







## Epidemiology of toxoplasmosis in felids and canids in Brazil: A brief One Health overview<sup>1</sup>

Andressa F. Silva<sup>2</sup> , Anna E. Athayde-Gusmão<sup>2</sup> , Gabriela O. Pereira<sup>3,4</sup> ,  
Daniel G. Ubiali<sup>4\*</sup> 

**ABSTRACT.-** Silva AF, Athayde-Gusmão AE, Pereira GO, Ubiali DG. **Epidemiology of toxoplasmosis in felids and canids in Brazil: A brief One Health overview.** *Pesquisa Veterinária Brasileira* 45:e07605, 2025. Setor de Anatomia Patológica, Departamento de Epidemiologia e Saúde Pública, Instituto de Veterinária, Universidade Federal Rural do Rio de Janeiro, Rodovia BR-465 Km 7, Seropédica, RJ 23890-000, Brazil. E-mail: [danielubiali@ufrj.br](mailto:danielubiali@ufrj.br)

Toxoplasmosis is a disease caused by the obligate intracellular protozoan *Toxoplasma gondii*, which infects animals and humans worldwide. Felids are definitive hosts that eliminate oocysts, contaminating the environment, food, and water. Among carnivores, cats are the most important hosts for the epidemiology of the disease since a single individual can shed millions of oocysts. Wild canids are considered sentinels and play an essential role in the epidemiology of toxoplasmosis due to tissue cysts in muscle cells, representing a source of infection for carnivores through predation, while environmental contamination is mainly due to oocyst shedding by felids. Free-ranging felids are more likely to be infected by *T. gondii* than felids living in captivity. The free-living wild canids have lower seropositivity compared to canids in captivity. This review article presents epidemiological data on toxoplasmosis in domestic and wild carnivores in Brazil, targeting professionals in clinical practice, veterinary pathology, diagnostics, and One Health. Therefore, we understand the importance of disseminating diagnoses, epidemiological investigations and animal health programs to control, prophylaxis and treat toxoplasmosis in domestic and wild carnivores.

INDEX TERMS: Epidemiology, wildlife conservation, wildlife medicine, veterinary pathology, toxoplasmosis, carnivore, Apicomplexa, *Toxoplasma gondii*.

**RESUMO.- [Epidemiologia da toxoplasmose em felídeos e canídeos no Brasil: uma breve visão geral em Saúde Única.]** A toxoplasmose é uma doença causada pelo protozoário intracelular obrigatório *Toxoplasma gondii*, responsável por infectar animais e seres humanos em todo o mundo. Os felinos são hospedeiros definitivos e eliminam oocistos que contaminam o ambiente, alimentos e água. Dentre os carnívoros, os felinos são os hospedeiros mais importantes para a epidemiologia da doença, visto que um único indivíduo é capaz de excretar milhões de oocistos. Canídeos selvagens são considerados sentinelas e desempenham um papel

essencial na epidemiologia da toxoplasmose, pois os cistos teciduais presentes nas células musculares representam uma fonte de infecção para carnívoros por meio da predação, enquanto a contaminação ambiental ocorre principalmente pela eliminação de oocistos por felídeos. Os felinos de vida livre têm maior probabilidade de serem infectados por *T. gondii* do que os felinos mantidos sob cuidados humanos. Os canídeos silvestres de vida livre apresentam menor soropositividade em comparação aos canídeos em cativeiro. Este artigo de revisão apresenta dados sobre a epidemiologia da toxoplasmose em carnívoros domésticos e silvestres no Brasil focado para profissionais da área clínica, patologia veterinária, diagnóstico e Saúde Única. Portanto entendemos a importância de divulgação de métodos de diagnósticos, investigações epidemiológicas e programas de saúde animal para contribuir com o controle, profilaxia e tratamento da toxoplasmose em carnívoros domésticos e silvestres.

TERMOS DE INDEXAÇÃO: Epidemiologia, conservação da natureza, medicina de animais silvestres, patologia veterinária, toxoplasmose, carnívoro, Apicomplexa, *Toxoplasma gondii*.

<sup>1</sup> Received on March 14, 2025.

Accepted for publication on May 25, 2025.

<sup>2</sup> Laboratório de Pesquisa Apicomplexa (LAPA), Universidade Federal Rural do Rio de Janeiro (UFRJ), BR-465 Km 7, Seropédica, RJ 23890-000, Brazil.

<sup>3</sup> Laboratório de Diversidade e Doenças Virais (LDDV), Departamento de Genética, Instituto de Biologia, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ 21941-617, Brazil.

<sup>4</sup> Setor de Anatomia Patológica (SAP), Universidade Federal Rural do Rio de Janeiro (UFRJ), BR-465 Km 7, Seropédica, RJ 23890-000, Brazil.

\*Corresponding author: [danielubiali@ufrj.br](mailto:danielubiali@ufrj.br)

## INTRODUCTION

*Toxoplasma gondii* infects all warm-blooded animal species. Toxoplasmosis continues to be a worldwide public health problem (Aguirre et al. 2019, Dubey 2022). The epidemiological scenario of toxoplasmosis in Brazil is impressive since it accounted for 35% of human toxoplasmosis outbreaks worldwide over the last decade (Dubey 2022). Felids (domestic and wild cats) are the only definitive hosts of *Toxoplasma gondii* and are capable of shedding environmentally resistant oocysts in their feces (Dubey et al. 2020a). However, skeletal muscle cells contain tissue cysts, representing an essential source of infection for omnivorous and carnivorous hosts and maintenance of the protozoans' biological cycle.

The carnivorous hosts of *T. gondii* are affected by a catastrophic environmental scenario, besides threats to human urban areas and diseases (Gering et al. 2021). An increasing number of wild carnivores have been attracted to urban or suburban areas due to easy access to food or safe shelter, and wild animals have become urban residents (Kornacka-Stackonis 2022). Currently, in Brazil, wildfire receives significant importance as an agent that implies the migration of wildlife populations, which could drive mortality across vast areas (Magioli et al. 2024), exerting intense selective pressure on disease occurrence (Tomas et al. 2021).

The species from the order Carnivora are mammals that feed by preying on other animals. Carnivores comprise around 280 species spread across the planet (Hudson et al. 2022). About 64% of carnivores species are threatened, and 80% have declining populations due to habitat loss and fragmentation, persecution by humans, and often livestock-related conflicts (Ubiali et al. 2018, Wolf & Ripple 2018). There are 28 wild carnivore species of mammals in the Brazilian fauna, comprising five taxonomic families, including 10 Felidae and six Canidae species (Instituto Pró-Carnívoros 2024). This order includes the most popular domestic species, including pets, dogs, and cats. Our affection for domestic carnivores reflects the number of domestic dogs and cats, quantified as 55.9 million canines and 25.6 million domestic felines in Brazil (Instituto Pet Brasil 2021). Otherwise, the Earth's large terrestrial carnivores are charismatic, highly endangered groups of species like jaguars and maned wolves. Most of these wild species have experienced major geographical range contractions, causing risk of extinction or becoming ecologically nonviable (Van Valkenburgh & Wayne 2010).

Serologic prevalence data are also important for determining the epidemiologic significance of *T. gondii* infection in cats because oocysts are rarely found in the feces of cats (Dubey et al. 1995). The definitive hosts eliminate oocysts and contribute to the perpetuation of the disease (Dubey 2022). Cats can eliminate rapidly around 20 million oocysts during the first infection (Dubey 1995). Experimentally reinfected cats could eliminate *T. gondii* oocysts years after the first infection (Zulpo et al. 2018), especially when the cat has been infected with different strains (Dubey 2022). Cats infected with Feline Immunodeficiency Virus (FIV) or Feline Leukemia Virus (FeLV) may be more susceptible to *T. gondii* infection due to immunosuppression (Munhoz et al. 2017, Pena et al. 2017). The human-animal bond, recognized as a special relationship between people and companion animals, has led to the hypothesis that humans and animals living in the same household, sometimes sharing a bed, may be closely

related from an epidemiological perspective (Paul et al. 2010, Benitez et al. 2017).

The population of domestic felines in Brazil has grown, and the seropositivity of the populations varies from 19% to 50%, demonstrating, as definitive hosts, at some point, that these felines eliminate oocysts in their feces, increasing high environmental contamination. (Dubey 2022, Carvalho-Alves et al. 2024). In Brazilian wildlife, 10 species of felids are distributed into five biomes (Instituto Pró-Carnívoros 2024). Interactions of wild felids could contaminate the food of many species and cause abortion due to toxoplasmosis in ruminants (Caldeira et al. 2011, Roman et al. 2024). Under other conditions, birds could be hunted by felids. Birds are susceptible to *T. gondii* infection and serve as intermediate hosts in the protozoan's life cycle. Consequently, birds are essential sources of infection for wildlife carnivores (Alves et al. 2022).

The present review provides information on the epidemiology of toxoplasmosis in domestic and wild carnivores in Brazil, targeting One Health professionals. In this context, a literature review was conducted on epidemiologic investigations of domestic and wild carnivores to identify toxoplasmosis and host-protozoan interactions.

## MATERIALS AND METHODS

**Ethical approval.** All data were obtained from database literature searches; we did not perform animal sampling or experiments for the present study.

Peer-reviewed scientific papers (original research, case reports, and reviews) on toxoplasmosis were searched in electronic databases: BASE, Google Scholar, Latindex, Medline, PubMed, SciELO, Scopus, Web of Science and WorldWideScience. We searched for carnivores, cats, dogs, wild carnivores, toxoplasmosis and *Toxoplasma gondii*. The title, abstract, materials and methods, and results from researches found in online database searches up to December 2024 were screened for relevance to inclusion in our review. This review is divided into toxoplasmosis epidemiology in domestic cats and domestic dogs, wild carnivores, wild felids and wild canids in Brazil; afterward, we prepare a Discussion section and the Conclusions.

The reported research spatial data on toxoplasmosis cases in domestic and wild carnivores were analyzed using ArcGIS™ v. 10.6.1 licensed software to elaborate epidemiological maps.

## DOMESTIC CATS

The prevalence of *Toxoplasma gondii* infection varies depending on the habits and housing of domestic cats. In general, it is higher in wild cats that hunt for food than in domestic cats without outdoor access. The availability of food sources is directly linked to high seroprevalence rates in domestic cats (Dubey et al. 2020a). Brazil is highlighted as one of the countries with the highest number of reports, emphasizing domestic cats' significant role in toxoplasmosis epidemiology. The frequency of *T. gondii* infection in Brazilian pet animal populations can vary from 0 to 92% in cats (Fig. 1 and Table 1).

The Brazilian domestic cats seropositivity to *T. gondii* shows remarkable variation, a key epidemiological feature. One study found a seroprevalence of just 5.6% in domestic cats. At the same time, other analyses indicate seropositivity between 61% and 92% in a free-living feline population in urban areas of the State of Rio de Janeiro (Mendes-de-

Almeida et al. 2007). This variation was also attributed to these animals' eating habits and lifestyle since domesticated felines have more access to industrialized food, sanitary litter boxes, and reduced access to hunting small rodents or other possible intermediate hosts of the protozoan.

Studies on the detection of anti-*T. gondii* and assessment of risk factors for infection are common. A current report evaluated the risk factors in Rio de Janeiro and observed that cats over ten years have a high probability of disease (Carvalho-Alves et al. 2024). An investigation by Fernandes et al. (2024a) in João Pessoa, Paraíba, also observed the cat's age and where they live (urban area) as risk factors. Domestic cats that eat offal and homemade food are more likely to become infected, as male cats become more infected than females (Arruda et al. 2021). This factor may be related to exploratory behavior, possibly associated with outside physical activities and high energy requirements (Miró et al. 2004).

The Southeast region has the highest number of seroepidemiological investigations in domestic cats and, consequently, a high prevalence. It is worth highlighting the State of Rio de Janeiro, which is endemic for toxoplasmosis in cats, with the most significant number of studies and, therefore, the one with the most important variation in seroprevalence: 8.1% to 92%. São Paulo comes next with seven studies in which a variation of 15% to 70% in seroprevalence

is observed. Minas Gerais and Espírito Santo have few analyses, just one of each, with seroprevalence of 7% and 20%, respectively. From the Northeast, in the state of Piauí, no seropositive cats were detected in the only study, unlike Pernambuco, where seroprevalence reached up to 70%. Bahia, Maranhão, Paraíba, and Rio Grande do Norte had an average of 50% of cats presenting anti-*T. gondii* antibodies. In the North region, studies were conducted only in Acre, Rondônia and Pará, with the percentage varying from 20% to 50%, demonstrating the need for further investigations to better understand toxoplasmosis in this region. Although one of the most significant outbreaks of human toxoplasmosis ever recorded occurred in the South region (Minuzzi et al. 2021), the seroprevalence of cats in this region averaged 30%.

A meta-analysis of published articles on *T. gondii* prevalence in cats in Brazil conducted by Lugoch et al. (2018) showed a seroprevalence of 35.9% for toxoplasmosis in cats in Brazil. Regarding the age group, it was found that adult cats are 2.84 times more likely to be seropositive than young cats. The seroprevalence of cats from the North-Northeast-Center region was 50.5% and 29.9% in the South-Southeast region, except for some studies in which the seroprevalence was higher.

