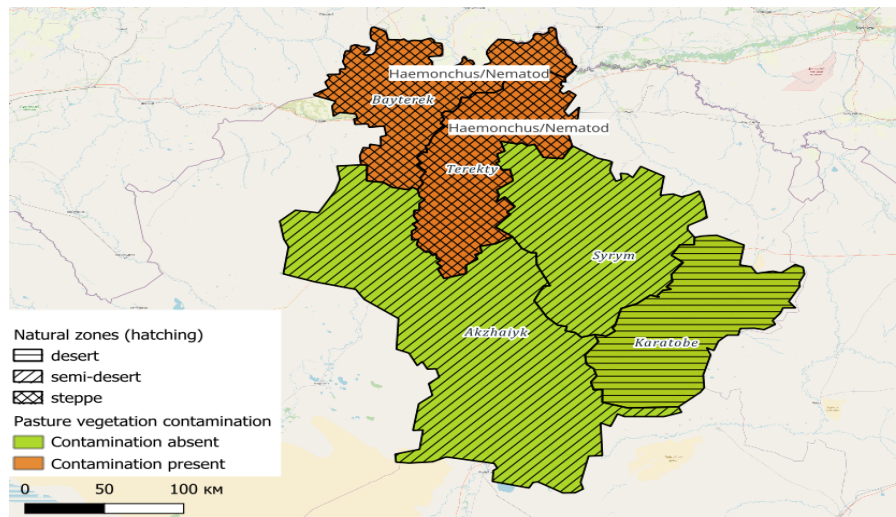


Figure 4. Spatial distribution of helminth contamination in pasture vegetation in the West Kazakhstan Region

GIS map showing the spatial distribution of helminth contamination in pasture vegetation within the West Kazakhstan Region. Contamination of vegetation was recorded primarily in the steppe zone and is associated with favorable hydrothermal conditions and high grazing pressure; the parasite fauna is dominated by nematodes of the genera *Haemonchus* and *Nematodirus* (Figure 4). No contamination was detected in semi-arid and arid zones, reflecting the limited survival of invasive stages under arid conditions. A pronounced spatial zonality of distribution was identified.

Table 2. Helminth infection of pasture vegetation by districts of the West Kazakhstan Region

District	Natural zone	Vegetation contamination	Dominant helminths	Epidemiological significance
Baiterek	Steppe	Present	<i>Haemonchus</i> , <i>Nematodirus</i>	Active transmission via forage
Terekty	Steppe	Present	<i>Haemonchus</i> , <i>Nematodirus</i>	Sustained pasture contamination
Syrym	Semi-desert	Absent	Not detected	Low transmission potential
Akzhaiyk	Semi-desert	Absent	Not detected	Unfavourable for egg survival
Karatobe	Desert	Absent	Not detected	Negligible epidemiological role

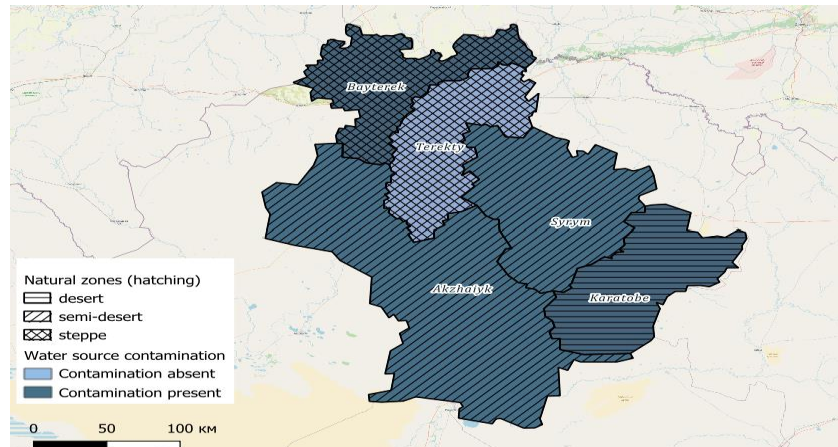


Figure 5. Spatial distribution of helminth contamination in water sources in the West Kazakhstan Region

