



## Occurrence of anti-*Toxoplasma gondii* antibodies in cats (*Felis catus*) in the municipality of Maceió, Alagoas<sup>1</sup>

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**ABSTRACT.-** Britto MFV, Oliveira PRF, Silva VV, Oliveira GA, Mota RA. **Occurrence of anti-*Toxoplasma gondii* antibodies in cats (*Felis catus*) in the municipality of Maceió, Alagoas.** *Pesquisa Veterinária Brasileira* 45:e07622, 2025. Department of Veterinary Medicine, Universidade Federal Rural de Pernambuco, Rua Dom Manuel de Medeiros s/n, Dois Irmãos, Recife, PE 52171-900, Brazil. E-mail: [rinaldo.mota@hotmail.com](mailto:rinaldo.mota@hotmail.com)

*Toxoplasma gondii* is an intracellular protozoan parasite responsible for toxoplasmosis, with felids serving as its definitive hosts. This neglected zoonotic disease affects both humans and animals worldwide. This study aimed to perform a serological survey and spatial analysis of the occurrence of anti-*T. gondii* IgG antibodies in cats from the municipality of Maceió, Alagoas. Overall, blood serum samples from 337 adult cats, collected from a private laboratory (137 samples) and the Zoonosis Surveillance Unit (200 samples), were tested using the indirect immunofluorescence test to detect IgG antibodies, with a cutoff dilution of 1:16. Samples with peripheral tachyzoite fluorescence were considered positive. Spatial distribution maps of Maceió's neighborhoods and Health Districts were designed, and additional factors such as age, sex, and breed were analyzed. Serological analysis revealed that 33.53% (113/337) of the samples were seropositive, with 57.52% (65/113) originating from the private laboratory. The neighborhoods with the highest positivity rates were Ponta Verde, with 14.15% (16/113), and Benedito Bentes, with 11.50% (13/113). Health District I, a coastal and affluent area, had the highest positivity rate at 31.86% (36/113). Age analysis indicated that 60.20% (68/113) of seropositive cats were older than two years, with males comprising 55.75% of the positive cases. Most seroreactive cats were of undefined breed, with 91.15% (103/113). This study seems to be the first serological survey of *T. gondii* in cats from Maceió, and its findings are consistent with those from other states in northeastern Brazil. Furthermore, it highlights the need to acknowledge the relationship between the occurrence of infection and social vulnerability.

INDEX TERMS: Toxoplasmosis, cat, epidemiology, antibodies.

**RESUMO.- [Ocorrência de anticorpos anti-*Toxoplasma gondii* em gatos (*Felis catus*) no município de Maceió, Alagoas.]** *Toxoplasma gondii* é um protozoário intracelular responsável pela toxoplasmose, tendo os felídeos como seus hospedeiros definitivos. Essa doença zoonótica negligenciada afeta tanto humanos quanto animais em todo o mundo. O objetivo deste estudo foi realizar um levantamento sorológico e uma análise espacial da ocorrência de anticorpos anti-*T.*

*gondii* IgG em gatos do município de Maceió, Alagoas. No total, 337 amostras de soro sanguíneo de gatos adultos, coletadas de um laboratório privado (137 amostras) e da Unidade de Vigilância de Zoonoses (200 amostras), foram testadas utilizando o teste de imuno fluorescência indireta para detectar anticorpos IgG, com uma diluição de corte de 1:16. Amostras com fluorescência periférica de taquizoítos foram consideradas positivas. Mapas de distribuição espacial dos bairros e distritos de saúde de Maceió foram elaborados, e fatores adicionais, como idade, sexo e raça, foram analisados. A análise sorológica revelou que 33,53% (113/337) das amostras foram soropositivas, sendo 57,52% (65/113) provenientes de laboratório privado. Os bairros com as maiores taxas de positividade foram Ponta Verde (14,15%; 16/113) e Benedito Bentes (11,50%; 13/113). O Distrito de Saúde I, uma área litorânea e de alto poder aquisitivo, apresentou a

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maior taxa de positividade, com 31,86% (36/113). A análise etária indicou que 60,20% (68/113) dos gatos soropositivos tinham mais de dois anos de idade, sendo que os machos representaram 55,75% dos casos positivos. A maioria dos gatos sororreativos era de raça indefinida (91,15%; 103/113). Este parece ser o primeiro levantamento sorológico de *T. gondii* em gatos de Maceió, e seus achados são consistentes com os de outros estados do nordeste do Brasil. Além disso, destaca a necessidade de reconhecer a relação entre a ocorrência da infecção e a vulnerabilidade social.

