TOXOPLASMOSIS CONTROL STRATEGIES IN THE RUSSIAN FEDERATION

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Abstract

This study aimed to comprehensively assess the management of toxoplasmosis in the context of the Russian Federation, encompassing its prevalence, transmission dynamics, and mitigation strategies. Through a thorough literature review of diverse scientific documents from 2005 to 2022, including peer-reviewed articles and conference abstracts, the research methodology involved systematic categorization, comparative analysis, and critical evaluation. Results underscored the extensive prevalence of toxoplasmosis across the Russian Federation, affecting a range of domestic animals, wildlife, and humans. The study's conclusion highlights the pressing need for effective management strategies to mitigate toxoplasmosis's impact on public health and animal well-being. This includes advocating responsible pet ownership practices, promoting proper hygiene, and raising awareness about safe handling of raw meat. The findings emphasize the significance of continued surveillance, education campaigns, and collaborative efforts to manage and prevent toxoplasmosis effectively.

Keywords: toxoplasmosis, humans, domestic and farm animals, distribution, extensiveness of invasion.

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INTRODUCTION

The problem of toxoplasmosis is relevant due to the almost ubiquitous spread of the pathogen, the high incidence rate and the ability of toxoplasmas to persist for a long time in affected cells, as well as the danger of infection of humans from animals. The disease is registered in all countries of the world, the sources of invasion are very many species of domestic and wild mammals and birds, among which there are significant epizootics, often accompanied by mass abortions. Infection of cats (definitive hosts)

with toxoplasmas was detected in most countries of the world: from 7.3% in Thailand to 87.3% in Brazil (Cavalcante et al., 2006). Widespread toxoplasmosis has been established in Romania, Greece, France, the Middle East, Great Britain, and Finland (Coelho et al., 2019; Dubey et al., 2014; Gotteland et al., 2014; Jokelainen et al., 2012; Lücht et al., 2019; Sioutas et al., 2022).

Toxoplasmosis is a zoonotic parasitic disease caused by the unicellular *Toxoplasma gondii* parasite. The infestation has been established in 350 species of animals and in humans. In natural foci, the circulation of the pathogen goes mainly down the victim-predator chain, in which the final host is a representative of the feline family, while numerous mammals and birds are intermediate hosts. In synanthropic foci, the causative agent of toxoplasmosis circulates through cats as the final hosts, in which sexual reproduction of the parasite takes place. Pigs, sheep, rabbits, chickens, and mice are the most affected being the intermediate hosts and sparrows are the most affected among the wild birds. Domestic mammals and synanthropic birds are invaded by toxoplasmas much more often than wild ones. Human is an intermediate host for toxoplasma; in human cells, toxoplasma reproduces asexually (Kobets et al., 2012; Kosminkov et al., 2019; Novak et al., 2005).

The main way of infection is oral, when cysts enter the human body when eating infected semi–raw meat, unwashed vegetables, fruits, herbs, and drinking water contaminated with oocysts. Infection of a person goes also through blood in case of microtrauma of the skin and mucous membranes and contact with infected raw materials (percutaneously), transplacentally. Cases of intrauterine invasion are not so rare (1-2 per 1000 pregnant women) (Cherchenko, Cheremena, 2019; Kharitonova, Grigoriev, 2016).

METHODS AND MATERIALS

The methodological approach of this study involved a comprehensive review of existing literature related to the topic of interest. A diverse range of scientific documents were considered, including peer-reviewed articles, book chapters, conference abstracts, and doctoral dissertations. These documents spanned a substantial timeframe, from the year 2005 up to and including 2022.

The search strategy was broad and comprehensive, not confined to a single source. It incorporated several prominent academic databases, encompassing the Russian Scientific Electronic Library and Cyberleninka, notable repositories of a significant volume of Russian scientific works, in addition to the internationally recognized databases PubMed, Web of Science (WoS), and Scopus.

A core focus of this review was the collection and analysis of data pertaining to the prevalence and propagation of toxoplasmosis. This included a thorough examination of occurrences and distribution of this condition among various animal species and human populations within the geographical boundaries of the Russian Federation. The methodical dissection and synthesis of this data facilitated the extraction of robust and reliable conclusions about the trends and patterns in the incidence and spread

of toxoplasmosis in these populations during the studied period.As part of the study a series of primary keywords was utilized to streamline the search process within the selected databases. The principal keywords included 'toxoplasmosis', 'humans', 'domestic and farm animals', 'spread', and 'extent of invasion'. These search terms were carefully chosen to encapsulate the central themes of the study and to ensure the retrieval of the most relevant documents.