A research group from Pará focused on applying an epidemiological questionnaire on toxoplasmosis to the owner, regardless of their level of education. Owners knew

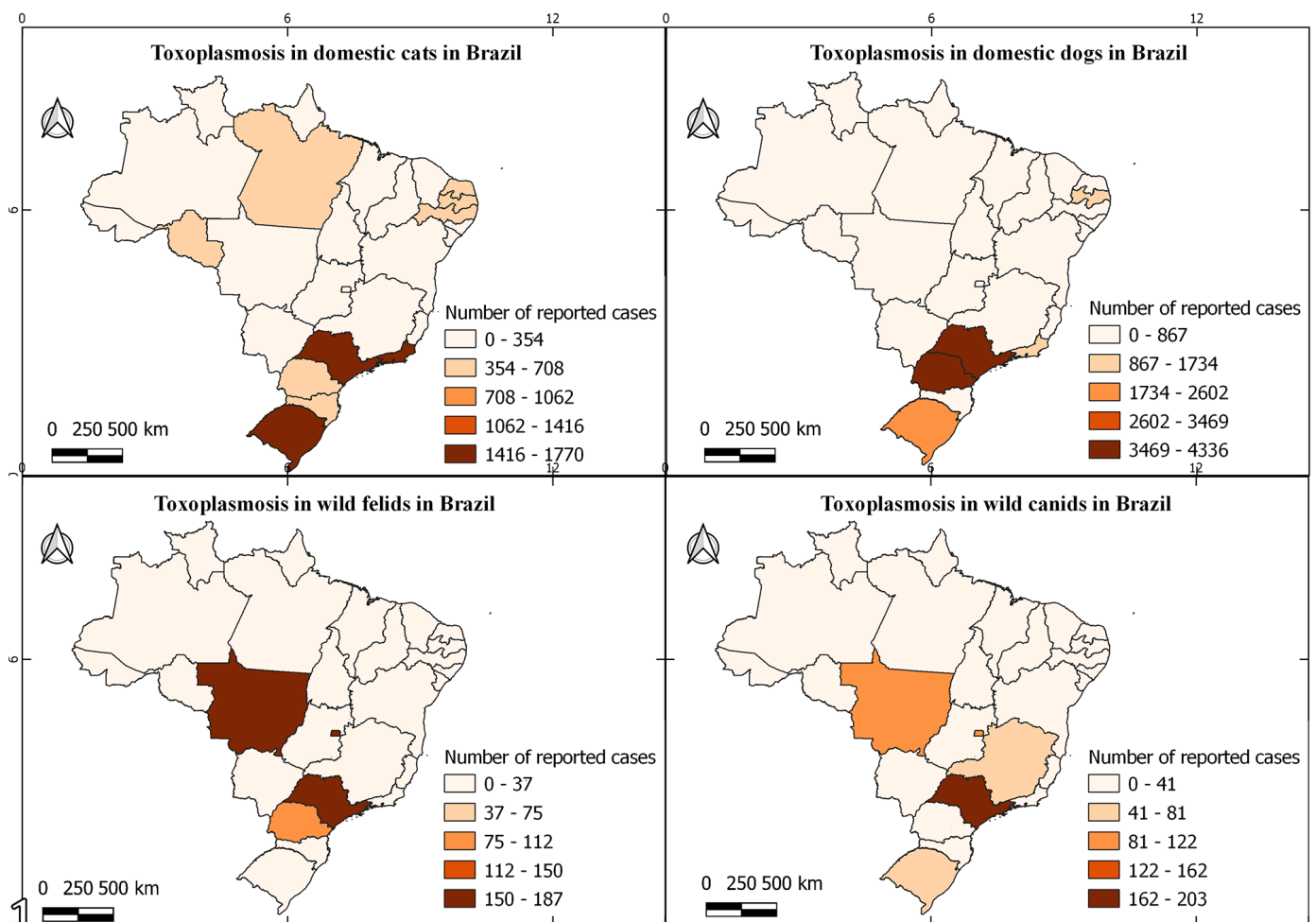


Fig. 1. Mapping toxoplasmosis in domestic cats and dogs, wild felids and canids in Brazil based on literature reports and research.

little about how the protozoan is transmitted to humans and animals (Rocha et al. 2020). This finding highlights the need for improved public awareness and education regarding

the pathways of toxoplasmosis transmission. As a widely distributed zoonosis, toxoplasmosis must involve guidance and joint research within the scope of One Health. Therefore,

**Table 1. Seroepidemiological survey for toxoplasmosis in domestic cats in Brazil**

State	N	Reactive (%)	Test	Dilution	Author and year
Acre	89	24.7	IFAT	1:64	Souza et al. (2015)
Bahia	231	45.4	IFAT	1:64	Munhoz et al. (2017)
	28	50.0	IFAT	1:64	Oliveira et al. (2019)
Espírito Santo	20	35.0	IHA	1:64	Deiró et al. (2021)
	79	15.2	ELISA	NM	Fux et al. (2020)
Maranhão		7.6	IFAT		
	200	50.5	IFAT	1:40	Braga et al. (2012)
Mato Grosso do Sul	14	57.14	MAT	1:25	Marques et al. (2009)
	50	4.0	IFAT	1:40	Braga et al. (2014)
	151	32.5	IFAT	1:16	Souza et al. (2014)
Minas Gerais	209	19.6	IFAT	1:16	Sebastiani (2021)
		21.0	ELISA		
Pará	447	21.92	IFAT	1:16	Rocha et al. (2020)
Paraíba	201	43.8	IFAT	1:16	Feitosa et al. (2014)
	103	53.4	IFAT	1:16	Feitosa et al. (2021)
	267	17.22	IFAT	1:16	Fernandes et al. (2024a)
	282	16.3	IFAT	1:16	Cruz et al. (2011)
Paraná	171	28.7	IFAT	1:16	Andrade et al. (2015)
	2	100.0	IFAT	1:24	Ferreira Neto et al. (2018)
	118	59.3	MAT	1:25	Costa et al. (2012)
Pernambuco	35	25.7	IFAT	1:16	Arraes-Santos et al. (2016)
	348	71.2	IFAT	1:16	Magalhães et al. (2017)
	31	58.0	IFAT	1:16	Melo et al. (2016)
	102	0	ELISA	NM	Teixeira et al. (2016)
Rio de Janeiro	41	24.4	ELISA	NM	Gonçalves Netto et al. (2003)
	75	92.0	HAI	1:16	Mendes-de-Almeida et al. (2007)
	108	5.6	HAI	1:16	Bastos et al. (2014)
	213	6.6	IFAT	1:64	Barros et al. (2015)
	372	9.7	MAT	1:25	Bolais et al. (2017)
	86	29.0	IFAT	1:16	Freitas (2017)
	433	21.9	IFAT	1:64	Pereira et al. (2018)
	272	8.1	IFAT	1:64	Arruda et al. (2021)
	91	18.7	MAT	1:25	Carvalho-Alves et al. (2024)
	53	52.8	MAT	1:25	Fournier et al. (2014)
Rio Grande do Norte	120	25.8	IFAT	1:16	Bezerra et al. (2023)
	100	37.0	HAI	1:64	Araújo et al. (2003)
Rio Grande do Sul	245	37.9	IFAT	1:64	Pinto et al. (2009)
	180	21.6	IFAT	1:64	Oliveira et al. (2014)
	112	38.0	IFAT	1:16	Fernandes et al. (2024b)
	63	87.3	MAT	1:25	Cavalcante et al. (2006)
Rondônia	100	26.0	IFAT	1:16	Silva et al. (2023)
	300	14.3	IFAT	1:64	Rosa et al. (2010)
Santa Catarina	60	50.0	IFAT	NM	Faria et al. (2018)
	248	17.7	IFAT	1:40	Lucas et al. (1999)
São Paulo	400	25.0	IFAT	1:64	Bresciani et al. (2007)
	237	35.4	MAT	1:25	Pena et al. (2006)
	59	78.0	ELISA	NM	Duarte et al. (2010)
	70	15.7	IFAT	1:64	Coelho et al. (2011)
	251	20.3	IFAT	1:16	Vicente Sobrinho et al. (2012)
	386	16.3	IFAT	1:64	Cardia et al. (2013)

IFAT = Indirect fluorescent antibody test, IHA = indirect hemagglutination, ELISA = enzyme-linked immunosorbent assay, MAT = modified agglutination test, NM = not mentioned.

it is essential to reinforce information on prophylaxis and monitor the profile of the epidemiological analysis of the animal population (Fernandes et al. 2024a).

Control and prophylaxis measures effectively reduce the incidence of infections and shed environmental oocysts. Feline infection risk depends on access to infected prey, reflecting their hunting behavior. Furthermore, methods such as castration and placing screens in homes so that animals do not have access to the streets are alternatives for control, as well as the presence of a litter box to defecate in an appropriate place (Dubey 2022). Controlling the food supply is also a protective measure and must be provided. In natural feeding, it is essential to freeze and cook meat before offering it (Arruda et al. 2021). Water is also a source of infection. Adequately treated and filtered water is recommended, as water treatment does not provide protection (England et al. 2018). The filtration efficiently retains *T. gondii* oocysts and prevents infection, instead of oocyst resistance to the most popular chlorination water treatment technique (Minuzzi et al. 2021, Dubey 2022).

Our review identified 47 Brazilian studies on anti-*T. gondii* seroprevalence in domestic cats (Table 1). In these studies, we observed variation in the serological tests used, with the Indirect Fluorescent Antibody Test (IFAT) being the most frequently used, followed by the Modified Agglutination Test (MAT), Enzyme-Linked Immunosorbent Assay (ELISA) and Indirect Hemagglutination Test (IHAT). When we look at the percentage of seropositive domestic cats, we notice that the country has a high prevalence. More than half of the analyses demonstrated a prevalence of 50% or higher, but depending on the region, this level reached only 20%. All reported studies were carried out after 1999 and cover the country's five regions: six in the North, 11 in the Northeast, three in the Midwest, eight in the South, and 18 in the Southeast.

Concerning the presented data, we found that toxoplasmosis affects domestic cats throughout the national territory, warning of possible environmental contamination, considering that felines, when infected, can shed millions of environment-resistant oocysts, which survive for years. In other regions, especially in the North and Midwest of Brazil, further research is needed to increase understanding of the epidemiology and possible spillover between human and wild species, given the scarcity of reports.

## DOMESTIC DOGS

*Toxoplasma gondii* strain isolates in dogs in Brazil revealed high recombination, being highly pathogenic to animals (Silva et al. 2017). Seropositivity for anti-*T. gondii* antibodies in dogs has epidemiological significance and indicates the circulation of the protozoan in the environment (Dubey et al. 2020b). The seropositivity of free-ranging dogs means sentinel animals for toxoplasmosis and indicates environmental contamination by *T. gondii* oocysts. Monitoring seroprevalence can offer a strategy for evaluating exposure and geographical distribution of protozoan circulation (Dini et al. 2024).

Although toxoplasmosis has typically been considered a foodborne disease, socioeconomic factors such as low household income can impact human seroprevalence. An example is that yards containing garbage affect canine seroprevalence (Benitez et al. 2017). Contact with oocysts can lead consequences beyond infection of the dog, as it has been demonstrated that dogs can act as mechanical transporters

of *T. gondii* oocysts from the surface of the body, hair, mouth and paws. Furthermore, in coprophagia cases, after ingesting infected feline feces and during the oocyst elimination phase, dogs are not definitive hosts of *T. gondii* and do not biologically shed oocysts in their feces. However, they may contribute to environmental dissemination by mechanically excreting viable oocysts in their feces after ingesting cat feces during coprophagy. Additionally, oocysts may be transported on their fur, paws, or oral cavity after contact with contaminated environments (Dubey et al. 2020b, Dini et al. 2024).

Ingestion of homemade food and water is the leading risk factor associated with *T. gondii* infection in dogs. Meireles et al. (2004) pointed out that dogs are more susceptible to ingesting one of the infectious forms of *T. gondii*, such as tissue cysts in raw or undercooked meat or oocysts in contaminated food. More recent studies have also identified food as the leading risk factor for infection in domestic dogs (Cunha et al. 2020, Arruda et al. 2021, Freitas et al. 2022, Dini et al. 2024). Mixed-breed dogs are more likely to be infected with *T. gondii* than purebred dogs (Arruda et al. 2021).

The environment in which the dog has access is strongly related to a risk factor for *T. gondii* infection. Dini et al. (2024) associated the high prevalence of anti-*T. gondii* with cohabitation with domestic cats; this factor was highly significant in this study. The author pointed out that environmental contamination and the coprophagy behavior of dogs are associated with the presence of felines in the same environment. On the other hand, Freitas et al. (2022) did not find an association between the infection and the presence of cats in the environment in their research. This research found an association between high disease prevalence in dogs and owners having anti-*T. gondii*, demonstrating that animals are prone to becoming infected through contaminated food or water.

The low socioeconomic level of the population and poor infrastructure are directly associated as risk factors for dog infection (Carlos 2010, Benitez et al. 2017, Olbera et al. 2020, Belaz et al. 2023, Remor-Sebolt et al. 2024). Toxoplasmosis in dogs is associated with precarious sanitary conditions and environmental conditions of intense social inequality and low economic power. The presence of stray small animals as reservoirs and the close relationship between humans and dogs are also factors that contribute to the spread of the protozoan (Belaz et al. 2023). Arruda et al. (2021) raised the hypothesis that the habit of domestic dogs walking on the streets and their owners may be a factor for the high prevalence.

In Brazil, 60 seroprevalence analyses of this species were recorded in the most diverse states (Fig. 1 and Table 2). In these studies, they investigated anti-*T. gondii* in domiciled, non-domesticated dogs and those living in peridomestic and the type of residence, in addition to the presence of different eating habits and water intake that are provided to each animal by each responsible family, who proposed to participate in the work by answering forms. The most used serological test was the IFAT, which is known to be reliable but not as sensitive as the MAT (Desmonts & Remington 1980, Dubey 1997), followed by IHAT and ELISA. The percentage of seropositive dogs varied from 6% to 85%, depending on the region of the country. However, Table 2 shows that more than half of the country's analyses demonstrated a prevalence of more than 50% of dogs.

