Research article

Mapping and analysis of the distribution of parasitic infections of cats in cities of Kazakhstan

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Abstract

Background and Aim. Endoparasitic infections in domestic and stray cats are of veterinary and public health importance due to their potential zoonotic transmission and environmental contamination. In Kazakhstan, systematic spatial data on the distribution of endoparasites in cats remain limited. This study aimed to develop an information database and a GIS-based cartographic model for collecting, analyzing, and spatially visualizing data on endoparasitic infections in cats and to identify areas with potentially increased infection risk.

Materials and Methods. Data from 1,301 cats from five major cities of Kazakhstan (Almaty, n=282; Astana, n=382; Shymkent, n=389; Uralsk, n=76; and Kostanay, n=192) were collected from veterinary clinics and animal shelters. Fecal samples from 1,301 cats were examined for helminth eggs and coccidian oocysts; 1,256 cats were tested for Giardia spp. coproantigen, and serum samples from 273 cats were tested for Toxoplasma gondii-specific IgG antibodies. The database included biological characteristics, sample types, laboratory results, and geographic coordinates of sampling sites. GIS-based spatial visualization was performed using ArcGIS to assess the distribution of *Toxocara* cati, *Giardia* spp., *Cystoisospora* spp., and *Cryptosporidium* spp. based on coprological examinations, as well as T. gondii seropositivity based on serological testing.

Results. GIS-based visualization demonstrated parasite-specific spatial variation among the studied cities. The distribution patterns differed according to parasite species; for example, higher proportions of *Toxocara cati*, *Cystoisospora* spp., and *Giardia* spp.-positive samples were observed in Almaty, whereas Cryptosporidium spp. showed the highest observed proportion in Uralsk. These descriptive spatial patterns should not be interpreted as evidence of specific climatic or anthropogenic determinants, which were not directly measured in the present study. The developed GIS model enabled visualization of parasite distribution and identification of areas with higher concentrations of positive samples.

Conclusion. The developed information database and GIS-based cartographic model provide useful tools for the systematic collection, spatial analysis, and visualization of data on endoparasitic infections in cats. Their application can support epidemiological surveillance, risk assessment, and the planning of targeted preventive measures in veterinary and public health programs in Kazakhstan.

Keywords: cat; geographic information system; Kazakhstan; spatial analysis; *Toxoplasma gondii*.

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Introduction

Parasitic zoonoses associated with domestic and stray animals remain a major concern for global public health, particularly in the context of rapid urbanization and increasing human–animal interactions. Among these, infections transmitted by cats are of particular importance due to their close contact with humans and their role as hosts of several clinically significant parasites. For instance, *Toxoplasma gondii*, whose definitive hosts are cats that excrete environmentally resistant oocysts in their feces, is estimated to infect up to 30–50% of the global human population, making it one of the most widespread parasitic infections worldwide [1].

Cats serve as hosts for a range of endoparasites, including *Toxocara cati*, *Giardia* spp., *Cryptosporidium* spp., *Cystoisospora* spp., and *Toxoplasma gondii* [2–4]. These pathogens are capable of persisting in the environment in the form of resistant eggs, oocysts, or cysts, contaminating soil, water, and urban surfaces. Protozoan parasites such as *Giardia* spp. and *Cryptosporidium* spp. are particularly important because of their low infectious dose and role in waterborne outbreaks [5], whereas *Toxoplasma gondii,* for which cats are the definitive hosts and a key component of transmission dynamics, poses a serious risk to pregnant women and immunocompromised individuals [6].

Large urban areas represent complex ecological systems in which high densities of domestic and stray animals, combined with variable sanitary conditions and anthropogenic factors, create favorable conditions for the maintenance and transmission of parasitic infections. In such environments, stable foci of parasite circulation may develop, contributing to sustained infection pressure and increasing the risk of zoonotic transmission [7].