Following this targeted search, a total of 151 entries were identified. Among these entries, there was a language distribution with 83 documents being in Russian and 68 documents in English. This diversification in language sources not only broadens the scope of the study but also enables a more comprehensive understanding of the research topic in both a global and regional context.

To accurately interpret and present the data collated, an assortment of research methods was employed. A systematic method was utilized to organize and categorize the literature in a clear, logical manner, facilitating easy analysis. A comparative method was then used to establish the similarities, differences, and trends in the incidence and spread of toxoplasmosis among different species and populations. Finally, an analytical method was adopted to critically assess the data, discern patterns, and draw meaningful conclusions from the compiled information. This tri-pronged methodological approach aided in meticulously scrutinizing the data and deriving substantial insights into the research problem at hand.

RESULTS

In agrocenoses and urbanized territories, due to socio-economic factors, the connection between the definitive host of toxoplasma – a domestic cat and intermediate hosts – different types of domestic animals, as well as humans is close. Thus, toxoplasmosis poses a serious threat to public health and is an important social problem (Novak et al., 2005).

Among protozoal diseases in the territory of the Russian Federation, toxoplasmosis is widespread among humans and animals. Both congenital and acquired toxoplasmosis are registered. Congenital toxoplasmosis is a serious problem despite the fact that it occurs in less than 1% of all cases of toxoplasmosis. In 2021, 407 cases of toxoplasmosis were registered in 30 subjects of the country (0.28 per 100 thousand population), which is 27.3% higher than the year before and 28% lower than the worldwide average (0.39). In 2021, 25 cases of toxoplasmosis were detected among children under 17 years of age (Federal Service for Supervision, 2022).

The prevalence of toxoplasmosis in Russia among the population aged 20 to 40 years is, according to various data, from 8 to 23% (Stepanova et al., 2018).

In cats infected with oocysts and toxoplasma cysts, the disease goes more often asymptomatic. In dogs, the signs of toxoplasmosis are also not very specific. The usual clinical manifestations are characterized by fever, apathy, disorders of the nervous system and digestion. With the decreased cat's

immunity the disease proceeds in an acute or subacute form. Carrier animals suffering from a chronic form of toxoplasmosis can also get sick following an immune stress. Since toxoplasmosis is transmitted from cats to humans in its acute and subacute course of the disease, care must be taken when communicating with a recovering pet. The disease is characterized by: high fever, cough, sneezing, nasal discharge, shortness of breath, weakness, apathy, muscle trembling, convulsions, disruption of the gastrointestinal tract - constipation, diarrhoea (Kosminkov et al., 2019; Novak et al., 2005; Oleynikov, 2006).

In the Central region of the Russian Federation, serological monitoring for toxoplasmosis revealed antibodies to *T. gondii* in 21.6% of cattle, 22.3% of small cattle and 30.9% of pigs, in the Nizhny Novgorod region – in 22.5% of sheep and 16.8% of goats (Makshakova, 2002).

Serological screening for toxoplasmosis of pigs and cattle, conducted in several farms of the Central Region of the Russian Federation, showed antibodies to *T. gondii* in indirect hemagglutination test in 25.7% of cattle and 42% of pigs. In the groups of young animals of 5-12 months, 11.5% are seropositive for toxoplasmosis, among bulls and heifer calves of 13-24 months – 21.8%, adult cattle – 17.8-29.7%. The results of studies of cattle in different seasons of the year showed an increase in the number of seropositive animals in the spring and summer period. In spring and summer, the extent of invasion was 53.3% and 55-70%, respectively. Studies on toxoplasmosis in indirect hemagglutination test and by chromatography revealed antibodies to *T. gondii* in sows, boars, rearing gilts, animals. The highest morbidity rates were observed among piglets on feed at the age of 9-10 months – 61.5% and sows 2-4 years old – 38%. Boars 2-4 years old, piglets on rearing of 2-3 months and rearing gilts of 6-12 months were 8, 34 and 37.5%, respectively seropositive in indirect hemagglutination test. Seasonal dynamics is characteristic for toxoplasmosis of pigs. The results of serological testing in the winter (19-25%), spring (21-61%), summer (19-59%) and autumn (15-17%) seasons of the year indicate an increase in the number of seropositive animals in the spring-summer period. The maximum levels of seropositivity for toxoplasmosis in pigs were in May - 61%, and the titers of antibodies to *T. gondii* also showed increase in April-May (1:640, 1:1280). The serological testing for toxoplasmosis of cows of 3-8 years old identified that 22.2% of samples were seropositive in titers 1:80 – 1:640 (Novak et al., 2018).

In the Moscow region, 41.3% of sheep were seropositive to *T. gondii*, and in Kaluga – 18% of animals. At the same time, the extent of invasion in spring was 43.6% higher than in autumn. High antibody titers indicate their recent infection with *T. gondii* (Shibitov et al., 2019).