**Table 2. Seroepidemiological survey for toxoplasmosis in domestic dogs in Brazil**

State	N	Reactive (%)	Test	Dilution	Author and year
Several	157	31.2	IFAT	1:16	Machado et al. (2019)
Amazonas	325	52.0	IFAT	1:16	Minervino et al. (2012)
	154	12.3	IFAT	1:16	Campos et al. (2022)
Bahia	529	36.5	IHA	1:16	Carlos (2010)
	21	33.3	IHA	1:16	Silva et al. (2017)
	61	44.3	IFAT	1:16	Oliveira et al. (2019)
Espírito Santo	187	47.0	IFAT	1:16	Acosta et al. (2016)
Mato Grosso	61	88.5	NM	NM	Santos et al. (2009)
	248	43.1	IFAT	1:16	Rodrigues et al. (2016)
	386	6.7	IFAT	1:16	Strital et al. (2016)
Minas Gerais	163	33.0	IFAT	1:16	Mineo et al. (2001)
	218	60.7	IFAT	1:16	Guimarães et al. (2009)
	72	70.8	IFAT	1:16	Valadas et al. (2010)
Pará	57	68.4	IFAT	1:16	Paz et al. (2019)
	88	36.4			
	16	18.7			
	31	61.3			
	128	35.9			
Paraíba	286	45.1	IFAT	1:16	Azevedo et al. (2005)
	384	9.6	IFAT	1:50	Brasil et al. (2018)
	1043	22.1	IFAT	1:64	Fernandes et al. (2018)
Paraná	649	51.3	IFAT	1:16	Garcia et al. (1999)
	134	34.4	MAT	1:20	Souza et al. (2003)
	61	70.5	IFAT	1:16	Ruffolo et al. (2016)
	24	20.8	IFAT	1:16	Romanelli et al. (2007)
	127	18.1	IFAT	1:50	Plugge et al. (2011)
	120	40.0			
	175	70.8	IFAT	1:16	Dreer et al. (2013)
	26	30.7	IFAT	1:20	Constantino et al. (2016)
	598	43.3	IFAT	1:16	Ferreira et al. (2016)
	729	16.3	IFAT	1:16	Benitez et al. (2017)
	649	51.3	ELISA	1:16	Pinto-Ferreira et al. (2019)
	364	48.0	IFAT	1:16	Almeida et al. (2016)
		29.67	MAT	1:25	
	264	7.95	IFAT	1:16	Cunha et al. (2020)
	283	23.3	IFAT	1:16	Freitas et al. (2022)
	133	9.8	IFAT	1:16	Sohn-Hausner et al. (2024)
Pernambuco	170	57.6	IFAT	1:16	Figueroa et al. (2008)
	60	40.0	MAT	1:25	Costa et al. (2012)
	320	48.7	IFAT	1:16	Magalhães et al. (2017)
	241	9.5	IFAT	1:16	Souza et al. (2019)
Piauí	530	18.8	IFAT	1:16	Lopes et al. (2011)
Rio de Janeiro	651	46.8	ELISA	1:16	Cunha et al. (2016)
	14	28.6	IFAT	1:16	Oliveira et al. (2017)
	400	34.0	IFAT	1:16	Arruda et al. (2021)
Rio Grande do Sul	2245	16.0	IFAT	1:16	Mortari et al. (2023)
Rio Grande do Norte	476	11.5	IFAT	1:64	Dantas et al. (2013)
Santa Catarina	102	12.7	IFAT	1:16	Lopes et al. (2015)
	400	22.3	IFAT	1:64	Moura et al. (2009)
São Paulo	110	19.7	MAT	1:25	Souza et al. (2003)
	205	25.4	IFAT	1:16	Silva et al. (2010)
	21	38.1	IFAT	1:64	Aguiar et al. (2012)
	50	22.0	IFAT	1:16	Langoni et al. (2012)
	93	47.3	IFAT	1:16	Paulan et al. (2013)
	10	50.0	IFAT	1:16	Zanette et al. (2014)

São Paulo	300	24.3	IFAT	1:16	Seabra et al. (2015)
	133	27.0	MAT	1:25	
	369	15.1	IFAT	1:16	Olbera et al. (2020)
	331	27.2	IFAT	1:16	Sevá et al. (2020)
	371	22.5			
	348	43.9			
	28	17.8	NM	NM	Gonçalves et al. (2022)
	336	52.9	MAT	1:25	Belaz et al. (2023)
	1194	10.5	IFAT	1:16	Santos et al. (2023)
	73	85.0	IFAT	1:16	Perin et al. (2024)
São Paulo/Paraná	238	23.1	IFAT	1:64	Remor-Sebolt et al. (2024)
	253	38.0	IFAT	1:16	Doline et al. (2023)
Tocantins	99	70.7	ELISA	1:20	Raimundo et al. (2015)

IFAT = indirect fluorescent antibody test, IHA = indirect hemagglutination, NM = not mentioned, MAT = modified agglutination test, ELISA = enzyme-linked immunosorbent assay.

All domestic dog toxoplasmosis studies were conducted after 1999, demonstrating research covering the country's five regions. According to the survey, the Southeast region of the country concentrates the most significant number of reports, totaling 20 studies with results ranging from 10% to 85% of dogs that present anti-*T. gondii* antibodies. They were followed by the South region, with 17 reports with seroprevalence ranging from 7 to 70%. We found 14 investigations in the Northeast with a seropositivity rate ranging from 9% to 60% of the dog population. The North and Midwest regions have the lowest number of reports, three and five, respectively, with seropositivity rates ranging from 6% to 70%. The number of dog investigations represents a level below 10% prevalence; they are lower than those that present a prevalence above 50%, indicating that toxoplasmosis is endemic in Brazil; this is also an indication of environmental contamination in the five regions of the country. The rate of positive dog studies varies, reflecting multifactorial factors such as different geographical scenarios, assay methodologies, sampling design, laboratory tests and study location (Olbera et al. 2020).

Control and prophylaxis measures lead to a low prevalence associated with the low prevalence of *T. gondii* in domestic dogs. Providing adequate food and filtered water is the primary measure to avoid infection. In cases where natural food is necessary, guidance on pre-freezing meat and adequate cooking is crucial. Furthermore, adequate hygiene of fruits and vegetables offered to the animal is recommended (Dubey 2022). Adopting practices such as restricting animals' access to places possibly contaminated by oocysts or cohabited by potential infective definitive hosts can minimize dogs' exposure to *T. gondii*. Veterinarians have an essential role in clinical work and guiding those responsible for disseminating prophylactic information that contributes to public health.

## WILD CARNIVORES

The order Carnivora comprises approximately 280 species (Hudson et al. 2022). Brazil has 28 native species of carnivores, 10 from the Felidae and six from the Canidae family. Felidae from Brazil are Geoffroy's cat (*Leopardus geoffroyi*), southern tiger cat (*Leopardus guttulus*), northern tiger cat (*Leopardus tigrinus*), margay (*Leopardus wiedii*), Pampas cat (*Leopardus braccatus*), Uruguayan pampas cat (*Leopardus munoai*), ocelot (*Leopardus pardalis*), jaguarundi (*Herpailurus yagouaroundi*),

mountain lion (*Puma concolor*), jaguar (*Panthera onca*) (Instituto Pró-Carnívoros 2024). Canidae from Brazil are crab-eating fox (*Cerdocyon thous*), short-eared dog (*Atelocynus microtis*), bush dog (*Speothos venaticus*), Pampas fox (*Lycalopex gymnocercus*), maned wolf (*Chrysocyon brachyurus*), hoary fox (*Lycalopex vetulus*) (ICMBio 2024, Instituto Pró-Carnívoros 2024). These wild species play an essential ecological role, such as controlling herbivores and smaller carnivorous populations, dispersing seeds and maintaining local flora (Lial et al. 2022).

Brazil's vast biodiversity is under threat due to increasing urbanization and agricultural activities. These human interventions bring domestic animal populations closer to wild animals, spreading infectious agents like *Toxoplasma gondii* to new species and areas (Padilha et al. 2021). Climate change has caused devastating changes in ecosystems and facilitated the emergence and expansion of pathogens. Understanding the complex reasons behind these phenomena is crucial for preventing and mitigating diseases in various hosts (Zhu et al. 2023). Emerging infectious diseases are considered a serious threat to biodiversity (Sacristán et al. 2021). The dependence of wild carnivores on large landscapes for shelter, reproduction, and hunting makes these species vulnerable to habitat loss, modification, and fragmentation. Furthermore, landscape transformation favors the spread of various pathogens (Lial et al. 2022). Wildlife is directly related to the stability of the entire ecosystem, playing a fundamental role throughout the biological world (Wei et al. 2021).

The circulation of various pathogens in wild nature is a topic that has been highlighted under the One Health approach. Therefore, carnivores are essential in this sense, as they are considered examples of biomagnification and bioaccumulation of pathogens, potentially acting as sentinel hosts and environmental indicators (Padilha et al. 2021). Regarding the *T. gondii* protozoan, these animals are considered sentinels for contamination of the environment (Dubey 2022).

In wild animal populations, observing healthy animals suggests that asymptomatic or subclinical infections may occur. Wild populations' infection routes include consuming animals infected with *T. gondii*, especially when dealing with carnivores through predation or direct ingestion of oocysts shed by the definitive host, contaminating the environment. Another form of transmission is the transplacental form, in

which tachyzoites cross the transplacental barrier, infecting the fetus (Aguirre et al. 2019, Dubey 2022).

Diagnosing and preventing toxoplasmosis in wild animals is challenging, especially from free-ranging origin (Padilha et al. 2021). The detection of anti-*T. gondii* in wild animals is extremely difficult, and for this surveillance to become part of the routine, much human and financial effort is required (González-Barrio et al. 2024).

### WILD FELIDS

Wild felids are definitive hosts of *Toxoplasma gondii*, capable of shedding oocysts to the environment when infected (Dubey 2022). In Brazil, there are few reports of seroprevalence in wild felids, most carried out in captive animals (Fig. 1 and Table 3). Ten seroepidemiological studies were carried out to detect anti-*T. gondii* in 13 different species of free-ranging or captive

neotropical felids. Various serological tests, predominantly the MAT, were used due to the highest sensitivity and specificity for *T. gondii* antibody detection (Dubey 2022).

Considering Brazilian territory, a concentration of wild felid studies on toxoplasmosis was observed in decreasing order in the Midwest, Southeast, Northeast, South and North regions. The Midwest region comprises the Pantanal wetland, a critical biome for jaguar conservation, as it harbors the second-largest population in the world. The average seroprevalence of free-living populations with values above 50%, reaching up to 100%, demonstrates the circulation of *T. gondii* in wild felid populations in Brazil. In felids living in captivity, seroprevalence ranged from 30% to 100%, showing that, even in captivity, they had contact with the protozoan at some point (Ullmann et al. 2010). Felids are excellent predators, and carnivory is the main route of *T. gondii* infection within the food chain (Dubey 2022). However, the possibility of infection

**Table 3. Seroepidemiological survey for toxoplasmosis in wild (native and exotic) felids in Brazil**

Species	State	Origin	N	Reactive (%)	Test	Dilution	Reference
Tiger ( <i>Panthera tigris</i> )	Distrito Federal/São Paulo/Mato Grosso	Under human care	6	66.7	IFAT	1:40	André et al. (2010)
Lion ( <i>Panthera leo</i> )	Distrito Federal/São Paulo/Mato Grosso	Under human care	9	55.5	IFAT	1:40	André et al. (2010)
	São Paulo	Under human care	3	100.0	MAT	1:64	Marujo et al. (2017)
Leopard ( <i>Panthera pardus</i> )	Distrito Federal/São Paulo/Mato Grosso	Under human care	1	100.0	IFAT	1:40	André et al. (2010)
Jaguar ( <i>Panthera onca</i> )	Several	Under human care	212	83.0	MAT	1:25	Silva et al. (2007)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	13	84.6	IFAT	1:40	André et al. (2010)
	Mato Grosso	Wildlife	10	90.9	IFAT	1:16	Onuma et al. (2014)
	São Paulo	Under human care	3	100.0	MAT	1:64	Marujo et al. (2017)
	Sergipe	Under human care	1	100.0	MAT	1:25	Pimentel et al. (2009)
Common genet ( <i>Genetta genetta</i> )	Distrito Federal/São Paulo/Mato Grosso	Under human care	1	100.0	IFAT	1:40	André et al. (2010)
Puma ( <i>Puma concolor</i> )	Several	Under human care	172	48.0	MAT	1:25	Silva et al. (2007)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	18	77.8	IFAT	1:40	André et al. (2010)
	São Paulo	Wildlife	2	50.0	MAT	1:40	Silva et al. (2014)
	São Paulo	Under human care	3	33.3	MAT	1:64	Marujo et al. (2017)
Oncila ( <i>Leopardus tigrinus</i> )	Several	Under human care	131	50.0	MAT	1:25	Silva et al. (2007)
	Paraná	Under human care	22	68.1	MAT	1:16	Ullmann et al. (2010)
	São Paulo	Under human care	15	37.0	MAT	1:64	Marujo et al. (2017)
Geoffroy's cat ( <i>Leopardus geoffroyi</i> )	Several	Under human care	168	58.0	MAT	1:25	Silva et al. (2007)
	Paraná	Under human care	1	100.0	MAT	1:16	Ullmann et al. (2010)
Ocelot ( <i>Leopardus pardalis</i> )	Several	Under human care	168	58.0	MAT	1:25	Silva et al. (2007)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	42	66.7	IFAT	1:40	André et al. (2010)
	Pará/Rio Grande do Norte	Under human care	3	100.0	MAT	1:25	Minervino et al. (2010)
	Paraná	Under human care	14	71.4	MAT	1:16	Ullmann et al. (2010)
	Rio de Janeiro	Under human care	2	50.0	MAT	1:16	Villar-Echarte et al. (2021)
Northern tiger cat ( <i>Leopardus tigrinus</i> )	São Paulo	Under human care	4	50.0	MAT	1:64	Marujo et al. (2017)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	35	62.8	IFAT	1:40	André et al. (2010)
	Paraná	Under human care	22	68.1	MAT	1:16	Ullmann et al. (2010)
Margay ( <i>Leopardus wiedii</i> )	Several	Under human care	63	54.0	MAT	1:25	Silva et al. (2007)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	4	100.0	IFAT	1:40	André et al. (2010)
Pampas cat ( <i>Oncifelis colocolo</i> )	Paraná	Under human care	17	58.8	MAT	1:16	Ullmann et al. (2010)
	Several	Under human care	72	48.0	MAT	1:25	Silva et al. (2007)
Jaguarundi ( <i>Herpailurus yagouaroundi</i> )	Distrito Federal/São Paulo/Mato Grosso	Under human care	3	33.3	IFAT	1:40	André et al. (2010)
	Several	Under human care	99	46.0	MAT	1:25	Silva et al. (2007)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	25	40.0	IFAT	1:40	André et al. (2010)
	Paraná	Under human care	3	66.6	MAT	1:16	Ullmann et al. (2010)

IFAT = indirect fluorescent antibody test, MAT = modified agglutination test.

by ingesting oocysts that can contaminate the environment, and water cannot be ruled out. The infection occurs in all species of wild felids. A study carried out by Ullmann et al. (2010) concluded that free-ranging felids are more likely to be infected than animals living in zoos, indicating that the ingestion of oocysts or cyst tissue occurs in nature.

Based on existing reports, *T. gondii* circulates widely among neotropical and exotic felid populations in zoos and conservation centers. Serological, molecular and biological studies on various wild animal species have documented the protozoan circulation at different trophic levels (Cañón-Franco et al. 2013). Although laboratory studies investigate the route of infection and elimination of oocysts when dealing with wild felids, many questions require further investigation. It is necessary to understand the frequency and amount of oocyst shedding, as oocysts in the environment are also a source of infection and can impact bradyzoite transmission by ingesting tissue cysts (Zhu et al. 2022).

Prophylactic measures to prevent infection of felids living in captivity, such as zoos, can be carried out. These measures include protecting the facilities to prevent contact between domestic cats, rodents, and birds and the animals' enclosure, as well as preventing owners from carrying oocysts on their shoes, thus providing disposable boot covers as a protective measure (Spriggs et al. 2020, Dubey 2022). Other forms of prophylaxis, such as veterinary care, monitoring the quality of the water offered, and drainage control to prevent rainwater from running off and carrying oocysts to the enclosures, are also effective. However, the essential way to prevent toxoplasmosis in felids in captivity is to control their diet. Under no circumstances should these animals be fed fresh meat or raw bones. Ideally, frozen meat should be offered, as it is less infectious, and beef should be preferred over lamb or pork (Dubey 2022).