TERMOS DE INDEXAÇÃO: Toxoplasmose, gato, epidemiologia, anticorpos.

## INTRODUCTION

Toxoplasmosis is a public health issue caused by *Toxoplasma gondii*, a protozoan that infects various hosts (Vilela & Feitosa 2024). Felids play a key role in maintaining the epidemiological cycle and contaminating the environment (Lopes & Berto 2012) as they are the only hosts that shed oocysts in their feces, which is associated with disease transmission to humans and other animal species (Györke et al. 2011).

Toxoplasmosis outbreaks have occurred relatively frequently in Brazil, with 12 outbreaks recorded from 1967 to March 2018 (Pinto-Ferreira et al. 2019). Globally, according to data published by Pinto-Ferreira et al. (2019), 44.12% (15/34) of outbreaks are associated with the ingestion of sporulated oocysts. In Europe (EFSA & ECDC 2019) and the United States (Hoffmann et al. 2012), this pathogen ranks among the three most common foodborne parasites. Notably, the two largest human toxoplasmosis outbreaks worldwide occurred in Brazil, in the cities of Santa Isabel do Ivaí in 2022 and Santa Maria in 2018, both caused by contamination of municipal water reservoirs with *T. gondii* sporulated oocysts (Moura et al. 2006, Minuzzi et al. 2021).

In the state of Alagoas, 245 cases of gestational toxoplasmosis (Padilha 2024) and 57 cases of congenital toxoplasmosis were reported in 2023 (Brasil 2023). In the same state, Melo et al. (2020) reported the first case of fatal congenital toxoplasmosis associated with the atypical, virulent genotype ToxoDB #162 (Melo et al. 2020).

Serological studies conducted on felines in the Northeast region of Brazil, using the indirect fluorescent antibody test (IFAT), showed seropositivity rates of 66.9% (398/595) in Pernambuco (Magalhães et al. 2017) and 17.22% (46/267) in Paraíba (Fernandes et al. 2024). In the North region of Brazil, in the state of Pará, 21.9% (98/447) of feline samples tested positive for anti-*T. gondii* antibodies (Rocha et al. 2020). These results demonstrate the circulation of *T. gondii* within the feline population to varying degrees, highlighting their role as significant sentinels of infection (Covre et al. 2022) and underscoring the need for sanitary control measures to reduce the spread of the parasite in the environment.

Studies focusing on the definitive host of *T. gondii* provide essential information for public institutions to implement control and prevention measures against toxoplasmosis in humans and animals, as cats are considered urban sentinels of the infection. This study aimed to conduct a serological survey and spatial analysis of IgG anti-*T. gondii* antibody occurrence in cats (*Felis catus*) in the municipality of Maceió,

Alagoas (AL), to provide data to support actions to reduce *T. gondii* infection across different Health Districts of this city.

## MATERIALS AND METHODS

**Ethical approval.** This study was submitted to the Ethics Committee on Animal Use of the “Universidade Federal Rural de Pernambuco” (UFRPE) under protocol number 7316060223. After reviewing the electronic request, the Committee, in an ordinary collegiate meeting, waived the requirement for ethical approval, as the study involved pre-collected serum samples.

**Location.** The study was conducted in the municipality of Maceió/AL, located at a southern latitude of -9°38'25.735" S and western longitude of 35°42'54.187" W. The area has an average temperature of 26.5 °C and an altitude of 16 m, characterized by a tropical rainy climate with a dry summer and a rainy season in the autumn/winter months (IBGE 2024a). The municipality comprises 50 neighborhoods organized into eight Health Districts, from which the samples were collected (Maceió 2024a).