Within the framework of the One Health concept, which integrates human, animal, and environmental health, the study of the spatial distribution of zoonotic infections is especially important [8]. Modern Geographic Information Systems (GIS) provide powerful tools for integrating epidemiological, veterinary, and environmental data, enabling spatial analysis, visualization of infection distribution, and identification of clustering patterns [9].

Despite the growing importance of this field, comprehensive studies combining parasitological data with spatial analysis remain limited in Central Asia, including Kazakhstan. The development of an information database containing epidemiological characteristics of feline parasitic zoonoses allows for the systematization and analysis of data, identification of high-risk foci, and visualization of parasite distribution using cartographic models. This approach improves the efficiency of monitoring and prevention programs and supports the development of strategies aimed at reducing the risk of human infection [10].

Therefore, the aim of the present study was to map and analyze the spatial distribution of parasitic infections in cats in major cities of Kazakhstan using a GIS-based approach, with emphasis on visualization of parasite-specific spatial patterns and areas with higher concentrations of positive samples.

Materials and Methods

A structured geospatial database integrating parasitological and epidemiological data was developed to assess the distribution of zoonotic parasitic infections in cats across major cities of Kazakhstan, including Astana, Almaty, Shymkent, Uralsk, and Kostanay.

All primary data, including information on sampling locations (precise geographic coordinates), biological characteristics of the animals (owned or stray cats, sex, age), type of biological material (feces, blood serum), sampling and laboratory examination dates, as well as results of parasitological analyses, were initially structured in tabular format using Microsoft Excel. Each record was assigned a unique identification code to facilitate database management and prevent duplication.

The prepared dataset was imported into ArcGIS 10.3 using the Display XY Data function, with the coordinate system set to GCS_Krasovsky_1940, which is considered the most suitable for cartographic analyses within Kazakhstan. Based on the input coordinates, a separate shapefile layer containing georeferenced information for each sampling case was created [11].

Spatial data analysis and visualization were performed in ArcGIS using built-in geoprocessing tools. The Definition Query function was applied to extract data subsets according to specific criteria (e.g., positive parasite detection, sampling by owned or stray cats, or administrative regions).

Graphical visualization was carried out using the Symbology module, in which parasitological results were represented as point features with varying color and size attributes reflecting parasite species, prevalence, or infection intensity. For improved spatial interpretation, these point layers were overlaid with raster maps of cities and administrative regions of Kazakhstan, allowing the identification of distribution patterns in relation to geographic and landscape factors.

Data sources included statistical records from veterinary clinics and animal shelters, encompassing information on animal health status, case frequency, and population size, as well as laboratory results obtained at the Institute of Animal Science and Veterinary Medicine of Saken Seifullin Kazakh Agrotechnical University and the Laboratory of Biodiversity and Genetic Resources of the National Center for Biotechnology. These analyses were aimed at detecting pathogens, determining infection prevalence, and assessing the overall epidemiological situation.

In total, the database included records for 1,301 urban cats: Almaty (n=282), Astana (n=382), Shymkent (n=389), Uralsk (n=76), and Kostanay (n=192), including both owned and stray (shelter-based) animals. Samples were collected from August 2023 to January 2025. Data were obtained from 20 veterinary clinics and 10 animal shelters that voluntarily participated in the study. The cats were older than one month of age. All animals were either presented by owners for routine or clinical examinations at veterinary clinics or housed in shelters. Cats that had received antiparasitic treatment within the previous four weeks were excluded from the study.

Fecal samples from 1,301 cats were examined for helminth eggs and coccidian oocysts using the standardized Sheather's sugar flotation method. *Giardia* spp. coproantigen was assessed in 1,256 cats using a commercial immunochromatographic assay. Blood serum samples from 273 cats were analyzed for *Toxoplasma gondii*-specific immunoglobulin G (IgG) antibodies using a commercially available enzyme-linked immunosorbent assay. Detection of *T. gondii*-specific IgG was interpreted as evidence of previous exposure to the parasite and not as proof of active infection at the time of sampling.