The level of parasitemia in house cats allowed outdoors reaches 50%, homeless cats show 60%. In dogs, toxoplasmosis is registered less frequently, the level of parasitemia is 30%. The disease was found in adult animals in 71.5 – 84.6% and in young animals in 15.4 – 28.5% of cases. There are various clinical manifestations of the disease. Pronounced seasonal and breed dynamics of the disease have not been established (Katkov, 2016).

In the Voronezh region, the prevalence of invasion in cats reaches 52.5%, in dogs – 36%. Toxoplasmosis was confirmed in 210 cases of the 400 cats examined. In house cats invasion was confirmed in 84 cases (40%), in stray cats – in 126 cases (60%). All examined animals were allowed outdoors and were in contact with intermediate hosts of the pathogen. The annual dynamics of the disease are characterized by an increase in the epizootic process in the cat population from September to December (prevalence – 8.09 – 10.0%) with maximum activation in January – March (prevalence – 11.90 – 14.76%) and a decrease in the incidence starting from April (prevalence – 8.57%). 48 cases out of 238 examined animals were found in dogs, the extent of invasion was 20.16%. Out of 120 examined stray dogs, 36 cases were detected (prevalence – 30%), among 118 domestic dogs, 12 cases were found (prevalence – 10.16%). In the dog population, an increase in the epizootic process of invasion was recorded from March (prevalence – 7.56%) to July (prevalence – 11.76%) reaching the maximum in June (prevalence – 15.12%) followed by a decrease in December (prevalence – 4.20%). The annual dynamics of invasion reflects the changes in the population of the causative agent of toxoplasmosis under the influence of biological and socio-economic factors in the territories under examination (Bespalova, Katkov, 2020).

The peculiarity of the epizootology of toxoplasmosis of cats in the territory of the city of Lipetsk is manifested in the annual and age dynamics of invasion, as well as the territorial unevenness in the distribution of cases of the disease. The rise in morbidity is in the autumn-winter period (October – prevalence- 11.4 ± 0.5%, November – 14,7 ± 0,4%, 11,1 ± 0,4% January). The highest prevalence was found in cats older than three years of age (prevalence – 63.7 ± 5.7%). Stray animals are infected with toxoplasmosis 4 times higher than domestic animals. The disease is more often registered in cats living in areas with old private buildings (prevalence – 26,8 ± 4,9–38,0 ± 6,3%) (Solomatina, Bespalova, 2018).

In Omsk, the analysis of the incidence of cats living in different conditions (private sector and apartment buildings) showed that out of 112 examined animals, the diagnosis was confirmed in 19 cases, the average infection was 16.9 ± 0.2%. Among cats kept in apartment buildings, 5 cases were found (18.42 ± 0.7%), among cats living in areas of old private buildings, among strays – 14 (81.58 ± 0.1%). Epizootic ups and downs of the incidence of cats with toxoplasmosis during the year have been established. The maximum increase in morbidity is in autumn (October – 10.4 ± 0.5% and November – 15.5 ± 0.4%). This is due to the more frequent seasonal contact of cats with rodents that favour foci of toxoplasmosis. In spring and summer, a decrease in the level of prevalence was recorded from May (2.6 ± 0.2%) to August (4.08 ± 0.1%). The incidence rate by age in percent was as follows: in cats under 1 year – 11%, under 3 years – 22 and over 3 years – 67%. The minimum number of positive reactions was found in service dogs – 21.0%; in dogs kept in municipal shelters – 42%. The maximum number of cases was registered in dogs owned by individuals is 60%. The transmission of the invasion went through feeding raw meat containing tissue cysts. When studying the serological status of cats and dogs,

31% of cats and 25% of dogs were found positive to toxoplasmosis. There were significantly more seropositive animals among clinically healthy animals, cats – 23.3%, and dogs – 11.7%. When studying the age aspect, the greatest invasiveness was found in cats (21.7%) and dogs (20.1%) aged over 3 years (Okolelov et al., 2019).

In Novosibirsk, in the spring seasons of 2011-2012, 80 (37.2%) of the surveyed domestic cats were seropositive to *T. gondii*. The results were obtained by enzyme immunoassay (EIA) with dilution of sera in the proportion 1/20 – 1/160. Among the multiple-aged groups, the level of invasion ranged from 12.5% to 57.0%, and in the groups of females and males, 19.6%-65.4% and 14.3%-52.8%, respectively. The results of the study show that the greatest spread of antibodies to *T. gondii* has been observed in domestic cats over the age of 10 years, both among females and males. Thus, the study showed the presence of antibodies to *T. gondii* in 34.1% of domestic cats (Adamenko et al., 2018).