**Samples.** Overall, 337 cats (*Felis catus*) blood serum samples were obtained from the Health Districts of the municipality from May 2023 to December 2023. A non-probabilistic convenience sampling method was used. The samples were sourced from a blood serum bank provided by the “Unidade de Vigilância de Zoonoses de Maceió” (Maceió Zoonosis Surveillance Unit – UVZ), offering a free public service, and a private clinical laboratory that provides paid services. Both facilities are in the municipality of Maceió. Of 337 samples, 200 were collected from UVZ, and 137 were obtained from the private laboratory.

The distribution of feline blood serum samples by Health District was as follows: Health District I, 70 samples; Health District II, 49 samples; Health District III, 21 samples; Health District IV, 38 samples; Health District V, 35 samples; Health District VI, 43 samples; Health District VII, 72 samples; and Health District VIII, nine samples.

**Data collection.** Epidemiological data of the sampled cats were obtained from the medical records provided by the facilities, considering the following factors: neighborhood of residence, sex, age, breed, source of blood serum samples bank (samples from the private laboratory and UVZ), and Health District.

**Serological diagnosis.** The IFAT technique described by Camargo (1964) was used to detect anti-*Toxoplasma gondii* IgG antibodies. Slides were sensitized with 10 µL/well of *T. gondii* tachyzoite (ME49 strain) suspensions (10<sup>7</sup> tachyzoites/mL), dried at room temperature (25 °C), and then fixed with chilled acetone for 30 min. Then, cat sera were diluted in phosphate-buffered saline solution (NaCl 8 g, KCl 0.2 g, Na<sub>2</sub>HPO<sub>4</sub> 1.44 g, and KH<sub>2</sub>PO<sub>4</sub> 0.24 g in 1,000 mL of sterile distilled water, pH 7.2) using a cutoff dilution of 1:16 (Dubey 2010). Additionally, a fluorescein-conjugated anti-cat IgG secondary antibody (Sigma-Aldrich, Saint Louis/MO, USA) was used. Samples were considered seropositive if they exhibited total peripheral fluorescence of tachyzoites of ≥ 50% present in each well (Dubey 1995). Reference blood serum samples, identified as positive and negative controls, were included on each slide.

**Spatial analysis.** To analyze the spatial distribution of anti-*T. gondii* IgG antibody occurrence in cats from the municipality of Maceió, thematic maps were created showing case distributions by neighborhoods and districts, as recorded in the medical records of the sampled cats. Map generation was performed using the QGIS software to identify the spatial clusters of feline samples seropositive for anti-*T. gondii* IgG.

**Statistical analysis.** Descriptive analyses were performed for the seropositive and non-seropositive variables. Associations

between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Variables with  $p$ -values  $< 0.05$  were further analyzed using logistic regression to identify potential predictors of seropositivity. All statistical analyses were conducted using Epi Info™ software, version 7.2.3.0.

## RESULTS

Of the 337 samples obtained, 33.53% (113/337) were seropositive, with 57.52% (65/113) originating from the private laboratory and 42.50% (48/113) from the UVZ.

A significant association was observed between the source of the blood serum bank ( $p < 0.05$ ; OR = 2.85; CI = 1.79-4.45 – Maceió UVZ and private Clinical Analysis Laboratory), health district ( $p = 0.003$ ) and age ( $p = 0.00$ ; OR = 1.87; CI = 1.15-3.05) with the serological result for the presence of anti-*Toxoplasma gondii* IgG antibodies. No significant associations were found between the other analyzed variables (Table 1).