Results

The characteristics of the studied cities, including geographic location, climate zone, human population size, and number of registered cats, are presented in Table 1.

Gastro-intestinal parasites were detected in cats in all five cities (Figure 1). Both helminths and protozoa were identified, with *Toxocara cati* representing the predominant helminth species, whereas protozoan findings included *Giardia* spp., *Cystoisospora* spp., and *Cryptosporidium* spp. The observed proportions varied among cities and parasite species:

- In Almaty (n=282), *Toxocara cati* was detected in 15.2% of samples, *Cystoisospora* spp. in 19.1%, *Giardia* spp. in 12.4%, and *Cryptosporidium* spp. in 2.9%.
- In Shymkent (n=389), *Toxocara cati* was detected in 5.4% of samples, *Giardia* spp. in 2.7%, *Cystoisospora* spp. in 1.6%, and *Cryptosporidium* spp. in 1.1%.
- In Uralsk (n=76), Toxocara cati was detected in 1.3% of samples, *Giardia* spp. in 8.7%, *Cystoisospora* spp. in 9.2%, and *Cryptosporidium* spp. in 6.6%. Other helminths were detected at low frequencies in the overall dataset, including *Capillaria* spp. (0.4%), taeniid eggs (0.4%), *Dipylidium* spp. (0.08%), and *Diphyllobothrium/Spirometra* spp. (0.08%).
- In Kostanay (n=192), *Toxocara cati* was detected in 4.2% of samples, *Giardia* spp. in 2.3%, *Cystoisospora* spp. in 1.6%, and *Cryptosporidium* spp. in 1.6%.
- In Astana (n=382), *Toxocara cati* was detected in 2.4% of samples, *Giardia* spp. in 6.4%, *Cystoisospora* spp. in 6.3%, and *Cryptosporidium* spp. in 2.9%.

Table 1. Geographic location, climatic zone, population size, and number of registered cats in the surveyed cities of Kazakhstan (from: *Lider* et al. 2025, *Veterinary World* 18(6), 1748–1758)

City	Coordinates[1]	Climate zone[2]	Population	Number of registered cats
Almaty	43.25°N 76.9167°E	Dfb – warm-summer humid continental climate with relatively constant precipitation throughout the year	2,290,000	43,450

Continuation of Table 1

Astana	51.1801°N 71.446°E	Dfb – humid continental climate with cold winters and warm summers	1,529,000	19,750
Uralsk	51.2333°N 51.3667°E	Dfa – hot-summer humid continental climate	369,000	ND
Kostanay	53.2144°N 63.6246°E	Dfb – humid continental climate with cold winters and warm summers	273,000	ND
Shymkent	42.3°N 69.6°E	Csa – Mediterranean climate with hot summers	1,125,000	ND

Notes: ND = No data available.
[1] Source: Geodata.
[2] Climate zones classified according to the Köppen–Geiger climate classification.