Attention must be paid to the reproduction of felids in captivity. Basso et al. (2005) reported *T. gondii* infection in puppies that ingested oocysts that were present in the female's feces. It is suggested that feline feces be removed from the enclosure daily to prevent the oocyst from being able to sporulate in the enclosure (Spriggs et al. 2020). Furthermore, the female must be monitored during pregnancy to ensure that transplacental transmission does not occur (Dubey 2022).

## WILD CANIDS

The reports of toxoplasmosis in wild canid species are still limited. Reports on seroprevalence listed 14 surveys from seven species of wild canids in Brazil (Fig. 1 and Table 4). Around five research studies were carried out on captives, eight on free-ranging canids, and one on captives and free-ranging canids. Considering all studies, canids' seropositivity varies from 7.6% to 75%. Considering the environment, research on captive animals is almost 50% greater than on free-ranging canines. Reports on captive animals are more frequent due to the efficient collection of samples. However, free-living wild canids have lower seropositivity rates than captive ones. It is highlighted that *Toxoplasma gondii* is widely disseminated in these populations, and that at some point, these canids had contact with the protozoan through environmental contamination, contaminated water, or even through their eating habits, depending on the species, such as contaminated fruit and infected meat (Dubey 2022).

Data are predominant from the Southeast region in the reports. The state of São Paulo demonstrates a high prevalence in this region, followed by the Northeast, Midwest, and South regions of Brazil with high prevalence rates, proving that toxoplasmosis is widely disseminated in Brazil (Pinto-Ferreira et al. 2019). Further investigation into these canid populations is needed, as they are considered sentinels (Dubey 2022). Wild canids have a close genetic relationship with domestic dogs, and intense contact with urban environments can favor the potential transmission of pathogens (Padilha et al. 2021). The role of *T. gondii* in the Brazilian Biomes has still not been explored.

Studies indicate that the increased fragmentation of environments may influence the occurrence of fatal accidents in wild animals, which, in general, may be linked to the development of infectious diseases (Souza et al. 2022). Disseminated toxoplasmosis in wild canines is rarely reported; these animals present non-specific clinical signs when it occurs concomitantly with immunosuppressive diseases, such as canine distemper (Pepper et al. 2019). In a study with maned wolves in Brazil, *T. gondii* infection was identified concomitantly with the canine distemper virus (Souza et al. 2022) as occurs in domestic dogs, demonstrating that the population of wild canines, although not know a lot about the pathogenesis of toxoplasmosis in these species, it is also subject to disseminated infection caused by the protozoan. Identifying highly recombinant *T. gondii* genotypes in Brazil (Dubey 2022), which have been associated with increased virulence, may alter the epidemiological dynamics and clinical outcomes in both domestic and wild hosts.

Whereas the effects of *T. gondii* infection in most intermediate hosts are known, these effects have been little studied in wild canid populations. Research demonstrated that gray wolves infected by *T. gondii* showed changes in their behavior, becoming more "courageous", thus dispersing and more likely to become pack leaders than seronegative wolves. *T. gondii* infection can affect behavior and decision-making in wild intermediate host species (Gering et al. 2021). One of Brazil's most significant concerns regarding the preservation of wild canids is the high incidence of motor vehicle collisions involving these species on highways. It was noted that wolves that tested anti-*T. gondii*-positive were more inclined to make poor decisions, and these decisions impacted the animal's fitness. However, there was a lack of correlation when they associated seropositivity with motor vehicle collisions (Gering et al. 2021, Dini et al. 2024).

Regarding wild canid toxoplasmosis prophylaxis, it is challenging to control the diet and environment of these carnivores. In this sense, preserving the biodiversity of natural habitats is an indirect focus to prevent disease transmission (Padilha et al. 2021). Controlling the access of cats near the enclosures and the water source offered is possible in canids from zoological gardens. In this way, some measures such as protection of enclosures, freezing of meat for at least three days before offering, cleaning of fruits that are part of the diet of some species, control of water quality and guidance to owners can be carried out to avoid contamination of the environment and consequent infection of canids.

## DISCUSSION

The seroprevalence of anti-*Toxoplasma gondii* in domestic cats in many Brazilian regions is high. We hypothesize that the cat's and the owner's habits can justify this result. It is widespread for owners to think that the cat is an animal that must live "free". This behavior is harmful, as there is no control over what the animal is hunting and ingesting outside, and if it becomes infected, it will contaminate the environment, shedding millions of oocysts. Another fact is that raw or undercooked meat and unfiltered water are provided for cats, which is very common among owners in Brazil (Benitez et al. 2017, Dubey 2022). As in domestic cats, seroprevalence in domestic dogs is also high. Many dog owners still let their dogs go for a "walk" without supervision, which increases the chances of infection, precisely due to the behavior of accessing trash and ingesting some infected meat or other contaminated food. Dogs are sentinels of environmental contamination by *T. gondii*; therefore, the high seroprevalence indicates an environment widely contaminated with oocysts. Providing unfiltered water and unsanitized food or raw meat is a risk factor for exposing the dog to the protozoan, as well

as the infrequent cleaning of yards in which many of these pets are housed.

One of the challenging questions in conservation medicine is diagnosing diseases in wildlife-free-ranging individuals (Corrêa & Passos 2001). Reporting complete data on fatal cases of animal toxoplasmosis should be systematically investigated using techniques such as physical examination, necropsy, histopathology, immunohistochemistry, Polymerase Chain Reaction (PCR), microsatellite techniques, genotyping and cytological examination of cerebrospinal fluid (Pena et al. 2017, Dubey 2022).

Discussing the epidemiological maps from this review, we suggest that regions presenting significant toxoplasmosis diagnoses in both wild and domestic carnivores are associated with greater diagnostic capacity or research. Veterinary Diagnostic Laboratories have contributed fundamentally to diagnosing animal diseases. Even so, there are large areas of the country where information regarding animal health is limited (Riet-Correa et al. 2025).

The major highlight of this review was the different occurrences of seropositivity of free-ranging felids and canids. Free-ranging felids are more likely to be infected by *T. gondii* than felids living in captivity. Free-ranging wild canids have

**Table 4. Seroepidemiological survey of toxoplasmosis in wild (native and exotic) canids in Brazil**

Species	State	Habitat	N	Reactive (%)	Test	Dilution	Reference
Bush dog ( <i>Speothos venaticus</i> )	Distrito Federal/São Paulo/Mato Grosso	Under human care	27	63.0	IFAT	1:40	André et al. (2010)
Crab-eating fox ( <i>Cerdocyon thous</i> )	Several	Wildlife	15	60.0	IFAT	1:16	Gennari et al. (2004)
	Several	Under human care	25	36.0	IFAT	1:50	Mattos et al. (2008)
	Distrito Federal	Wildlife	7	71.4	MAT	1:25	Proença et al. (2013)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	39	35.9	IFAT	1:40	André et al. (2010)
	Minas Gerais	Wildlife	10	70.0	MAT	1:25	Curi et al. (2010)
	Goiás	Wildlife	13	7.6	MAT	1:16	Carneiro et al. (2014)
	Northeast	Under human care and wildlife	25	36.0	MAT	1:25	Almeida et al. (2018)
	São Paulo	Under human care	52	19.2	MAT/IFAT	1:16	Catenacci et al. (2014)
	São Paulo	Wildlife	3	33.3	MAT	1:10	Silva et al. (2014)
	São Paulo	Under human care	11	27.2	MAT	1:16	Marujo et al. (2017)
Hoary Fox ( <i>Lycalopex vetulus</i> )	Rio Grande do Sul	Wildlife	30	13.0	IHA	1:64	Padilha et al. (2021)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	7	71.4	IFAT	1:40	André et al. (2010)
	São Paulo	Wildlife	6	16.6	MAT	1:10	Silva et al. (2014)
Pampas fox ( <i>Lycalopex gymnocercus</i> )	São Paulo	Under human care	7	14.2	MAT	1:16	Marujo et al. (2017)
	Several	Wildlife	12	91.7	IFAT	1:16	Gennari et al. (2004)
	Several	Under human care	5	60.0	IFAT	1:50	Mattos et al. (2008)
Maned wolf ( <i>Chrysocyon brachyurus</i> )	Rio Grande do Sul	Wildlife	22	36.4	IHA	1:64	Padilha et al. (2021)
	Several	Under human care	14	71.4	IFAT	1:50	Mattos et al. (2008)
	Bahia	Wildlife	11	54.0	IFAT	1:32	Gomes et al. (2024)
	Brasília	Under human care	7	100	ELISA	1:64	Vitaliano et al. (2004)
	Distrito Federal/São Paulo/Mato Grosso	Under human care	21	54.2	IFAT	1:40	André et al. (2010)
	Minas Gerais	Under human care	35	80.0	ELISA	1:64	Vitaliano et al. (2004)
	Gerais	Wildlife	7	85.0	MAT	1:25	Curi et al. (2010)
	Minas Gerais	Wildlife	8	75.0	MAT	1:25	Curi et al. (2012)
	São Paulo	Wildlife	17	88.2	IFAT	1:16	Oliveira et al. (2016)
	São Paulo	Under human care	3	100.0	MAT	1:64	Marujo et al. (2017)

IFAT = indirect fluorescent antibody test, MAT = modified agglutination test, ELISA = enzyme-linked immunosorbent assay.

lower seropositivity rates compared to those in captivity. Many studies should verify these issues to contribute to conservation medicine. The literature data compiled in this review allow us to hypothesize that habits of free-ranging wild felid species, such as feeding on small rodents, increase the chance of consuming prey infected with *T. gondii*, besides contact with other felid species' feces. The low prevalence of captive felids can be explained by good hygiene and management practices in the zoos where they live, thereby reducing contact with *T. gondii*. The high seropositivity in wild canids in captivity seems to have a high frequency of contamination with oocysts in the zoo environment due to the proximity of felid enclosures (Dubey et al. 2020a, Dubey 2022).

## CONCLUSIONS

*Toxoplasma gondii* infections are widespread among domestic and wild carnivores across all Brazilian regions. We suppose that regions presenting significant occurrence fit with greater diagnostic capacity or research in both domestic and wild carnivores. We agree on continuing diagnosis efforts by health and educational institutions to draw an epidemiologic scenario representing sampling from the whole country. The diagnosis of toxoplasmosis in carnivores must be established with serology, clinical findings, necropsy, histopathology and laboratory tests that confirm the presence of the protozoan in tissues with inflammatory and necrotizing lesions. Only serological tests for detecting antibodies indicate an immune response instead of clinical diseases.

Free-ranging felids are more likely to be infected by *T. gondii* than felids living in captivity. The free-living wild canids have lower seropositivity compared to the canids in captivity. Researching wildlife-free-ranging animals in Brazil is challenging due to logistical issues. The role of *T. gondii* in the Brazilian biomes should be better investigated.

This review brought relevant and updated information to understand the epidemiology of toxoplasmosis in Brazil's domestic and wild carnivores, linking human, animal, and ecosystem health. Toxoplasmosis demands integrative approaches that break disciplinary boundaries to generate new approaches to managing and controlling the disease. Practitioners and researchers from medical and wildlife sciences could join in applying their expertise on One Health, aiming for public health authorities to raise awareness and implement prophylaxis measures.

**Acknowledgment.**- To "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior" (CAPES) for granting scholarships, financing code 001. The authors thank Niriele B. Rodrigues from UFRuralRJ for elaborating on the maps. This publication was supported by resources from the approved Project related to the Basic Research Support Notice (APQ1) - 2023" (SEI-260003/003363/2023) from "Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro" (FAPERJ).

**Conflict of interest statement.**- The authors declare no potential conflict of interest concerning this article's research, authorship, and publication.

**Credit author statement.**- Andressa Silva and Daniel Ubiali: Conception. Andressa Silva: Wrote original draft. All authors: writing reviewing and editing. All authors approved the last version of the manuscript.

**Data availability.**- Scientific literature was consulted to prepare the present review article. No datasets were generated or analyzed during the current study.

## REFERENCES

- Acosta ICL, Centoducatte LD'A, Soares HS, Marcilli A, Gondim MFN, Rossi Junior JL, Gennari SM. Occurrence of *Neospora caninum* and *Toxoplasma gondii* antibodies in dogs from rural properties surrounding a biological reserve, Espirito Santo, Brazil. *Revta Bras Parasitol Vet* 2016; <https://doi.org/10.1590/S1984-296120160075>
- Aguiar DM, Amude AM, Santos LGF, Ribeiro MG, Ueno TEH, Megid J, Paes AC, Alfieri AF, Alfieri AA, Gennari SM. Canine distemper virus and *Toxoplasma gondii* co-infection in dogs with neurological signs. *Arq Bras Med Vet Zootec* 2012; <https://doi.org/10.1590/S0102-09352012000100032>
- Aguirre AA, Longcore T, Barbieri M, Dabritz H, Hill D, Klein PN, Lepczyk C, Lilly EL, McLeod R, Milcarsky J, Murphy CE, Su C, Van Wormer E, Yolken R, Sizemore GC. The one health approach to toxoplasmosis: epidemiology, control, and prevention strategies. *EcoHealth* 2019; <https://doi.org/10.1007/s10393-019-01405-7>
- Almeida JC, Frehse MS, Navarro IT, Garcia JL, Biondo AW, Freire RL. Comparison of indirect fluorescent antibody test and the modified agglutination test for the detection of *Toxoplasma gondii* antibodies in stray dogs from Southern Brazil. *Acta Parasitol* 2016; <https://doi.org/10.1515/ap-2016-0097>
- Almeida JC, Melo RPB, Kim PCP, Guerra NR, Alves LC, Costa DF, Alves CJ, Porto WJN, Mota RA. Molecular and serological investigation of infectious diseases in captive and free-range crab-eating fox (*Cerdocyon thous*-Linnaeus, 1776) from northeastern Brazil. *Acta Parasitol* 2018; <https://doi.org/10.1515/ap-2018-0021>
- Alves MEM, Fernandes FD, Bräunig P, Murer L, Minuzzi CE, Santos HF, Sangioni LA, Vogel FSF. *Toxoplasma gondii*, *Neospora caninum* and *Sarcocystis* spp. in species of naturally infected birds. *Pesq Vet Bras* 2022; <https://doi.org/10.1590/1678-5150-PVB-7026>
- Andrade ACS, Bittencourt LHF, Godoi NFC, Libardi KA, Weschenfelder DRS, Picolotto GCGP. Prevalência de anticorpos anti-*Toxoplasma gondii* em felinos frequentadores de clínicas e hospitais veterinários de Cascavel, Paraná, Brasil. *Arq Ciênc Vet Zool UNIPAR* 2015; <https://doi.org/10.25110/arqvet.v18i4.2015.5747>
- André MR, Adania CH, Teixeira RH, Silva KF, Jusi MM, Machado ST, Bortolli CP, Falcade M, Sousa L, Alegretti SM, Felipe PA, Machado RZ. Antibodies to *Toxoplasma gondii* and *Neospora caninum* in captive neotropical and exotic wild canids and felids. *J Parasitol* 2010; <https://doi.org/10.1645/GE-2502.1>
- Araújo FAP, Silva NRS, Olicheski AT, Beck C, Rodrigues RJD, Fialho CG. Anticorpos para *Toxoplasma gondii* em soro de gatos internados no Hospital de Clínicas Veterinárias da UFRGS, Porto Alegre, RS, Brasil, detectados através da técnica de hemaglutinação indireta. *Acta Scient Vet* 2003; <https://doi.org/10.183/19811>
- Arraes-Santos AI, Araújo AC, Guimarães MF, Santos JR, Pena HFJ, Gennari SM, Azevedo SS, Labruna MB, Horta MC. Seroprevalence of anti-*Toxoplasma gondii* and anti-*Neospora caninum* antibodies in domestic mammals from two distinct regions in the semi-arid region of northeastern Brazil. *Vet Parasitol Reg Stud Reports* 2016; <https://doi.org/10.1016/j.vprsr.2016.08.007>
- Arruda IF, Millar PR, Barbosa AS, Abboud LCS, Reis IC, Moreira ASC, Guimarães MPP, Amendoeira MRR. *Toxoplasma gondii* in domiciled dogs and cats in urban areas of Brazil: risk factors and spatial distribution. *Parasite* 2021; <https://doi.org/10.1051/parasite/2021049>
- Azevedo SS, Batista CSA, Vasconcellos SA, Aguiar DM, Ragozo AMA, Rodrigues AAR, Alves CJ, Gennari SM. Seroepidemiology of *Toxoplasma gondii* and *Neospora caninum* in dogs from the state of Paraíba, Northeast region of Brazil. *Res Vet Sci* 2005; <https://doi.org/10.1016/j.rvsc.2004.10.001>
- Barros RS, Menezes RC, Pereira SA, Figueredo FB, Oliveira RVC, Nicolau JL, Neves LB, Millar PR, Kitada AAB, Amendoeira MRR. Feline sporotrichosis: coinfection with *Toxoplasma gondii*, feline immunodeficiency virus and feline leukemia virus in cats from an endemic area in Brazil. *Acta Scient Vet* 2015;43:1-6.