The highest percentage of seropositive samples for anti-*T. gondii* IgG antibodies in cats were detected in Ponta Verde (14.15%, 16/113), located in the southern region of the city. This was followed by Benedito Bentes (11.50%, 13/113) and Cidade Universitária (10.61%, 12/113), both located in the northern region; followed by two neighborhoods in the south, Chã da Jaqueira (8.84%, 10/113) and Vergel (7.96%, 9/113). The neighborhoods with the lowest number of seropositive feline samples were Jatiúca (5.30%, 6/113); Gruta de Lourdes, Farol, Mangabeiras, Trapiche, and Pajuçara (3.53%, 4/113 each); Prado (2.65%, 3/113); Clima Bom, Bom Parto, Jacintinho, Ponta Grossa, and Feitosa (1.76%, 2/113 each); and Guaxuma, Ponta da Terra, Pitanguinha, Centro, Cruz das Almas, Chã de Bebedouro, and Barro Duro (1.00%, 1/113 each) (Fig. 1).

The Health District with the highest frequency of seropositive samples was District I, with 31.86% (36/113), followed by District II with 16.81% (19/113) and District VII with 12.40% (14/113). Districts IV and VI both had a frequency of 11.50% (13/113). District III accounted for 7.96% (9/113), District V for 6.19% (7/113), and District VIII for 1.77% (2/113) (Fig. 2).

Notably, 60.20% of seropositive animals (68/113) were over two years old, and 39.82% (45/113) were 1-2 years old, with a female-to-male ratio of 55.75% (63/113) male and 44.25% (50/113) female. Regarding breed, most seropositive cats were mixed breeds, accounting for 91.15% (103/113), whereas 8.85% (10/113) were Persian, Siamese, or Exotic. No significant associations were found between sex and breed and seropositivity (Table 1).

## DISCUSSION

To the best of our knowledge, this is the first serological survey on the occurrence of anti-*Toxoplasma gondii* antibodies in cats in the municipality of Maceió/AL. Considering that felids are definitive hosts of *T. gondii* and shed oocysts in their feces (Dubey 2010), studying the serological profile and spatial distribution of *T. gondii* infections has significant public health implications, especially in regions where epidemiological information remains lacking.

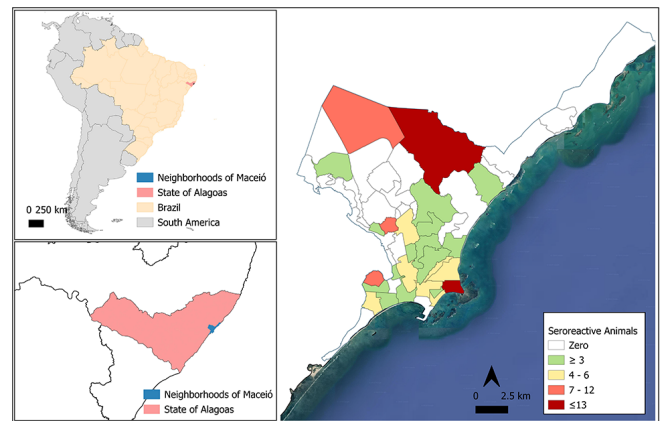


Fig. 1. Spatial distribution of anti-*Toxoplasma gondii* IgG antibody occurrence in cats by neighborhoods in the municipality of Maceió, Alagoas.

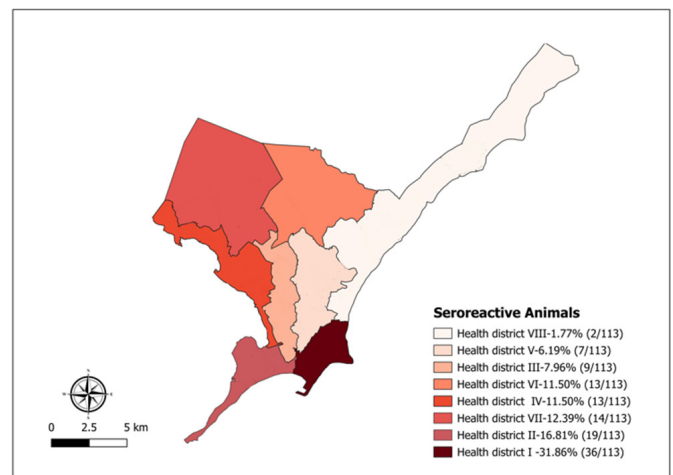


Fig. 2. Spatial distribution of anti-*Toxoplasma gondii* IgG antibody occurrence in cats according to the Health District in the municipality of Maceió, Alagoas.