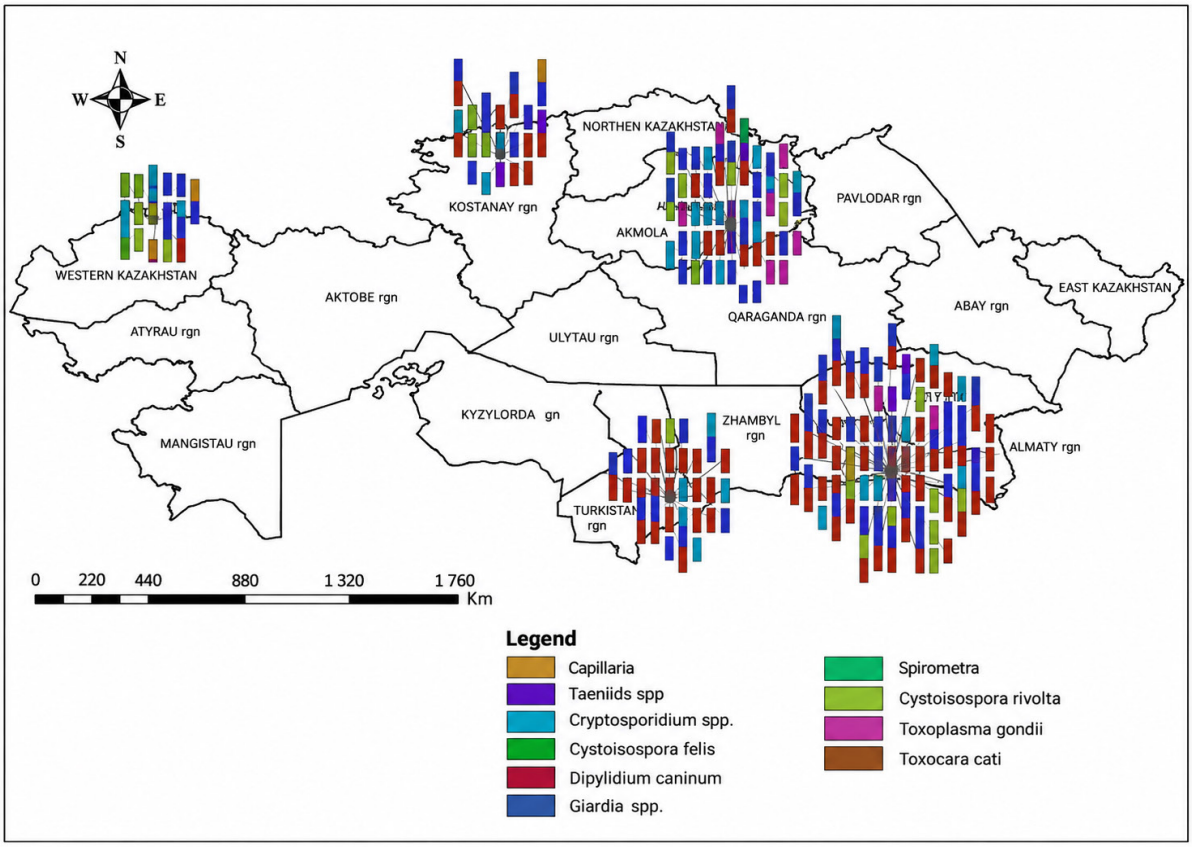

Figure 1. Cartographic model of the distribution of gastro-intestinal parasites of cats in five cities of Kazakhstan

City-specific spatial distributions of parasites are presented in Figures 2–4. Mapping of the sampling locations revealed an uneven distribution of positive cases within each city.