- Basso W, Edelhofer R, Zenker W, Möstl K, Kübber-Heiss A, Prosl H. Toxoplasmosis in Pallas' cats (*Otocolobus manul*) raised in captivity. *Parasitology* 2005; <https://doi.org/10.1017/s0031182004006584>
- Bastos BF, Brener B, Gershony L, Willi L, Labarthe N, Pereira C, Mendes-De-Almeida F. Seroprevalence of *Toxoplasma gondii* (Nicole & Manceaux, 1909) and retroviral status of client-owned pet cats (*Felis catus*, Linnaeus, 1758) in Rio de Janeiro, Brazil. *Revta Inst Med Trop São Paulo* 2014; <https://doi.org/10.1590/s0036-46652014000300004>
- Belaz LD, Santana CFS, Victória C, Pantoja JCF, Freitas JC, Navarro IT, Pereira MR, Arabe-Filho MF, Oliveira LM, Paes AC, Ribeiro MG, Megid J. Spatial analysis of leptospirosis and toxoplasmosis seroprevalence in the canine population in an area of socioeconomic and environmental vulnerability. *Arq Bras Med Vet Zootec* 2023; <https://doi.org/10.1590/1678-4162-12817>
- Benitez AN, Martins FDC, Mareze M, Santos NJR, Ferreira FP, Martins CM, Garcia JL, Mitsuka-Breganó R, Freire RL, Biondo AW, Navarro IT. Spatial and simultaneous representative seroprevalence of anti-*Toxoplasma gondii* antibodies in owners and their domiciled dogs in a major city of southern Brazil. *PLoS One* 2017; <https://doi.org/10.1371/journal.pone.0180906>
- Bezerra JAB, Haisi A, Rocha GS, Lima SG, Brasil AWL, Tomaz KLR, Fornazari F, Langoni H, Araújo Junior JP, Antunes JMAP, Azevedo SS. Coinfection with *Leishmania infantum* and *Toxoplasma gondii* in domestic cats from a region with a high prevalence of feline Immunodeficiency Virus. *Microorganisms* 2023; <https://doi.org/10.3390/microorganisms12010071>
- Bolais PF, Vignoles P, Pereira PF, Keim R, Aroussi A, Ismail K, Dardé M-L, Amendoeira MR, Mercier A. *Toxoplasma gondii* survey in cats from two environments of the city of Rio de Janeiro, Brazil by Modified Agglutination Test on sera and filter-paper. *Parasit Vectors* 2017; <https://doi.org/10.1186/s13071-017-2017-8>
- Braga ARC, Corrêa APFL, Camossi LG, Silva RC, Langoni H, Lucheis SB. Coinfection by *Toxoplasma gondii* and *Leishmania* spp. in domestic cats (*Felis catus*) in State of Mato Grosso do Sul. *Rev Soc Bras Med Trop* 2014; <https://doi.org/10.1590/0037-8682-0041-2014>
- Braga MSCO, Andre MR, Jusi MMG, Freschi CR, Teixeira MCA, Machado RZ. Occurrence of anti-*Toxoplasma gondii* and anti-*Neospora caninum* antibodies in cats with outdoor access in São Luís, Maranhão, Brazil. *Rev Bras Parasitol Vet* 2012; <https://doi.org/10.1590/S1984-29612012000200007>
- Brasil AWL, Parentoni RN, Silva JG, Santos CSAB, Mota RA, Azevedo SS. Risk factors and anti-*Toxoplasma gondii* and *Neospora caninum* antibody occurrence in dogs in João Pessoa, Paraíba state, northeastern Brazil. *Rev Bras Parasitol Vet* 2018; <https://doi.org/10.1590/s1984-29612018006>
- Bresciani KDS, Gennari SM, Serrano ACM, Rodrigues AAR, Ueno T, Franco LG, Perri SHV, Amarante AFT. Antibodies to *Neospora caninum* and *Toxoplasma gondii* in domestic cats from Brazil. *Parasitol Res* 2007; <https://doi.org/10.1007/s00436-006-0262-4>
- Caldeira FHB, Ubiali DG, Godoy I, Dutra V, Aguiar DM, Melo ALT, Riet-Correa F, Colodel EM, Pescador CA. Outbreak of caprine abortion by *Toxoplasma gondii* in Midwest Brazil. *Pesq Vet Bras* 2011; <https://doi.org/10.1590/S0100-736X2011001100001>
- Campos HGN, Soares HS, Azevedo SS, Gennari SM. Occurrence of *Toxoplasma gondii* and *Neospora caninum* antibodies and risk factors in domiciliated dogs of Manaus, Amazonas, Brazil. *Rev Bras Parasitol Vet* 2022; <https://doi.org/10.1590/S1984-29612022024>
- Cañón-Franco WA, Araújo FAP, López-Orozco N, Jardim MMA, Keid LB, Dalla-Rosa C, Cabral AD, Pena HFJ, Gennari SM. *Toxoplasma gondii* in free-ranging wild small felids from Brazil: molecular detection and genotypic characterization. *Vet Parasitol* 2013; <https://doi.org/10.1016/j.vetpar.2013.07.019>
- Cardia DFF, Camossi LG, Silveira Neto L, Langoni H, Bresciani KDS. Prevalence of *Toxoplasma gondii* and *Leishmania* spp. infection in cats from Brazil. *Vet Parasitol* 2013; <https://doi.org/10.1016/j.vetpar.2013.07.017>
- Carlos RSA. Ocorrência de anticorpos contra *Toxoplasma gondii* e fatores determinantes da infecção canina em Ilhéus-Itabuna, BA. Tese de Doutorado, Universidade Federal Rural do Rio de Janeiro, Seropédica, 2010, 56p.
- Carneiro BF, Miranda MM, Silveira Neto OJ, Linhares GFC, Araújo LBM. Inquérito sorológico para *Toxoplasma gondii* em mamíferos neotropicais mantidos no centro de triagem de animais silvestres, Goiânia, Goiás. *Rev Patol Trop* 2014; <https://doi.org/10.5216/rpt.v43i1.29373>
- Carvalho-Alves LM, Frazão-Teixeira E, Barbosa CG, Ubiali DG, Baldani CD, Souza HJM, Silva AA, Silva AF. *Toxoplasma gondii* seroprevalence and risk factors in cats in Rio de Janeiro. *Vet Parasitol Reg Stud Reports* 2024; <https://doi.org/10.1016/j.vprsr.2024.101063>
- Catenacci LS, Griese J, Silva RC, Langoni H. *Toxoplasma gondii* and *Leishmania* spp. infection in captive crab-eating foxes, *Cerdocyon thous* (Carnivora, Canidae) from Brazil. *Vet Parasitol* 2014; <https://doi.org/10.1016/j.vetpar.2009.12.019>
- Cavalcante GT, Aguiar DM, Chiebao D, Dubey JP, Ruiz VLA, Dias RA, Camargo LMA, Labruna MB, Gennari SM. Seroprevalence of *Toxoplasma gondii* antibodies in cats and pigs from rural Western Amazon, Brazil. *J Parasitol* 2006; <https://doi.org/10.1645/GE-830R.1>
- Coelho WMD, Amarante AFT, Apolinário JC, Coelho NMD, Lima VMF, Perri SHV, Bresciani KDS. Seroepidemiology of *Toxoplasma gondii*, *Neospora caninum*, and *Leishmania* spp. infections and risk factors for cats from Brazil. *Parasitol Res* 2011; <https://doi.org/10.1007/s00436-011-2461-x>
- Constantino C, Pellizzaro M, Paula EFE, Vieira TSWJ, Brandão APD, Ferreira F, Vieira RFC, Langoni H, Biondo AW. Serosurvey for *Leishmania* spp., *Toxoplasma gondii*, *Trypanosoma cruzi* and *Neospora caninum* in neighborhood dogs in Curitiba-Paraná, Brazil. *Rev Bras Parasitol Vet* 2016; <https://doi.org/10.1590/S1984-29612016062>
- Corrêa SHR, Passos EC. Wild animals and public health. In: Fowler ME. *Biology, Medicine, and Surgery of South American Wild Animals*. 2001; <https://doi.org/10.1002/9780470376980.ch42>
- Costa DGC, Marvulo MFV, Silva JSA, Santana SC, Magalhães FJR, Lima Filho CDF, Ribeiro VO, Alves LC, Mota RA, Dubey JP, Silva JCR. Seroprevalence of *Toxoplasma gondii* in domestic and wild animals from the Fernando de Noronha, Brazil. *J Parasitol* 2012; <https://doi.org/10.1645/GE-2910.1>
- Cruz MA, Ullmann LS, Montaña PY, Hoffmann JL, Langoni H, Biondo AW. Seroprevalence of *Toxoplasma gondii* infection in cats from Curitiba, Paraná, Brazil. *Rev Bras Parasitol Vet* 2011; <https://doi.org/10.1590/s1984-29612011000300016>
- Cunha GR, Pellizzaro M, Martins CM, Rocha SM, Yamakawa AC, Silva EC, Santos AP, Morikawa VM, Langoni H, Biondo AW. Spatial serosurvey of anti-*Toxoplasma gondii* antibodies in individuals with animal hoarding disorder and their dogs in Southern Brazil. *PLoS One* 2020; <https://doi.org/10.1371/journal.pone.0233305>
- Cunha NC, Cordeiro MD, Bravo SAC, Matos PCM, Almosny NRP, Fonseca AH. Soroepidemiologia de *Toxoplasma gondii* em cães no estado do Rio de Janeiro. *Rev Bras Med Vet* 2016;38(Supl.3):109-112.
- Curi NHA, Araújo AS, Campos FS, Lobato ZIP, Gennari SM, Marvulo MFV, Silva JCR, Talamoni SA. Wild canids, domestic dogs and their pathogens in Southeast Brazil: disease threats for canid conservation. *Biodivers Conserv* 2010; <https://doi.org/10.1007/s10531-010-9911-0>
- Curi NHA, Coelho CM, Malta MCC, Magni EMV, Sábado MAL, Araújo AS, Lobato ZIP, Santos JLC, Santos HA, Ragozo AAM, Souza SLP. Pathogens of wild maned wolves (*Chrysocyon brachyurus*) in Brazil. *J Wildl Dis* 2012; <https://doi.org/10.7589/2011-10-304>
- Dantas SBA, Fernandes ARF, Souza Neto OL, Mota RA, Alves CJ, Azevedo SS. Ocorrência e fatores de risco associados às infecções por *Toxoplasma gondii* e *Neospora caninum* em cães no município de Natal, Estado do Rio Grande do Norte, Nordeste do Brasil. *Ciência Rural* 2013; <https://doi.org/10.1590/S0103-84782013001100020>