**Table 1. Association between demographic factors and serum bank origin and the occurrence of anti-*Toxoplasma gondii* IgG antibodies in cats**

Association variable	OR	95% CI	P-value
Serum bank source (UVZ vs. private)	2.85	1.79 – 4.55	< 0.05
Sanitary district	-	-	0.003
Sex (M/F)	1.05	0.65 – 1.66	0.822
Age (1-2/ > 2 years)	1.87	1.15 – 3.05	0.00

OR = Odds ratio, CI = confidence interval, UVZ = "Unidade de Vigilância de Zoonoses de Maceió" (Maceió Zoonosis Surveillance Unit), M = male, F = female.

According to data from the “Ministério da Saúde” (Ministry of Health) available on the “Departamento de Informação e Informática do Sistema Único de Saúde” (Department of Informatics of the Unified Health System – DATASUS) platform, the number of human gestational toxoplasmosis cases in Maceió increased from 18 cases in 2019 to 57 in 2023, indicating an exponential elevation in disease incidence (Brasil 2023). Melo et al. (2020) reported a case of congenital toxoplasmosis involving an atypical and virulent *T. gondii* genotype in this municipality, highlighting the importance of understanding the epidemiological and transmission dynamics of *T. gondii*.

Despite records of human disease in Maceió, the serological profile of *T. gondii* infection in cats was unknown. A significant association between the Health District and seropositivity ( $p = 0.003$ ) was observed. Health District I had the highest number of seropositive samples (31.85%), including neighborhoods with a high population density and varied urban infrastructure, such as areas with poor sanitation. Health Districts II and VII, with 16.81 and 12.40%, respectively, also contain neighborhoods with inadequate sanitation conditions, as evidenced in the report of the health situation analysis conducted by the Health District, prepared by the Health Department of Maceió (Maceió 2024b).

Melo et al. (2024) identified risk areas for congenital toxoplasmosis in humans in Brazil and their association with social vulnerability and health indicators. Additionally, they documented a positive association between congenital toxoplasmosis incidence and the Social Vulnerability Index, coverage by community health workers, and percentage of prenatal visits. Extrapolating these findings to the cat population suggests that a higher number of *T. gondii*-seropositive animals can be found in socially vulnerable areas. Thus, socioeconomic, educational, sanitary, and demographic factors could be directly associated with and influence the occurrence of anti-*T. gondii* antibodies in cats, as regions with poor sanitary conditions are known to facilitate its spread among human populations. However, detailed studies with cats are still required.

Fernandes et al. (2024) evaluated the seroprevalence of *T. gondii* in 2018 in naturally infected cats, both before and after the largest recorded human toxoplasmosis outbreak in Brazil, which involved 902 human cases. Water was identified as the primary source of infection. They observed a significant increase in anti-*T. gondii* antibody levels in domestic feline blood serum samples. Environmental contamination with *T. gondii* oocysts may promote infection in both definitive and intermediate hosts (Jones & Dubey 2010, Montazeri et al. 2020).

Among the neighborhoods studied, those with the highest percentage of seropositive domestic feline samples were Ponta Verde (14.15%), Benedito Bentes (11.50%), Cidade Universitária (10.61%), Chã da Jaqueira (8.84%), Vergel (7.96%), and Jatiúca (5.30%).

In the municipality of Maceió, neighborhoods such as Ponta Verde and Jatiúca are classified as upper-middle-class, while neighborhoods such as Benedito Bentes and Cidade Universitária are considered peripheral areas, with deficient urban infrastructure and inadequate sanitation. Approximately 57% of the public roads in the municipality of Maceió have tree coverage, while 47.1% of households have access to adequate sewage systems (IBGE 2024b).