The data in the table clearly demonstrate a strong correlation between the level of contamination of pasture vegetation and natural climatic conditions. The presence of helminths has been recorded exclusively in steppe regions (Baiterek, Terekta), where nematodes of the genera *Haemonchus* and *Nematodirus* dominate, ensuring active circulation of the infestation through forage plants. In semi-arid (Syrym, Akzhaiksky) and desert (Karatobe) zones, no infestation was detected, indicating unfavorable conditions for the survival and development of the invasive stages. The results obtained confirm the presence of pronounced zonality and point to the leading role of steppe pastures in sustaining the epizootiological process.

The study of helminth contamination of water sources was conducted to assess their epizootiological role in the formation of the parasite burden in the pasture ecosystems of the West Kazakhstan Region. The study focused on temporary and seasonal water bodies actively used for watering small ruminants. Laboratory analysis of water samples revealed helminth eggs, indicating contamination of the aquatic environment with parasitic material. The obtained data were processed using geoinformation technologies, which allowed for the visualization of spatial patterns of contamination distribution.

According to the results of the cartographic analysis, the highest degree of contamination of water sources was observed in areas belonging to the semi-arid zone. In these territories, especially in the spring after floods, temporary water bodies form, in which helminth eggs accumulate due to the washout of fecal material from pastures. In steppe and desert regions, the level of contamination is significantly lower, which is associated with the shorter duration of water bodies, their flow, as well as less favorable conditions for the survival and development of parasites.

It should be noted that no larval stages of helminths were detected in the water samples analyzed, which may indicate unfavorable environmental conditions for their further development in the aquatic environment. The temperature regime, mineralization level, and hydrodynamic characteristics of the water bodies likely limit the viability of the parasites at this stage.

Thus, the contamination of water sources with helminths is distinctly seasonal and geographically determined. The aquatic environment in semi-arid regions plays a role as a temporary vector for transmission, but its significance in sustaining a sustained epizootic process is secondary to environmental components such as soil and vegetation. The results obtained underscore the need to take natural and climatic conditions into account when developing measures for the prevention of helminthiasis in farm animals.

Table 3. **Helminth contamination of water sources by district in the West Kazakhstan Region**

District	Natural area	Type of water source	Water contamination	Intensity (egg/L)	Epizootological significance
Syrym	Desert	Temporary reservoir	Detected	Up to 117	Seasonal threat after flooding
Akzhaik	Desert	Temporary reservoir	Detected	Up to 8	Risk of local transmission
Baiterek	Steppe	Irrigation tank	Detected	Up to 6	Low epizootological role
Karatobe	Semi-desert	Irrigation tank	Detected	Up to 6	Limited danger
Terekta	Steppe	Irrigation tank	Not detected	0	It has no epizootological significance

An analysis of contamination in water sources across various districts of West Kazakhstan Region revealed significant differences in both contamination levels and epizootological significance. It was found that the degree of helminth contamination in the aquatic environment depends on natural and climatic conditions, the type of water body, and its use in livestock farming.

The highest contamination intensity was recorded in the Syrym District, which is part of a desert zone, where water samples from temporary water bodies contained up to 117 helminth eggs per liter. This indicator points to a significant degree of contamination, especially during the post-flood period, when fecal material is actively washed away from pastures. Consequently, water sources in this district pose a seasonal epizootological threat to small ruminants.

In the Akzhaik District, also located in a desert zone, the contamination level was significantly lower (up to 8 eggs/L); however, the presence of infective material indicates a risk of local transmission of helminthiasis when temporary water bodies are used for watering animals.