- Deiró AGJ, Prado DP, Sousa IP, Rocha DS, Bezerra RA, Gaiotto FA, Albuquerque GR, Munhoz AD. Presence of atypical genotypes of *Toxoplasma gondii* isolated from cats in the state of Bahia, Northeast of Brazil. *PLoS One* 2021; <https://doi.org/10.1371/journal.pone.0253630>
- Desmots G, Remington JS. Direct agglutination test for diagnosis of *Toxoplasma* infection: method for increasing sensitivity and specificity. *J Clin Microbiol* 1980; <https://doi.org/10.1128/jcm.11.6.562-568.1980>
- Dini FM, Stancampiano L, Poglayen G, Galuppi R. Risk factors for *Toxoplasma gondii* infection in dogs: a serological survey. *Acta Vet Scand* 2024; <https://doi.org/10.1186/s13028-024-00734-0>
- Doline FR, Farinhas JH, Biondo LM, Oliveira PRF, Rodrigues NJL, Patrício KP, Mota RA, Langoni H, Pettan-Brewer C, Giuffrida R, Santarém VA, Castro WAC, Santos AP, Kmetiuk LB, Biondo AW. *Toxoplasma gondii* exposure in Brazilian indigenous populations, their dogs, environment, and healthcare professionals. *One Health* 2023; <https://doi.org/10.1016/j.onehlt.2023.100567>
- Dreer MKP, Gonçalves DD, Caetano ICS, Gerônimo E, Menegas PH, Bergo D, Lopes-Mori FMR, Benitez A, Freitas JC, Evers F, Navarro IT, Martins LA. Toxoplasmosis, leptospirosis and brucellosis in stray dogs housed at the shelter in Umuarama municipality, Paraná, Brazil. *J Venom Anim Toxins Incl Trop Dis* 2013; <https://doi.org/10.1186/1678-9199-19-23>
- Duarte J, Pacheco MTT, Villaverde AB, Machado RZ, Zangaro RA, Silveira Jr L. Near-infrared Raman spectroscopy to detect anti-*Toxoplasma gondii* antibody in blood sera of domestic cats: quantitative analysis based on partial least-squares multivariate statistics. *J Biomed Opt* 2010; <https://doi.org/10.1117/1.3463006>
- Dubey JP, Cerqueira-Cézar CK, Murata FHA, Kwok OCH, Yang YR, Su C. All about toxoplasmosis in cats: the last decade. *Vet Parasitol* 2020a; <https://doi.org/10.1016/j.vetpar.2020.109145>
- Dubey JP, Lappin MR, Thulliez P. Long-term antibody responses of cats fed *Toxoplasma gondii* tissue cysts. *J Parasitol* 1995; <https://doi.org/10.2307/3284035>
- Dubey JP, Murata FHA, Cerqueira-Cézar CK, Kwok OCH, Yang Y, Su C. *Toxoplasma gondii* infections in dogs: 2009-2020. *Vet Parasitol* 2020b; <https://doi.org/10.1016/j.vetpar.2020.109223>
- Dubey JP. Duration of immunity to shedding of *Toxoplasma gondii* oocysts by cats. *J Parasitol* 1995;81(3):410-415. PMID:7776126
- Dubey JP. Toxoplasmosis of Animals and Humans. 2022; <https://doi.org/10.1201/9781003199373>
- Dubey JP. Validation of the specificity of the modified agglutination test for toxoplasmosis in pigs. *Vet Parasitol* 1997; [https://doi.org/10.1016/S0304-4017\(97\)00016-2](https://doi.org/10.1016/S0304-4017(97)00016-2)
- England JH, Bailin SS, Gehlhausen JR, Rubin DH. Toxoplasmosis: the heart of the diagnosis. *Open Forum Infect Dis* 2018; <https://doi.org/10.1093/ofid/ofy338>
- Faria JLM, Couto C, Wierzynski SL, Bottari NB, Baldissera MD, Pereira WAB, Da Silva AS. Feline toxoplasmosis: tumor necrosis factor, nitric oxide, and free radicals in seropositive cats. *J Parasitol* 2018; <https://doi.org/10.1645/17-85>
- Feitosa TF, Costa FTR, Ferreira LC, Silva SS, Santos A, Silva WI, Brasil AWL, Vilela VLR. High rate of feline immunodeficiency virus infection in cats in the Brazilian semiarid region: Occurrence, associated factors and coinfection with *Toxoplasma gondii* and feline leukemia virus. *Comp Immunol Microbiol Infect Dis* 2021; <https://doi.org/10.1016/j.cimid.2021.101718>
- Feitosa TF, Vilela VLR, Dantas ES, Souto DVO, Pena HFJ, Athayde ACR, Azevêdo SS. *Toxoplasma gondii* and *Neospora caninum* in domestic cats from the Brazilian semi-arid: seroprevalence and risk factors. *Arq Bras Med Vet Zootec* 2014; <https://doi.org/10.1590/1678-6696>
- Fernandes ALP, Alves MM, Silva JO, Bison I, Silva ACT, Parentoni RN, Santos JRS, Feitosa TF, Vilela VLR, Brasil AWL. Geoeidemiology, seroprevalence and factors associated with *Toxoplasma gondii* infection in domiciled cats from Paraíba (Brazil). *Parasite* 2024a; <https://doi.org/10.1051/parasite/2024017>
- Fernandes ARF, Costa DF, Andrade MR, Bezerra CS, Mota RA, Alves CJ, Langoni H, Azevedo SS. Soropositividade e fatores de risco para leptospirose, toxoplasmose e neosporose na população canina do Estado da Paraíba. *Pesq Vet Bras* 2018; <https://doi.org/10.1590/1678-5150-PVB-5137>
- Fernandes FDA, Tagarra LG, Roman IJ, Moraes DAO, Rodrigues D, Andrade CM, Bräunig P, Oliveira-Filho EF, Cargnelutti JF, Sangioni LA, Vogel FSF. Correction to: increased frequency of detection of anti-*Toxoplasma gondii* antibodies in domestic cats after outbreak of human toxoplasmosis. *Parasitol Res* 2024b; <https://doi.org/10.1007/s00436-024-08243-9>
- Ferreira FP, Miura AC, Mareze M, Garcia JL, Freire RL, Navarro IT. Frequência de anticorpos anti-*Toxoplasma gondii* em cães com sinais clínicos compatíveis com toxoplasmose. *Ciênc Anim Bras* 2016; <https://doi.org/10.1590/1089-6891v17i440999>
- Ferreira Neto JM, Ferreira FP, Miura AC, Almeida JC, Martins FDC, Souza M, Bronkhorst DE, Romanelli PR, Pasquali AKS, Santos HLEPL, Benitez AN, Caldart ET, Zanella LF, Freire RL, Navarro IT. An outbreak of caprine toxoplasmosis - Investigation and case report. *Ciência Rural* 2018; <https://doi.org/10.1590/0103-8478cr20170790>
- Figueredo LA, Dantas-Torres F, Faria EB, Gondim LFP, Simões-Mattos L, Brandão-Filho SP, Mota RA. Occurrence of antibodies to *Neospora caninum* and *Toxoplasma gondii* in dogs from Pernambuco, Northeast Brazil. *Vet Parasitol* 2008; <https://doi.org/10.1016/j.vetpar.2008.07.009>
- Fournier GFSR, Lopes MG, Marcili A, Ramirez DG, Acosta ICL, Ferreira JIGS, Cabral AD, Lima JTR, Pena HFJ, Dias RA, Gennari SM. *Toxoplasma gondii* in domestic and wild animals from forest fragments of the municipality of Natal, northeastern Brazil. *Rev Bras Parasitol Vet* 2014; <https://doi.org/10.1590/S1984-29612014092>
- Freitas AR, Delai RR, Kmetiuk LB, Silva EC, Martini R, Brandão APD, Giuffrida R, Barros-Filho IR, Silva RC, Langoni H, Figueiredo FB, Pimpão CT, Dos Santos AP, Santarém VA, Biondo AW. Seropositivity of anti-*Toxoplasma gondii* antibodies in owners and their dogs living on island and mainland seashore areas of southern Brazil. *Trop Med Infect Dis* 2022; <https://doi.org/10.3390/tropicalmed7100252>
- Freitas RL. Pesquisa de *Toxoplasma gondii* em felinos: sorologia e histopatologia, imunohistoquímica e PCR em tecidos do aparelho reprodutivo de machos naturalmente infectados. Dissertação de Mestrado, Universidade Federal Fluminense, Niterói, 2017, 52p.
- Fux B, Covre K, Lopes REN, Salaroli LB, Vitor RWA. Seroprevalence of toxoplasmosis in cats in Espírito Santo State, Brazil. *Curr Dev Nutr* 2020; [https://doi.org/10.1093/cdn/nzaa043\\_037](https://doi.org/10.1093/cdn/nzaa043_037)
- Garcia JL, Navarro IT, Ogawa L, Oliveira RC. Soroepidemiologia da toxoplasmose em gatos e cães de propriedades rurais do município de Jaguapitã, estado do Paraná, Brasil. *Ciência Rural* 1999; <https://doi.org/10.1590/S0103-84781999000100018>
- Gennari SM, Canón-Franco WA, Yai LEO, Souza SLP, Santos LC, Farias NAR, Ruas J, Rossi FW, Gomes AAB. Seroprevalence of *Toxoplasma gondii* antibodies from wild canids from Brazil. *Vet Parasitol* 2004; <https://doi.org/10.1016/j.vetpar.2004.02.023>
- Gering E, Laubach ZM, Weber PSD, Hussey GS, Lehmann KDS, Montgomery TM, Turner JW, Perng W, Pioon MO, Holekamp KE, Getty T. *Toxoplasma gondii* infections are associated with costly boldness toward felids in a wild host. *Nat Commun* 2021; <https://doi.org/10.1038/s41467-021-24092-x>
- Gomes PD, Hirano LQL, Paula RC. Epidemiological survey of infectious agents in free-ranging maned wolves (*Chrysocyon brachyurus*) in Northeastern Brazil. *Braz J Microbiol* 2024. <https://doi.org/10.1007/s42770-023-01231-8>
- Gonçalves LR, Merino MMGJ, Freschi CR, Fernandes SJ, André MR, Machado RZ. Serological evidence of exposure to *Bartonella* sp. in dogs with suspected vector-borne diseases, toxoplasmosis and neosporosis. *Rev Bras Parasitol* 2022; <https://doi.org/10.1590/S1984-29612022050>

- Gonçalves Netto E, Munhoz AD, Albuquerque GR, Lopes CWG, Ferreira AMR. Ocorrência de gatos soropositivos para *Toxoplasma gondii* Nicolle e Manceaux, 1909 (apicomplexa: toxoplasmatinae) na cidade de Niterói, Rio de Janeiro. *Rev Bras Parasitol Vet* 2003;12(4):145-149.
- González-Barrio D, Carpio AJ, Preite L, Miguel-Vicedo M, Estévez-Reboredo RM, González-Viadero M, Barba-Sánchez R, Calero-Bernal R, Carmena D, Fuentes I. *Toxoplasma gondii* exposure in wildlife in Spain: Is there any predictable threat for humans and domestic animals? *Sci Total Environ* 2024; <https://doi.org/10.1016/j.scitotenv.2024.173290>
- Guimarães AM, Rocha CMBM, Oliveira TMES, Rosado IR, Morais LG, Santos RRD. Fatores associados à soropositividade para *Babesia*, *Toxoplasma*, *Neospora* e *Leishmania* em cães atendidos em nove clínicas veterinárias do município de Lavras, MG. *Rev Bras Parasitol Vet* 2009; <https://doi.org/10.4322/rbvp.018e1009>
- Hudson R, Szenczi P, Bánszegi O. Parental behavior in carnivores. In: González-Mariscal, G. *Patterns of Parental Behavior*. 2022; [https://doi.org/10.1007/978-3-030-97762-7\\_2](https://doi.org/10.1007/978-3-030-97762-7_2)
- ICMBio. Centro Nacional de Pesquisa e Conservação de Mamíferos Carnívoros. Carnívoros Brasileiros, Instituto Chico Mendes de Conservação da Biodiversidade. 2024. Accessed on July 23, 2025. <https://www.gov.br/icmbio/pt-br/assuntos/centros-de-pesquisa/mamiferos-carnivoros>
- Instituto Pet Brasil. Projeção 2021. Projeção do Instituto Pet Brasil aponta que setor pet deve crescer 22,1% em 2021. 2021. Accessed on July 23, 2025. <https://www.gov.br/agricultura/pt-br/assuntos/camaras-setoriais-tematicas/documentos/camaras-setoriais/animais-e-estimacao/2021/32a-ro-10-11-2021/projecao-setor-pet-2021.pdf>
- Instituto Pró-Carnívoros. Neotropical Carnivore Conservation. Institute Pró-Carnívoros. 2024. Accessed on October 1, 2024. <https://procarnivoros.org.br/en/animals/>
- Kornacka-Stackonis A. *Toxoplasma gondii* infection in wild omnivorous and carnivorous animals in Central Europe – A brief overview. *Vet Parasitol* 2022; <https://doi.org/10.1016/j.vetpar.2022.109701>
- Langoni H, Matteucci G, Medici B, Camossi LG, Richini-Pereira VB, Silva RC. Detection and molecular analysis of *Toxoplasma gondii* and *Neospora caninum* from dogs with neurological disorders. *Rev Soc Bras Med Trop* 2012; <https://doi.org/10.1590/s0037-86822012000300016>
- Lial HC, Navas-Suárez PE, Ewbank AC, Novoselecki HE, Ferreira-Machado E, Cirqueira CS, Fernandes NCCA, Esperón F, Catão-Dias JL, Sacristán C. Adenovirus surveillance in wild carnivores from Brazil. *Infect Genet Evol* 2022; <https://doi.org/10.1016/j.meegid.2022.105246>
- Lopes MG, Hernandez M, Lima JTR, Grisi Filho JHH, Gennari SM. Occurrence of antibodies anti-*Toxoplasma gondii* and anti-*Neospora caninum* in dogs from Natal, RN, Brazil. *Braz J Vet Res Anim Sci* 2015; <https://doi.org/10.11606/issn.1678-4456.v52i2p120-124>
- Lopes MG, Mendonça IL, Fortes KP, Amaku M, Pena HFJ, Gennari SM. Presence of antibodies against *Toxoplasma gondii*, *Neospora caninum* and *Leishmania infantum* in dogs from Piauí. *Rev Bras Parasitol Vet* 2011; <https://doi.org/10.1590/s1984-29612011000200004>
- Lucas SRR, Hagiwara MK, Loureiro VS, Ikesaki JYH, Birgel EH. *Toxoplasma gondii* infection in Brazilian domestic outpatient cats. *Rev Inst Med Trop S Paulo* 1999; <https://doi.org/10.1590/S0036-46651999000400003>
- Lugoch G, Noro M, Andrade J. Metanálise da prevalência de toxoplasmose em gatos e ovinos no Brasil. *Rev Ciênc Vet Saúde Públ* 2018; <https://doi.org/10.4025/revcivet.v6i1.41361>
- Machado FP, Kmetiuk LB, Teider-Junior PI, Pellizzaro M, Yamakawa AC, Martins CM, Bach RVW, Morikawa VM, Barros-Filho IR, Langoni H, Santos AP, Biondo AW. Seroprevalence of anti-*Toxoplasma gondii* antibodies in wild boars (*Sus scrofa*), hunting dogs, and hunters of Brazil. *PLoS One* 2019; <https://doi.org/10.1371/journal.pone.0223474>
- Magalhães FJR, Ribeiro-Andrade M, Souza FM, Lima Filho CDF, Biondo AW, Vidotto O, Navarro IT, Mota RA. Seroprevalence and spatial distribution of *Toxoplasma gondii* infection in cats, dogs, pigs and equines of the Fernando de Noronha Island, Brazil. *Parasitol Int* 2017; <https://doi.org/10.1016/j.parint.2016.11.014>
- Magioli M, Lima LHA, Villela PMS, Sampaio R, Bonjorne L, Ribeiro RLA, Kantek DLZ, Miyazaki SS, Semedo TBF, Libardi GS, Saranholi BH, Eriksson CE, Morato RG, Berlink CN. Forest type modulates mammalian responses to megafires. *Sci Rep* 2024; <https://doi.org/10.1038/s41598-024-64460-3>
- Marques JM, Isbrecht FB, Lucas TM, Guerra IMP, Dalmolin A, Silva RC, Langoni H, Silva AV. Detecção de anticorpos anti-*Toxoplasma gondii* em animais de uma comunidade rural do Mato Grosso do Sul, Brasil. *Semin Ciênc Agrár* 2009; <https://doi.org/10.5433/1679-0359.2009v30n4p889>
- Marujo RB, Langoni H, Ullmann LS, Pellizzaro M, Dias Neto RN, Camossi LG, Teixeira RF, Nunes AV, Silva RC, Menozzi BD. *Toxoplasma gondii* antibodies and related risk factors in mammals at Sorocaba zoo, São Paulo, Brazil. *Semin Ciênc Agrár* 2017; <https://doi.org/10.5433/1679-0359.2017v38n4Supl1p2845>
- Mattos BC, Patrício LFL, Plugge NF, Lange RR, Richartz RRTB, Dittrich RL. Soroprevalência de anticorpos anti-*Neospora caninum* e anti-*Toxoplasma gondii* em canídeos selvagens cativos. *Rev Bras Parasitol Vet* 2008;17(Supl.1):267-272. PMID:20059860
- Meiros LR, Galisteo Jr AJ, Pompeu E, Andrade Jr HF. *Toxoplasma gondii* spreading in an urban area evaluated by seroprevalence in free-living cats and dogs. *Trop Med Int Health* 2004; <https://doi.org/10.1111/j.1365-3156.2004.01280.x>
- Melo RPB, Almeida JC, Lima DCV, Pedrosa CM, Magalhães FJR, Alcântara AM, Barros LD, Vieira RFC, Garcia JL, Mota RA. Atypical *Toxoplasma gondii* genotype in feral cats from the Fernando de Noronha Island, northeastern Brazil. *Vet Parasitol* 2016; <https://doi.org/10.1016/j.vetpar.2016.05.023>
- Mendes-de-Almeida F, Labarthe N, Guerrero J, Faria MCF, Branco AS, Pereira CD, Barreira JD, Pereira MJS. Follow-up of the health conditions of an urban colony of free-roaming cats (*Felis catus* Linnaeus, 1758) in the city of Rio de Janeiro, Brazil. *Vet Parasitol* 2007; <https://doi.org/10.1016/j.vetpar.2007.03.035>
- Mineo TWP, Silva DAO, Costa GHN, von Ancken ACB, Kasper LH, Souza MA, Cabral DD, Costa AJ, Mineo JR. Detection of IgG antibodies to *Neospora caninum* and *Toxoplasma gondii* in dogs examined in a veterinary hospital from Brazil. *Vet Parasitol* 2001; [https://doi.org/10.1016/s0304-4017\(01\)00441-1](https://doi.org/10.1016/s0304-4017(01)00441-1)
- Minervino AHH, Cassinelli ABM, Lima JTR, Soares HS, Malheiros AF, Marcili A, Gennari SM. Prevalence of anti-*Neospora caninum* and anti-*Toxoplasma gondii* antibodies in dogs from two different indigenous communities in the Brazilian Amazon Region. *J Parasitol* 2012; <https://doi.org/10.1645/GE-3151.1>
- Minervino AHH, Soares HS, Barrêto-Júnior RA, Neves KAL, Pena HFJ, Ortolani EL, Dubey JP, Gennari SM. Seroprevalence of *Toxoplasma gondii* antibodies in captive wild mammals and birds in Brazil. *J Zoo Wildl Med* 2010; <https://doi.org/10.1638/2010-0046.1>
- Minuzzi CE, Fernandes Fd'A, Portella LP, Bräunig P, Sturza DAF, Giacomini L, Salvagni E, Ribeiro JS, Silva CR, Difante CM, Farinha LB, Menegolla IA, Gehrke G, Dilkin P, Sangioni LA, Mallmann CA, Vogel FSF. Contaminated water formed as source of infection by bioassay in an outbreak of toxoplasmosis in South Brazil. *Transbound Emerg Dis* 2021; <https://doi.org/10.1111/tbed.13741>
- Miró G, Montoya A, Jiménez S, Frisuelos C, Mateo M, Fuentes I. Prevalence of antibodies to *Toxoplasma gondii* and intestinal parasites in stray, farm and household cats in Spain. *Vet Parasitol* 2004; <https://doi.org/10.1016/j.vetpar.2004.08.015>
- Mortari APG, Tagarra LG, Souza ML, Roman IJ, Ratzlaff FR, Braunig P, Andrade CM, Cargnelutti JF, Sangioni LA, Vogel FSF. Increased seroprevalence of anti-*Toxoplasma gondii* antibodies in dogs in southern Brazil after an outbreak of human toxoplasmosis. *Parasitol Res* 2023;122(4):1009-1014. PMID:36881160