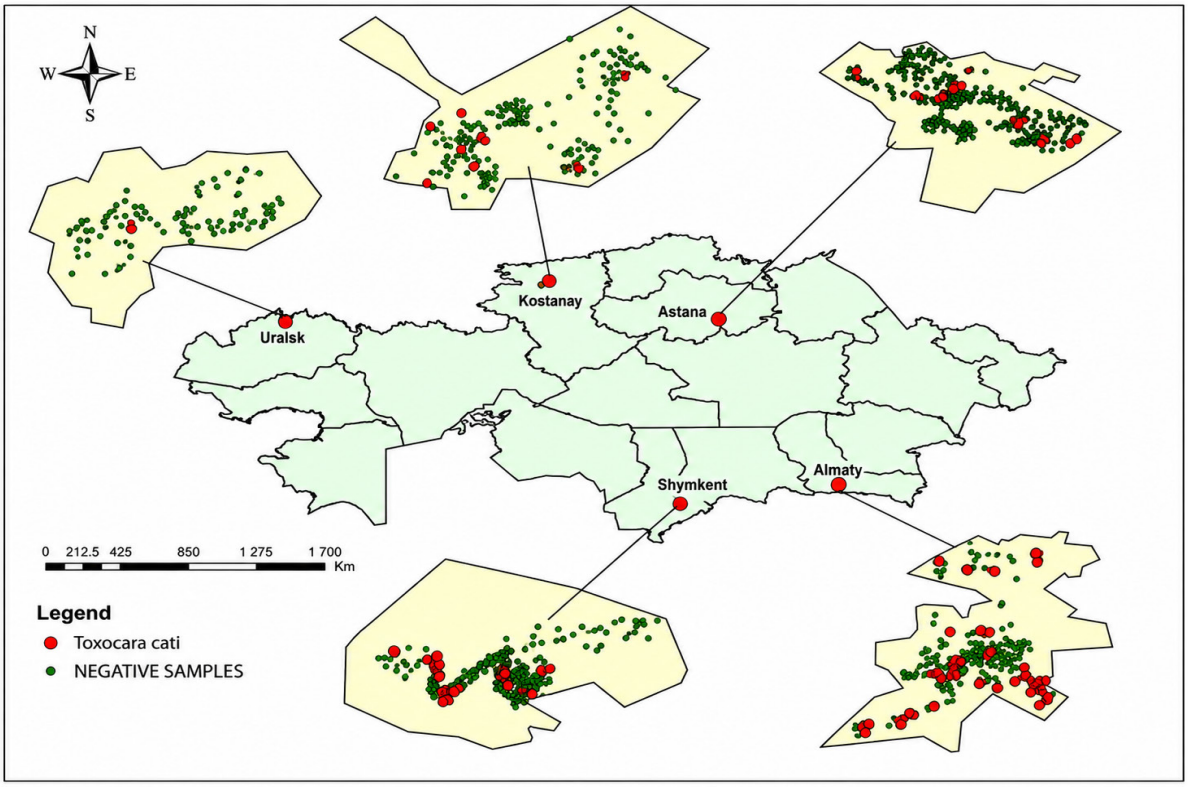

Figure 2. Distribution of *Toxocara cati* egg-positive fecal samples in cats

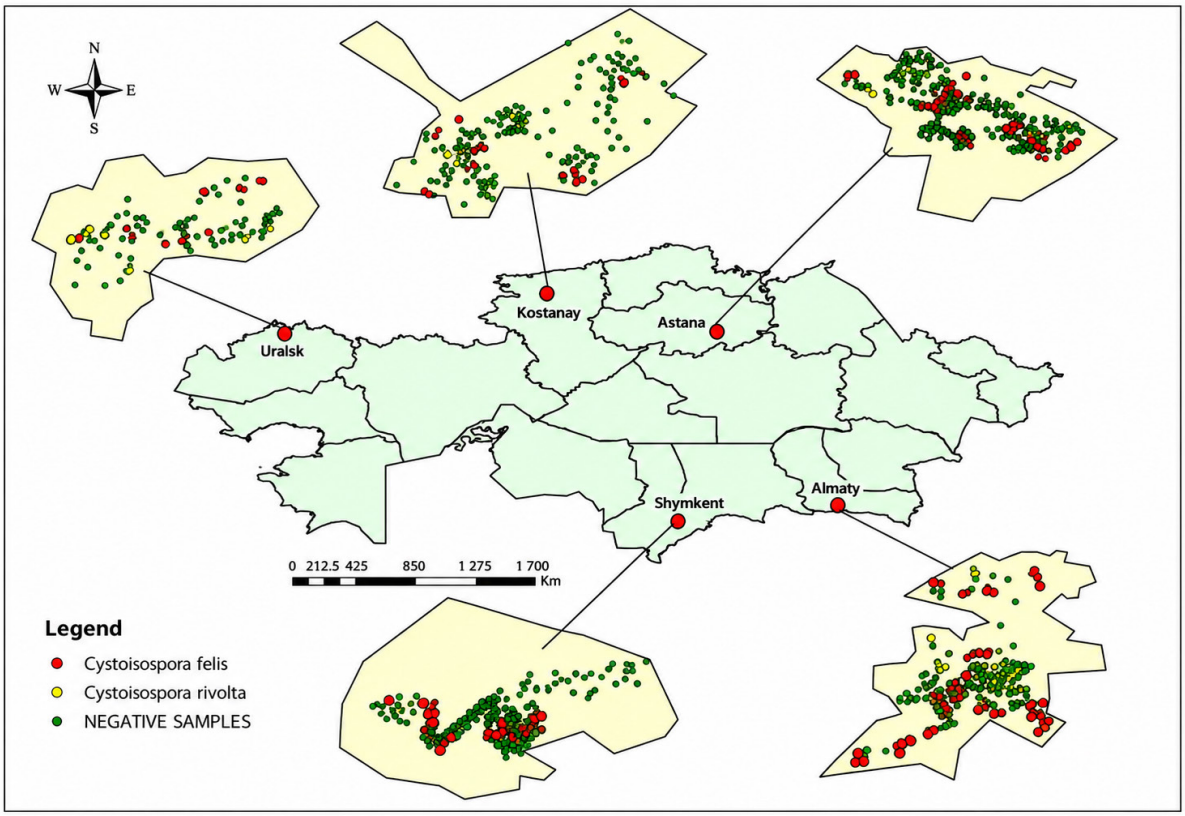