For the period from 2011 to 2016, Tyumen had the highest percentage of dogs and cats that had antibodies to *T. gondii*, the level was 15.5 in 2013. This was followed by a sharp decline, when 4% of positive samples were recorded (2015), and a rapid increase in the number of infected animals (15% of positive samples) in 2016 (Domatsky, Antimirova, 2017; Domatsky et al., 2019).

In Crimea, according to the results of a serological examination, 68 sheep of various sex and age groups revealed 10 positive samples, which amounted to 14.7% of the total number of examined animals. In Krasnoperekopsky district, the incidence of sheep was at the level of 10%, in Simferopol – 19.2%, in the Soviet district – 13.6%. The highest infection rate was recorded in females (16.3%). Males were less invaded by toxoplasmas – 10.5% of the sheep had antibodies to *T. gondii* in their blood serum. Six animals (60%) of the invaded belonged to the older age groups – sheep aged 2 to 4 years. Animals up to one year were less affected by toxoplasmosis – 40%. Information about the infestation of animals, depending on gender, age, is extremely contradictory. According to some authors, females and males approximately equally serologically react to toxoplasmosis, while others believe that females have a more intense reaction than males (Makarova, Lukyanova, 2015).

Toxoplasmosis should be considered as a potentially dangerous zoonosis, proceeding in a latent and chronic form and manifested mainly by sporadic cases of acute disease in humans and animals with a decrease in population immunity and genetically determined immunodeficiency states (Fig. 1).

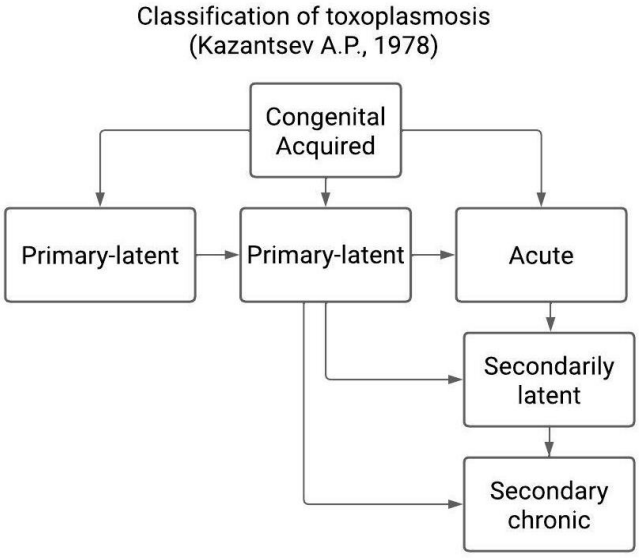

Figure 1. Classification of toxoplasmosis

The immunochromatographic rapid test allows detecting *T. gondii* antigens in the blood of animals with high accuracy and in combination with other diagnostic methods (indirect immunofluorescence test, polymerase chain reaction) to determine the stage and the course of the disease. Using the immunochromatographic method in the form of an express test allows to achieve high efficacy of research work in routine epizootological monitoring at livestock and meat processing enterprises. In farms conditionally safe for toxoplasmosis, it is advisable to conduct random seroepizootological monitoring for toxoplasmosis twice a year using an immunochromatographic rapid test, and at meat processing plants and slaughterhouses - to examine tissues and organs of all animals received from farms where cases of clinically pronounced disease and positive results of serological screening are registered (Novak et al., 2020).

To prevent all forms of toxoplasmosis, it is important to observe the rules of personal hygiene and the rules of cats housing. In this regard, it is advisable to keep cats indoors, feed cats only with ready-made food, not to feed them scraps of raw meat; clean and disinfect the "cat toilet" at least once a day. Pregnant women should avoid contact with environmental objects that may be contaminated with cat feces. Do not try meat during cooking; cook meat in a way that insures the heat treatment of inner layers up to at least 60 °C (Puzyreva et al., 2016).

CONCLUSION

Toxoplasmosis is widespread in the Russian Federation. In 2021, 407 cases of human toxoplasmosis were registered in 30 subjects of the RF (0.28 per 100 thousand population), which is 27.3% higher than in 2020. In Central Russia, antibodies to *T. gondii* were detected in 30.9% of pigs, 22.5% of sheep, 21.6% of cattle and 16.8% of goats. The level of parasitemia in house cats allowed outdoors reaches 50%, homeless cats show 60%. In dogs, toxoplasmosis is registered less frequently,

the level of parasitemia is 30%. The disease was found in adult animals in 71.5 – 84.6% and in young animals in 15.4 – 28.5% of cases.

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