- Moura AB, Souza AP, Sartor AA, Bellato V, Teixeira EB, Pissetta GM, Heusser Junior A. Ocorrência de anticorpos e fatores de risco para infecção por *Toxoplasma gondii* em cães, nas cidades de Lages e Balneário Camboriú, Santa Catarina, Brasil. *Rev Bras Parasitol Vet* 2009; <https://doi.org/10.4322/rbpv.01803009>
- Munhoz AD, Hage SB, Cruz RDS, Calazans APF, Silva FL, Albuquerque GR, Lacerda LC. Toxoplasmosis in cats in northeastern Brazil: Frequency, associated factors and coinfection with *Neospora caninum*, feline immunodeficiency virus and feline leukemia virus. *Vet Parasitol Reg Stud Reports* 2017; <https://doi.org/10.1016/j.vprsr.2017.01.007>
- Olbera AVG, Fornazari F, Babboni SD, Rossi RS, Sev AP, Latosinski GS, Silva MARX, Modolo JR, Langoni H. Cumulative incidence and spatial distribution of dogs exposed to *Toxoplasma gondii*. *Rev Bras Parasitol Vet* 2020; <https://doi.org/10.1590/s1984-29612020025>
- Oliveira CS, Camillo G, Cadore GC, Bagolin C, Anjos STL, Sangioni LA, Vogel FSF. Detecço de anticorpos anti-*Toxoplasma gondii* em felinos domsticos. *Rev Inst Adolfo Lutz* 2014; <https://doi.org/10.18241/0073-98552014731598>
- Oliveira GMS, Simes JM, Schaer RE, Freire SM, Nascimento RJM, Pinheiro AMCM, Carvalho SMS, Mariano APM, Carvalho RC, Munhoz AD. Frequency and factors associated with *Toxoplasma gondii* infection in pregnant women and their pets in Ilhus, Bahia, Brazil. *Rev Soc Bras Med Trop* 2019; <https://doi.org/10.1590/0037-8682-0250-2019>
- Oliveira S, Mattos PSR, Mattos KK, Toppa RH, Costa AP, Marcili A, Ferreira JIGS, Krawczak FS, Labruna MB, Gennari SM, Pena HFJ. Presence of anti-*Toxoplasma gondii*, *-Neospora caninum*, *-Leishmania* spp. and *-Ehrlichia canis* antibodies in free-ranging maned wolves (*Chrysocyon brachyurus*) in the northeastern region of the state of So Paulo, Brazil. *Braz J Vet Res Anim Sci* 2016; <https://doi.org/10.11606/issn.1678-4456.bjvras.2016.107917>
- Oliveira VC, Boechat VC, Mendes Junior AAV, Madeira MF, Ferreira LC, Figueiredo FB, Campos MP, Rodrigues FCC, Oliveira RVC, Amendoeira MRR, Menezes RC. Occurrence of *Leishmania infantum* in the central nervous system of naturally infected dogs: Parasite load, viability, co-infections and histological alterations. *PLoS One* 2017; <https://doi.org/10.1371/journal.pone.0175588>
- Onuma SSM, Melo ALT, Kantek DLZ, Crawshaw-Junior PG, Morato RG, May-Jnior JA, Pacheco TA, Aguiar DM. Exposure of free-living jaguars to *Toxoplasma gondii*, *Neospora caninum* and *Sarcocystis neurona* in the Brazilian Pantanal. *Rev Bras Parasitol Vet* 2014; <https://doi.org/10.1590/S1984-29612014077>
- Padilha TC, Zitelli LC, Webster A, Dall'Agnol B, Rosa VB, Souza U, Peters FB, Jardim M, Trigo TC, Rodrigues RO, Marks FS, Reck J. Serosurvey of antibodies against zoonotic pathogens in free-ranging wild canids (*Cerdocyon thous* and *Lycalopex gymnocercus*) from Southern Brazil. *Comp Immunol Microbiol Infect Dis* 2021; <https://doi.org/10.1016/j.cimid.2021.101716>
- Paul M, King L, Carlin EP. Zoonoses of people and their pets: a US perspective on significant pet-associated parasitic diseases. *Trends Parasitol* 2010; <https://doi.org/10.1016/j.pt.2010.01.008>
- Paulan SC, Lins AGS, Tenrio MS, Silva DT, Pena HFJ, Machado RZ, Gennari SM, Buzetti WAS. Seroprevalence rates of antibodies against *Leishmania infantum* and other protozoan and rickettsial parasites in dogs. *Rev Bras Parasitol Vet* 2013; <https://doi.org/10.1590/s1984-29612013000100031>
- Paz GS, Colhado BS, Anton MM, Rocha KS, Silva DB, Moraes CCG, Luchesi SB, Langoni H. Infecço por *Toxoplasma gondii*, *Neospora caninum*, *Leishmania major* e *Trypanosoma cruzi* em ces do estado do Par. *Cinc Anim Bras* 2019; <https://doi.org/10.1590/1809-6891v20e-33566>
- Pena HFJ, Evangelista CM, Casagrande RA, Bieuz G, Wisser CS, Ferian PE, Moura AB, Rolim VM, Driemeier D, Oliveira S, Alves BF, Gennari SM, Traverso SD. Fatal toxoplasmosis in an immunosuppressed domestic cat from Brazil caused by *Toxoplasma gondii* clonal type I. *Rev Bras Parasitol Vet* 2017; <https://doi.org/10.1590/S1984-29612017025>
- Pena HFJ, Soares RM, Amaku M, Dubey JP, Gennari SM. *Toxoplasma gondii* infection in cats from So Paulo state, Brazil: seroprevalence, oocyst shedding, isolation in mice, and biologic and molecular characterization. *Res Vet Sci* 2006; <https://doi.org/10.1016/j.rvsc.2005.09.007>
- Pepper A, Mansfield C, Stent A, Johnstone T. Toxoplasmosis as a cause of life-threatening respiratory distress in a dog receiving immunosuppressive therapy. *Clin Case Rep* 2019; <https://doi.org/10.1002/ccr3.2121>
- Pereira PF, Barbosa AS, Santos ALC, Bolais PF, Dard M-L, Amendoeira MRR. *Toxoplasma gondii*: infection among shelter and stray cats in Rio de Janeiro, Brazil. *Rev Bras Parasitol Vet* 2018; <https://doi.org/10.1590/S1984-296120180061>
- Perin PP, Arias-Pacheco CA, Andrade LO, Gomes JS, Ferreira AFM, Pavaneli RO, Loureiro FA, Franco AL, Oliveira WJ, Mendonça TO, Zolla NO, Mioni MSR, Machado RZ, Barros LD, Garcia JL, Jurkevics RMB, Cavallieri AC, Hoppe EGL. *Toxoplasma gondii* and *Neospora caninum* in invasive wild boars (*Sus scrofa*) and hunting dogs from Brazil. *Int J Parasitol Parasites Wildl* 2024; <https://doi.org/10.1016/j.ijppaw.2024.100951>
- Pimentel JS, Gennari SM, Dubey JP, Marvulo MFV, Vasconcellos SA, Morais ZM, Silva JCR, Evncio Neto J. Inqurito sorolgico para toxoplasmose e leptospirose em mamferos selvagens neotropicais do Zoolgico de Aracaju, Sergipe. *Pesq Vet Bras* 2009; <https://doi.org/10.1590/S0100-736X2009001200010>
- Pinto LD, Arajo FAP, Stobb NS, Marques SMT. Seroepidemiology of *Toxoplasma gondii* in domestic cats treated in private clinics of Porto Alegre, Brazil. *Cincia Rural* 2009; <https://doi.org/10.1590/S0103-84782009005000185>
- Pinto-Ferreira F, Caldart ET, Pasquali AKS, Mitsuka-Bregan R, Freire RL, Navarro IT. Patterns of transmission and sources of infection in outbreaks of human toxoplasmosis. *Emerg Infect Dis* 2019; <https://doi.org/10.3201/eid2512.181565>
- Plugge NF, Ferreira FM, Richartz RRTB, Siqueira A, Dittrich RL. Occurrence of antibodies against *Neospora caninum* and/or *Toxoplasma gondii* in dogs with neurological signs. *Rev Bras Parasitol Vet* 2011; <https://doi.org/10.1590/s1984-29612011000300004>
- Proena LM, Silva JCR, Galera PD, Lion MB, Marinho-Filho JS, Ragozo AMA, Gennari SM, Dubey JP, Vasconcellos AS, Souza GO, Pinheiro Jnior JW, Santana VLA, Frana GL, Rodrigues FHG. Serologic survey of infectious diseases in populations of maned wolf (*Chrysocyon brachyurus*) and crab-eating fox (*Cerdocyon thous*) from guas Emendadas Ecological Station, Brazil. *J Zoo Wildl Med* 2013; <https://doi.org/10.1638/1042-7260-44.1.152>
- Raimundo JM, Guimares A, Moraes LMB, Santos LA, Nepomuceno LL, Barbosa SM, Santos LA, Nepomuceno LL, Barbosa SM, Pires MS, Santos HA, Massard CL, Machado RZ, Baldani CD. *Toxoplasma gondii* and *Neospora caninum* in dogs from the state of Tocantins: serology and associated factors. *Rev Bras Parasitol Vet* 2015; <https://doi.org/10.1590/S1984-29612015068>
- Remor-Sebolt AP, Lima FR, Amrico L, Padilha MAC, Chryssafidis AL, Moura AB. Occurrence of antibodies and epidemiological significance of *Toxoplasma gondii* and *Neospora caninum* infections in canine populations of Laguna, State of Santa Catarina. *Vet Res Commun* 2024; <https://doi.org/10.1007/s11259-024-10462-5>
- Riet-Correa F, Lemos RAA, Guizelini CC. The importance of veterinary diagnostic laboratories for disease surveillance, research, and postgraduate studies in animal health in Brazil. *Pesq Vet Bras* 2025; <https://doi.org/10.1590/1678-5150-PVB-7633>
- Rocha KS, Lima MS, Monteiro TRM, Honorio BET, Pinho APVB, Paz GS, Scofield A, Cavalcante GG, Magalhes-Matos PC, Sampaio Junior FD, Abel I, Langoni H, Moraes CCG. Serological prevalence of *Toxoplasma gondii* infection in cats (Belm, Par, Brazil). *Rev Bras Parasitol Vet* 2020; <https://doi.org/10.1590/s1984-29612020038>
- Rodrigues JY, Almeida ABPF, Sorte ECB, Gasparetto ND, Cruz FACS, Souza VRF. Seroprevalence of *Toxoplasma gondii* in dogs of riverside communities of Mato Grosso Pantanal, Brazil. *Rev Bras Parasitol Vet* 2016; <https://doi.org/10.1590/S1984-29612016067>
- Roman IJ, Tagarra LG, Rodrigues FS, Cargnelutti JF, Sangioni LA, Vogel FSF. *Sarcocystis neurona*, *Toxoplasma gondii*, and *Neospora caninum* infection