Figure 3. Distribution of *Cystoisospora* spp. oocyst-positive fecal samples in cats

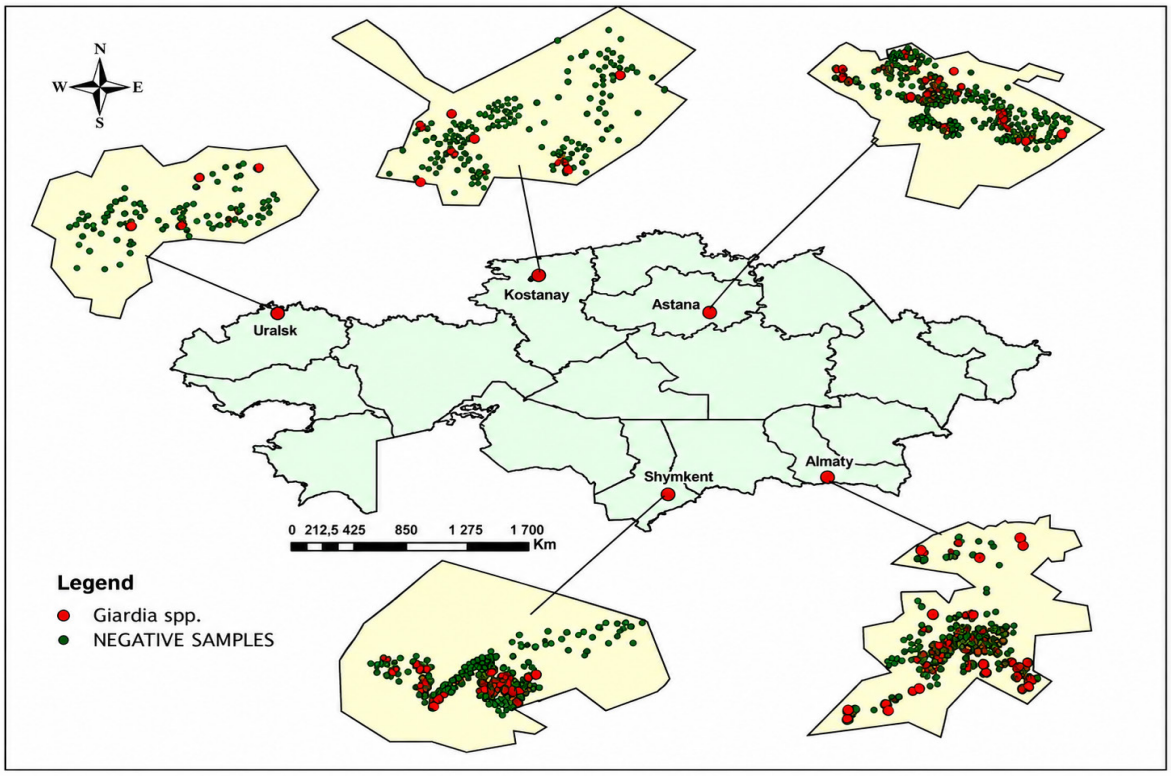

Figure 4. Distribution of *Giardia* spp. coproantigen-positive fecal samples in cats