In our study, we did not observe a significant association between the frequency of seroreactive domestic feline samples and their neighborhood of origin, despite the different health situation characteristics by neighborhood, as highlighted in the health situation analysis report prepared by the Health Department of Maceió (Maceió 2024b). These factors may influence the occurrence of *T. gondii* infection. Maceió faces significant challenges regarding basic sanitation, being one of the Brazilian capitals with the worst indicators in this area. Additionally, Maceió has the worst socioeconomic indicators in this area (SEMURB, 2024) and was ranked by the Instituto Trata Brasil (2024) as the 89th worst in terms of poor sanitation.

Notably, observation of higher antibody frequencies in cats residing in neighborhoods with better socioeconomic conditions suggests that other variables may influence infection rates in these neighborhoods. These findings are consistent with those of previous studies, indicating that indoor cats can become infected similarly to cats in areas with lower sanitary and economic standards. Thus, dietary and behavioral habits play a direct role in *T. gondii* infection in cats (Marques et al. 2019).

The private laboratory samples were 57.52% (65/113) positive for anti-*T. gondii* IgG antibodies. Since this is a private facility, it was expected, although not explicitly evaluated in this study, that most animals cared for there would be indoor cats. Therefore, a group with a lower *T. gondii* exposure risk. A higher prevalence of indoor cats, due to dietary habits such as the consumption of raw meat and contaminated water, is a significant risk factor for infection, as even accidental exposure can cause infection (Moura et al. 2015, Marques et al. 2019, Silva et al. 2021). Thus, contaminated meat and water consumption, as well as habitat and environmental factors, are directly associated with *T. gondii* infection (Silva et al. 2021). Notably, feeding commercial pet food and filtered water acts as a protective factor against diseases (Marques et al. 2019).

Herein, the occurrence of anti-*T. gondii* IgG antibodies in the analyzed cats may be related to dietary and other factors such as the influence of the animal's environment, outdoor access, and hunting habits (Galvão et al. 2014).

Cats older than two years accounted for the majority of seropositive samples, with a statistically significant difference between age groups ( $p < 0.05$ ). The longer the exposure period, the greater the chance of contact with coccidian and the development of anti-*T. gondii* antibodies (Awad & Barakat 2019, Fernandes et al. 2024). Additionally, over the years, if cats have access to outdoor environments or somehow come into contact with the parasite, they may experience reactivation and/or reinfection, leading to the new shedding of oocysts into the environment (Jamra & Sanchis 1985).

Cats of any sex or breed are susceptible to *T. gondii* infection (Dubey 2010); therefore, these variables are rarely described as risk factors (Marques et al. 2019, Dubey et al. 2020). Herein, these variables were not significantly associated with the presence of anti-*T. gondii* IgG antibodies.

Although the data from this research are relevant, it should be noted that the number of samples obtained in some neighborhoods and Health Districts was relatively small, as these samples were collected on a voluntary basis, limiting a more in-depth and comparative discussion regarding frequency across different areas of Maceió.

## CONCLUSION

This study demonstrates a significant prevalence of cats infected with *Toxoplasma gondii* in the city of Maceió, Alagoas, with potential for environmental contamination. It emphasizes the need for effective sanitary measures, such as community health education, basic sanitation, and feline population control. Recognizing the relationship between the occurrence of infections and social vulnerability is instrumental in guiding the formulation of comprehensive public policies that address this issue.

**Conflict of interest statement.**- The authors declare that there are no conflicts of interest.

**Credit author statement.**- Mariana F.V. Britto: Conceptualization, Methodology, Writing – original draft, Visualization, Investigation. Pollyanne R.F. Oliveira: Methodology, Writing – Review and Editing. Valdir V. Silva: Methodology, Writing – Review and Editing. Gilsan A. Oliveira: Writing – Review and Editing, Conceptualization, Investigation, Supervision. Rinaldo A. Mota: Writing – Review and Editing, Conceptualization, Investigation, Supervision.

**Data availability statement.**- The data used in this study are available and can be accessed upon request from the corresponding author.

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