- in bovine fetuses from a slaughterhouse in southern Brazil. *Pesq Vet Bras* 2024; <https://doi.org/10.1590/1678-5150-PVB-7504>
- Romanelli PR, Freire RL, Vidotto O, Marana ERM, Ogawa L, De Paula VSO, Garcia JL, Navarro IT. Prevalence of *Neospora caninum* and *Toxoplasma gondii* in sheep and dogs from Guarapuava farms, Paraná State, Brazil. *Res Vet Sci* 2007; <https://doi.org/10.1016/j.rvsc.2006.04.001>
- Rosa LD, Moura AB, Trevisani N, Medeiros AP, Sartor AA, Souza AP, Bellato V. *Toxoplasma gondii* antibodies on domiciled cats from Lages municipality, Santa Catarina State, Brazil. *Rev Bras Parasitol Vet* 2010; <https://doi.org/10.1590/s1984-29612010000400017>
- Ruffolo BB, Toledo RS, Martins FDC, Bugni FM, Costa L, Marana ERM, Navarro IT, Garcia JL, Su C, Freire RL. Isolation and genotyping of *Toxoplasma gondii* in seronegative urban rats and presence of antibodies in communicating dogs in Brazil. *Rev Inst Med Trop S Paulo* 2016; <https://doi.org/10.1590/S1678-9946201658028>
- Sacristán I, Acuña F, Aguilar E, García S, López MJ, Cabello J, Hidalgo-Hermoso E, Sanderson J, Terio KA, Barrs V, Beatty J, Johnson WE, Millán J, Poulin E, Napolitano C. Cross-species transmission of retroviruses among domestic and wild felids in human-occupied landscapes in Chile. *Evol Appl* 2021; <https://doi.org/10.1111/eva.13181>
- Santos EZ, Soares HS, Santos SR, Moraes Filho J, Pena HFJ, Amaku M, Gennari SM. *Toxoplasma gondii* and *Neospora caninum* antibody seroprevalence and risk factors among dogs treated at Public Veterinary Hospitals in São Paulo, Brazil. *Rev Bras Parasitol Vet* 2023; <https://doi.org/10.1590/S1984-29612023058>
- Santos TR, Costa AJ, Toniollo GH, Luvizotto MCR, Benetti AH, Santos RR, Matta DH, Lopes WZ, Oliveira JA, Oliveira GP. Prevalence of anti-*Toxoplasma gondii* antibodies in dairy cattle, dogs, and humans from the Jauru micro-region, Mato Grosso state, Brazil. *Vet Parasitol* 2009; <https://doi.org/10.1016/j.vetpar.2009.01.017>
- Seabra NM, Pereira VF, Kuwassaki MV, Benassi JC, Oliveira TMFS. *Toxoplasma gondii*, *Neospora caninum* and *Leishmania* spp. serology and *Leishmania* spp. PCR in dogs from Pirassununga, SP. *Rev Bras Parasitol Vet* 2015; <https://doi.org/10.1590/S1984-29612015046>
- Sebastiani MC. Levantamento de hemopatógenos, ectoparasitos e soroprevalência de *Toxoplasma gondii* em gatos comunitários do Parque Municipal Américo Renné Giannetti de Belo Horizonte, Minas Gerais, Brasil. Dissertação de Mestrado, Universidade Federal de Minas Gerais, Belo Horizonte, 2021, 103p.
- Sevá AP, Chiebao DP, Brandão APD, Godoy SN, Jimenez-Villegas T, Pena HFJ, Ferreira F. Seroprevalence and incidence of *Toxoplasma gondii* and *Neospora caninum* infection in naturally exposed domestic dogs from a rural area of São Paulo state, Brazil. *Rev Bras Parasitol Vet* 2020; <https://doi.org/10.1590/S1984-29612020053>
- Silva ALP, Lima EF, Silva Filho GM, Ferreira LC, Campos BA, Bison I, Brasil AWL, Parentoni RN, Feitosa TF, Vilela VLR. Seroepidemiological survey of anti-*Toxoplasma gondii* and anti-*Neospora caninum* antibodies in domestic cats (*Felis catus*) in Rolim de Moura, state of Rondônia, North Brazil. *Trop Med Infect Dis* 2023; <https://doi.org/10.3390/tropicalmed8040220>
- Silva JCR, Marvulo MFV, Dias RA, Ferreira F, Amaku M, Adania CH, Ferreira Neto JS. Risk factors associated with sero-positivity to *Toxoplasma gondii* in captive neotropical felids from Brazil. *Prev Vet Med* 2007; <https://doi.org/10.1016/j.prevetmed.2006.10.013>
- Silva JR, Maciel BM, Santos LKNSS, Carvalho FS, Rocha DS, Lopes CWG, Albuquerque GR. Isolation and genotyping of *Toxoplasma gondii* in Brazilian dogs. *Korean J Parasitol* 2017; <https://doi.org/10.3347/kjp.2017.55.3.239>
- Silva RC, Machado GP, Cruvinel TMA, Cruvinel CA, Langoni H. Detection of antibodies to *Toxoplasma gondii* in wild animals in Brazil. *J Venom Anim Toxins Incl Trop Dis* 2014; <https://doi.org/10.1186/1678-9199-20-41>
- Silva RC, Souza LC, Langoni H, Tanaka EM, Lima Vy, Silva AV. Risk factors and presence of antibodies to *Toxoplasma gondii* in dogs from the coast of São Paulo State, Brazil. *Pesq Vet Bras* 2010; <https://doi.org/10.1590/S0100-736X2010000200011>
- Sohn-Hausner N, Correa RG, Kmetiuk LB, Silva EC, Moraes GN, Rocha GS, Langoni H, Biondo AW. One Health approach to toxoplasmosis: owner and dog seropositivity as spatial indicators of risk areas for acquired, gestational and congenital transmission. *Trop Med Infect Dis* 2024; <https://doi.org/10.3390/tropicalmed9070143>
- Souza IB, Fernandes PR, Silva TRM, Santos CVB, Silva NMM, Ubirajara-Filho CRC, Carvalho GA, Alves LC, Mota RA, Ramos RAN. Seroprevalence of *Neospora caninum* and *Toxoplasma gondii* in dogs from an urban area of North-eastern Brazil: a spatial approach. *Rev Soc Bras Med Trop* 2019; <https://doi.org/10.1590/0037-8682-0440-2018>
- Souza KCM, Herrera HM, Domingos IH, Campos JBV, Santos IMC, Neves HH, Machado RZ, André MR. Serological detection of *Toxoplasma gondii*, *Leishmania infantum* and *Neospora caninum* in cats from an area endemic for leishmaniasis in Brazil. *Rev Bras Parasitol Vet* 2014; <https://doi.org/10.1590/S1984-29612014078>
- Souza LR, Carvalho MPN, Lopes CEB, Lopes MC, Campos BH, Teixeira ÉPT, Mendes EJ, Santos LP, Caixeta EA, Costa EA, Cunha JLR, Fraiha ALS, Silva ROS, Ramos CP, Varaschin MS, Ecco R. Outbreak of canine distemper and coinfections in a maned wolf (*Chrysocyon brachyurus*) and in three giant anteaters (*Myrmecophaga tridactyla*). *Braz J Microbiol* 2022; <https://doi.org/10.1007/s42770-022-00783-5>
- Souza SF, Medeiros LS, Belfort AS, Cordeiro ALL, Federle M, Souza AP, Moura AB. *Toxoplasma gondii* antibodies in domiciled cats from rio branco Municipality, Acre State, Brazil. *Semin Ciênc. Agrár* 2015; <https://doi.org/10.5433/1679-0359.2015v36n6p3757>
- Souza SLP, Gennari SM, Yai LEO, D'Auria SRN, Cardoso SMS, Guimarães-Júnior JS, Dubey JP. Occurrence of *Toxoplasma gondii* antibodies in sera from dogs of the urban and rural areas from Brazil. *Rev Bras Parasitol Vet* 2003; 12:1-3.
- Spriggs M, Jiang T, Gerhold R, Stedman N, López-Orozco N, Su C. Genotype identification of *Toxoplasma gondii* in macropods from a zoological park in Florida, USA. *J Zoo Wildl Med* 2020; <https://doi.org/10.1638/2019-0093>
- Strital AD, Igarashi M, Muraro LS, Aguiar DM, Pacheco TA, Garcia JL, Freitas SH, Amude AM. Estudo epidemiológico e avaliação de fatores de risco da infecção por *Toxoplasma gondii* e achados clínico-patológicos da infecção aguda em cães admitidos em um Hospital Escola Veterinário. *Pesq Vet Bras* 2016; <https://doi.org/10.1590/S0100-736X2016001000012>
- Teixeira JV, Oliveira JLS, Almeida DMPF, Gonçalves LS, Oliveira FLL. Seroprevalence of feline toxoplasmosis in Teresina, Piauí, Brazil. *Rev Bras Hig Sanid Anim* 2016; 10(4):549-555.
- Tomas WM, Berlinck CN, Chiaravalloti RM, Faggioni GP, Strüssmann C, Libonati R, Abrahão CR, Alvarenga GV, Bacellar AEF, Batista FRQ, Bornato TS, Camilo AR, Castedo J, Fernando AME, Freitas GO, Garcia CM, Gonçalves HS, Guilherme MBF, Layme VMG, Lustosa APG, De Oliveira AC, Oliveira MR, Pereira AMM, Rodrigues JA, Semedo TBF, Souza RAD, Tortato FR, Viana DFP, Vicente-Silva L, Morato R. Distance sampling surveys reveal 17 million vertebrates directly killed by the 2020's wildfires in the Pantanal, Brazil. *Sci Rep* 2021; <https://doi.org/10.1038/s41598-021-02844-5>
- Ubiali DG, Weiss B, Ubiali BG, Colodel EM, Valderrama-Vasquez C, Garrido EP, Tortato FR, Hoogesteijn R. É possível integrar pecuária à conservação da biodiversidade? Estudo de casos de depredação de ovinos por onça-parda (*Puma concolor*). *Pesq Vet Bras* 2018; <https://doi.org/10.1590/1678-5150-PVB-6219>
- Ullmann LS, Silva RC, Moraes W, Cubas ZS, Santos LC, Hoffmann JL, Moreira N, Guimaraes AMS, Montaña P, Langoni H, Biondo AW. Serological survey of *Toxoplasma gondii* in captive neotropical felids from southern Brazil. *Vet Parasitol* 2010; <https://doi.org/10.1016/j.vetpar.2010.04.013>
- Valadas S, Minervino AHH, Lima VMF, Soares RM, Ortolani EL, Gennari SM. Occurrence of antibodies anti-*Neospora caninum*, anti-*Toxoplasma gondii*, and anti-*Leishmania chagasi* in serum of dogs from Pará State, Amazon, Brazil. *Parasitol Res* 2010; <https://doi.org/10.1007/s00436-010-1890-2>
- Van Valkenburgh B, Wayne RK. Carnivores. *Curr Biol* 2010; <https://doi.org/10.1016/j.cub.2010.09.013>

- Vicente Sobrinho LS, Rossi CN, Vides JP, Braga ET, Gomes AAD, Lima VMF, Perri SHV, Generoso D, Langoni H, Leutenegger C, Biondo AW, Laurenti MD, Marcondes M. Coinfection of *Leishmania chagasi* with *Toxoplasma gondii*, Feline Immunodeficiency Virus (FIV) and Feline Leukemia Virus (FeLV) in cats from an endemic area of zoonotic visceral leishmaniasis. *Vet Parasitol* 2012; <https://doi.org/10.1016/j.vetpar.2012.01.010>
- Villar-Echarte G, Arruda IF, Barbosa AS, Guzmán RG, Augusto AM, Troccoli F, Segón AMR, Santos ALC, Zanotto PFC, Gava MZ, Langoni H, Amendoeira MRR. *Toxoplasma gondii* among captive wild mammals in zoos in Brazil and Cuba: seroprevalence and associated risk factors. *Rev Bras Parasitol Vet* 2021; <https://doi.org/10.1590/S1984-29612021053>
- Vitaliano SN, Silva DAO, Mineo TWP, Ferreira RA, Bevilacqua E, Mineo JR. Seroprevalence of *Toxoplasma gondii* and *Neospora caninum* in captive maned wolves (*Chrysocyon brachyurus*) from southeastern and midwestern regions of Brazil. *Vet Parasitol* 2004; <https://doi.org/10.1016/j.vetpar.2004.04.004>
- Wei X-Y, Gao Y, Lv C, Wang W, Chen Y, Zhao Q, Gong Q-L, Zhang X-X. The global prevalence and risk factors of *Toxoplasma gondii* among foxes: a systematic review and meta-analysis. *Microb Pathog* 2021; <https://doi.org/10.1016/j.micpath.2020.104699>
- Wolf C, Ripple WJ. Rewilding the world's large carnivores. *R Soc Open Sci* 2018; <https://doi.org/10.1098/rsos.172235>
- Zanette MF, Lima VMF, Laurenti MD, Rossi CN, Vides JP, Vieira RFC, Biondo AW, Marcondes M. Serological cross-reactivity of *Trypanosoma cruzi*, *Ehrlichia canis*, *Toxoplasma gondii*, *Neospora caninum* and *Babesia canis* to *Leishmania infantum chagasi* tests in dogs. *Rev Soc Bras Med Trop* 2014; <https://doi.org/10.1590/0037-8682-1723-2013>
- Zhu S, Shapiro K, VanWormer E. Dynamics and epidemiology of *Toxoplasma gondii* oocyst shedding in domestic and wild felids. *Transbound Emerg Dis* 2022; <https://doi.org/10.1111/tbed.14197>
- Zhu S, VanWormer E, Shapiro K. More people, more cats, more parasites: Human population density and temperature variation predict prevalence of *Toxoplasma gondii* oocyst shedding in free-ranging domestic and wild felids. *PLoS One* 2023; <https://doi.org/10.1371/journal.pone.0286808>
- Zulpo DL, Sammi AS, Santos JR, Sasse JP, Martins TA, Minutti AF, Cardim ST, Barros LD, Navarro IT, Garcia JL. *Toxoplasma gondii*: A study of oocyst shedding in domestic cats. *Vet Parasitol* 2018; <https://doi.org/10.1016/j.vetpar.2017.10.021>