Serological analysis of Toxoplasma gondii-specific IgG demonstrated variability in seropositivity among the cities (Figure 5). Seropositive animals were recorded in Astana (21.5%), Almaty (20.5%), Uralsk (15.2%), Shymkent (10.5%), and Kostanay (8.0%). These results indicate previous exposure to *T. gondii* and should not be interpreted as evidence of active infection at the time of sampling.

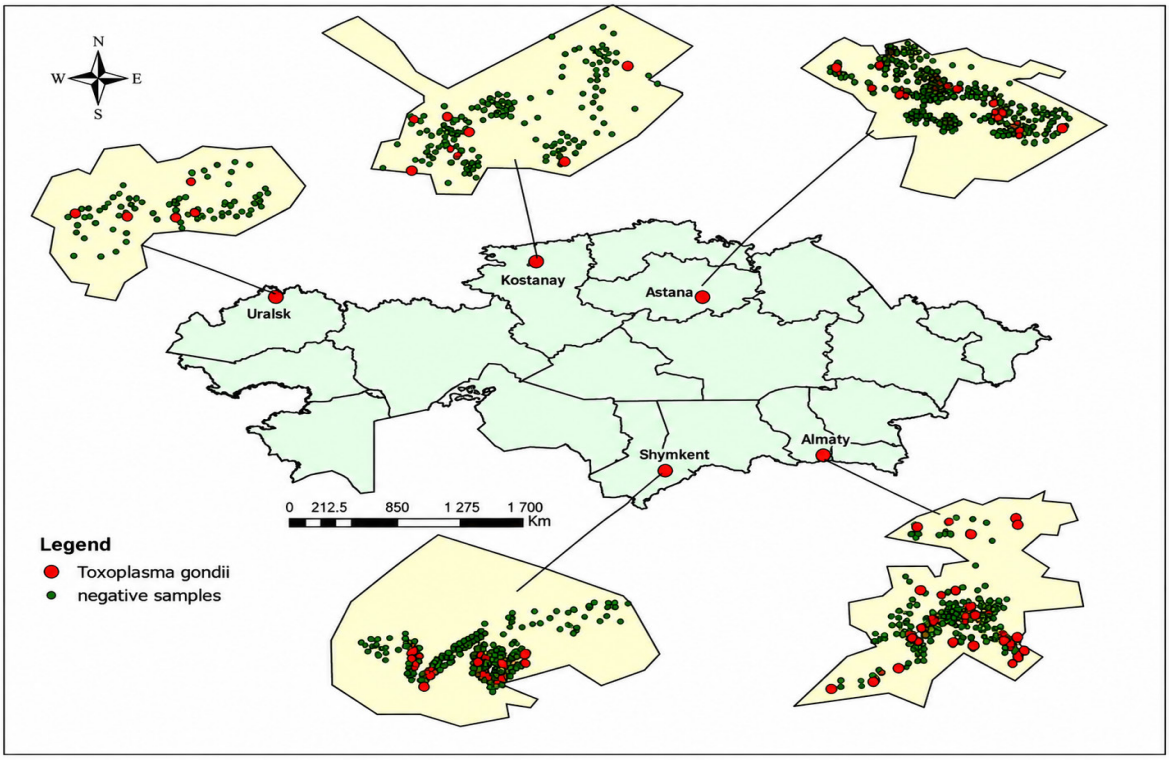

Figure 5. Distribution of *Toxoplasma gondii* antibody-positive blood samples in cats

Discussion

The present study demonstrated spatial variation in the distribution of feline parasites across five major cities of Kazakhstan. The observed patterns were parasite-specific and should be interpreted descriptively. Environmental, climatic, and anthropogenic factors may plausibly contribute to spatial variation; however, these variables were not directly measured or statistically evaluated in the present study and therefore cannot be considered established determinants of the observed patterns.