In the steppe zone (Baiterek and Terekta districts) and the semi-arid zone (Karatobe district), the level of contamination in water sources was minimal or absent. In the Baiterek and Karatobe districts, isolated helminth eggs (up to 6 eggs/L) were detected in irrigation reservoirs, indicating low or limited epizootological significance of these water bodies. In the Terekta District, no contamination was detected, allowing these water sources to be considered safe from an epizootological perspective.

Thus, the data confirm that temporary water bodies in desert areas, which form during spring floods, play the greatest role in the transmission of helminthiasis. At the same time, irrigated and relatively stable water systems in steppe and semi-arid zones are characterized by low levels of contamination and limited involvement in the circulation of the infestation. This underscores the need for a differentiated approach to the prevention of helminthiasis, taking into account regional characteristics of water use and the natural zone.

Discussion

The results obtained demonstrate that the development of mixed helminth infections in sheep in the West Kazakhstan Region is a complex phenomenon determined by the interaction of natural and climatic conditions, the characteristics of pasture-based husbandry, and environmental factors. The identified seasonal dynamics, with minimal infection rates in winter and a peak in the summer-fall season, are fully consistent with data presented in studies on the epizootiology of strongylosis in ruminants [14]. This is due to the fact that the development of the invasive stages of nematodes directly depends on the temperature and humidity of the environment.

The increase in the extent and intensity of infestation during the spring period is associated with the start of the grazing season and the mass emergence of larvae from overwintering stages in the soil. Similar patterns have been noted in the works of other authors, who emphasize the role of spring pasture contamination as a key factor in the infection of young animals.

The results of the soil contamination study confirm that this particular environmental component plays a leading role in sustaining the epizootic process. High counts (>700 eggs/g) in desert and semi-desert regions indicate a cumulative effect of contamination due to limited pasture area and the concentration of animals near water sources. This is consistent with the concept of the “pasture reservoir of infection,” widely discussed in modern veterinary parasitology

In contrast to soil, contamination of pasture vegetation showed a marked zonal pattern and was recorded exclusively in steppe regions. The dominance of nematodes of the genera *Haemonchus* and *Nematodirus* confirms their key role in the structure of the sheep parasite community.

The results of the analysis of water sources are of particular interest. Despite the detection of helminth eggs, the absence of larval stages indicates a limited role of the aquatic environment in the completion of the parasites' life cycle. Similar conclusions are reported in studies on parasite ecology, which note that the aquatic environment more often acts as a transit factor for transmission rather than as a full-fledged reservoir of infection [16]. At the same time, the high contamination of temporary water bodies in desert regions following floods confirms their significance as a short-term source of infection.

Thus, the data obtained allow us to establish a hierarchy of helminth transmission factors: the leading role belongs to soil, the secondary role to pasture vegetation, and the least significant role to water sources. The spatial heterogeneity of the distribution of infestation reflects the influence of natural zones, where steppe regions ensure sustained circulation of parasites, whereas desert and semi-desert areas are characterized by seasonal outbreaks [17, 18].

The practical significance of these findings lies in the need for a differentiated approach to the prevention of helminth infections. Specifically, in steppe regions, priority should be given to pasture management and rotational grazing, whereas in desert areas, special attention should be paid to controlling watering holes during the flood season. These approaches are consistent with modern strategies for sustainable control of parasitic diseases, aimed at reducing the parasitic burden without excessive use of anthelmintics [19, 20].

Conclusion

The conducted studies have shown that mixed helminth infections in sheep in the West Kazakhstan Region exhibit distinct seasonal and spatial patterns. The lowest infection rates were recorded during the winter, and the highest during the summer and fall.

It was found that the soil serves as the primary reservoir for parasites, while the epizootiological significance of pasture plants was primarily observed in steppe regions. The role of water sources was seasonal in nature.

The results obtained indicate the need to plan deworming measures taking into account the natural and climatic characteristics of pasture ecosystems and the age structure of livestock.

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