In Almaty, relatively high observed proportions were recorded for *Toxocara cati, Cystoisospora* spp., and *Giardia* spp. Previous studies have shown that temperature, humidity, host density, and animal management can influence the persistence and transmission of parasitic stages [2, 10]. However, the present study did not directly measure these factors; therefore, they should be regarded only as possible explanations for the observed spatial pattern.

Astana showed lower observed proportions for some parasites, including *Toxocara cati*, whereas the proportions of *Giardia* spp., *Cystoisospora* spp., and *Cryptosporidium* spp. followed different patterns. Although climatic conditions may influence the survival of parasite developmental stages in the environment [11], no direct association between climate and parasite occurrence was tested in the present study.

The distribution patterns of protozoan parasites, especially *Giardia* spp. and *Cryptosporidium* spp., varied among cities. *Cryptosporidium* spp. showed the highest observed proportion in Uralsk (6.6%), compared with lower proportions in the other surveyed cities. Because environmental and host-related determinants were not directly assessed here, the reasons for this pattern cannot be established from the present data. *Giardia* spp. and *Cryptosporidium* spp. include taxa of recognized zoonotic importance; however, species- or genotype-specific zoonotic transmission was not evaluated in this study [5, 12].

Geospatial mapping of sampling points was used to visualize the distribution of *Toxoplasma gondii*-seropositive cats across the surveyed cities. The proportions of seropositive animals were 21.5% in Astana, 20.5% in Almaty, 15.2% in Uralsk, 10.5% in Shymkent, and 8.0% in Kostanay. These findings do not support a simple south-to-north or central-to-western geographic gradient. Moreover, *T. gondii*-specific IgG indicates previous exposure and does not demonstrate active infection or current oocyst shedding.

The application of GIS-based methods provided an effective approach for integrating epidemiological and spatial data and visualizing the geographic distribution of positive samples. In the present study, the maps were used for descriptive spatial visualization rather than formal statistical cluster detection. Accordingly, areas with a higher concentration of positive samples are interpreted as descriptive spatial patterns and not as statistically validated hotspots. Similar GIS-based approaches are widely used in spatial epidemiology to support visualization and subsequent hypothesis-driven analyses [9, 13, 14].

From a One Health perspective, the detection of parasites with recognized zoonotic potential in urban cats highlights the relevance of integrated veterinary, environmental, and public health surveillance. However, the present study did not investigate human infections or directly assess transmission from cats to humans. Therefore, the findings should be interpreted as indicating potential zoonotic relevance rather than demonstrating zoonotic transmission.

Conclusion

A GIS-based spatial analysis and cartographic visualization of feline endoparasites, including *Toxocara cati, Giardia* spp., *Cystoisospora* spp., and *Cryptosporidium* spp., together with *Toxoplasma gondii* seropositivity, was developed for five cities of Kazakhstan using ArcGIS.

The spatial visualization demonstrated parasite-specific heterogeneity among and within the five surveyed cities. Local areas with higher concentrations of positive samples were observed on the maps; these represent descriptive spatial patterns rather than statistically validated hotspots. The GIS-based approach can support veterinary surveillance and help prioritize locations for further targeted epidemiological investigation. Because environmental determinants and human infection were not directly assessed, causal and zoonotic transmission inferences should not be drawn from these spatial patterns alone.

Author's Contributions

LL and CB: Conceptualized and designed the study, conducted a comprehensive literature search. VK, MYe and IS: Analyzed the gathered data and drafted the manuscript. DS, RU and CB: Conducted

the final revision and proofreading of the manuscript. All authors have read, reviewed, and approved the final manuscript

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Conflicts of Interest

The authors declare that they have no conflicts of interest related to this study. No financial or non-financial competing interests exist that could have influenced the results or interpretation of the data presented in this manuscript.

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