

Toxoplasma gondii* in the sheep industry: a global overview and the situation in Brazil

***Toxoplasma gondii* na ovinocultura: um panorama global e a situação no Brasil**

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Abstract

Toxoplasma gondii is one of the most widely studied parasites due to its medical and veterinary importance. The parasitic infection of sheep occurs worldwide, with studies showing prevalences ranging from 1.8% in North Tunisian to 95.7% in Turkey. In this ruminant species, infection with *T. gondii* causes fetal death, mummification, stillbirth, the birth of debilitated animals and frequent abortion. The latter has been reported as the primary cause of economic losses in the sheep industry because of the high rates of infection. Concerns over toxoplasmosis infections in sheep, as well as the economic losses they can cause, induced this literature review. A review of the topic will provide the reader with some basic information concerning the importance of this parasite in the sheep industry in Brazil and worldwide, which might assist in controlling the disease and promptly identifying the problem in a flock, thus avoiding losses from potential abortions caused by this important parasite.

Keywords: *Ovis aires*, zoonosis, abortion, toxoplasmosis, pathology, epidemiology.

Resumo

Toxoplasma gondii é um dos parasitas mais bem estudados devido à sua importância médica e veterinária. A infecção pelo parasito em ovinos é de distribuição mundial com estudos de prevalência que variaram de 1,8% no norte da Tunísia até 95,7% na Turquia. Nesta espécie de ruminante, a infecção é causa de morte fetal, mumificação, natimortalidade, nascimentos de animais debilitados e principalmente abortamentos. Esta última é relatada como a causa primária de perdas econômicas na pecuária industrial de ovinos devido à alta prevalência da infecção. Neste sentido, a preocupação com a infecção toxoplásmica em ovinos, assim como os prejuízos econômicos que ela pode causar deu origem a presente revisão de literatura. A revisão sobre o assunto trará ao leitor noções básicas e fundamentais sobre a importância desta parasitose na ovinocultura brasileira e mundial, o que pode auxiliar no controle da enfermidade e na identificação imediata do problema no rebanho, evitando assim, prejuízos em decorrência de abortamentos causados por este importante parasita.

Palavras-Chave: *Ovis aires*, zoonose, aborto, toxoplasmose, patologia, epidemiologia.

Introduction

In Brazil and several other regions of the world, the sheep industry is expanding and the production chain must therefore be attentive to health problems, especially involving reproduction, which has a direct effect on the production and productivity of flocks. Toxoplasmosis, besides causing reproductive problems in sheep, such as abortion, is also an important zoonosis (Moreno et al., 2012; Silva et al., 2013).

Toxoplasmosis, as well as other infectious diseases, causes major losses to the sheep industry and, indirectly, to public health (Pinheiro e Alves, 2003). The toxoplasmosis infection in sheep is known by farmers, ranchers, veterinarians and other

professionals to be the cause of these economic losses and, primarily, to be responsible for abortion, stillbirth or the birth of weak and debilitated animals (Bispo et al., 2010). Another factor that causes concern with respect to the disease is its zoonotic potential, due in this case to the consumption of raw sheep meat, not only in Brazil but also in other regions of the world.

Issues concerning toxoplasmosis infections in sheep, as well as the economic losses they can cause initiated the present literature review. Therefore, the objective of this review was to report the issues with and fundamental information about the importance of this parasite in the Brazilian and global sheep industry, which will assist in controlling the disease, promptly identifying the problem, and subsequently avoiding losses from abortions.

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History

Toxoplasma gondii is among the best studied parasites due to its medical and veterinary importance. Up to and including the twentieth century, fifteen thousand original articles and 500 reviews had been published on the subject (Tenter et al., 2000). From the year 2000 through the current year (2013), over eight thousand articles with the terms “toxoplasma” or “toxoplasmosis” were indexed in PubMed, the National Center for Biotechnology Information U.S. (NCBI).

The parasite was discovered over a century ago (Dubey, 2008a), when and Manceaux (1908) reported its presence in the tissues of an African rodent, *Ctenodactylus gundi*, which had been used to study leishmaniasis. Concurrently, in Brazil, Alfonso Splendore (1908) had also detected the parasite in rabbits, but the parasite was appointment by Nicolle and Manceaux in 1909 (Dubey, 2008a).

About thirty years after its discovery, the parasite was first isolated in animals (Sabin and Olitsky, 1937) and in humans (Wolf et al., 1939) because it is not only a parasite that affects animals but also a human disease of public health importance, a zoonosis. Twenty years after its isolation, *T. gondii* was finally recognized worldwide as an important cause of abortion in sheep (Hartley and Marshall, 1957). Since this time, several studies have been published on the issue, noting the significant facts that the parasite is capable of being transmitted to humans through the consumption of undercooked meat (Villena et al., 2012) and that it can cause economic losses to farmers by causing pathologic abortion in small ruminants (Motta et al., 2008; Bispo et al., 2011).

Currently, the economic losses caused by *T. gondii* infection in sheep are difficult to estimate because the disease occurs sporadically. Moreover, only a small number of the lambs aborted are subjected to diagnosis. In addition, the material sent for diagnosis, besides being potentially inadequate, might also be examined erroneously and finally, serological testing lacks specificity (Dubey, 2009).

Life cycle and forms of transmission

Not only the domestic cat but also all species of cats can excrete *T. gondii* non-sporulated oocysts after ingesting the infective stage of the parasite, which consists of bradyzoites; bradyzoites are present in the tissue cysts of the intermediate host, or as sporozoites, which are formed inside the sporocysts after the sporulation of the oocysts (Dubey, 2010). These non-sporulated oocysts are eliminated by the definitive host into the environment, undergo a change in their structure and become potentially infectious, able to sporulate one to five days after excretion (Dubey, 1994; Dubey, Lindsay and Speer 1998; Tzanidakis et al., 2012). Tachyzoites are observed only in acute infections and systemic disease states and are present primarily during congenital transmission (Dubey et al., 2010).

The principal routes of transmission for toxoplasmosis through intermediate hosts are

as follows: transplacentally (vertical/congenital) and horizontally by the ingestion of tissue cysts contained in raw or undercooked animal tissues and the ingestion of food or water contaminated with sporulating oocysts (Dubey, 1994) (Figure 1). According to Dubey (2009), the ingestion of undercooked beef and lamb is a major source of infection for humans.

Recent studies have drawn attention to the consumption of raw milk and unpasteurized sheep meat that might contain tachyzoites if the animal is in the acute phase of the disease. Camossi et al., (2011) detected DNA from *T. gondii* in seven milk samples from 20 sheep that had been naturally infected by the parasite, thus demonstrating that milk can also be a route of infection for humans. However, for this to occur, no lesion needs to be present in the oral cavity of the host because the tachyzoites show little resistance to the action of gastric juices and are therefore destroyed in a short time when ingested orally, while the bradyzoite forms are resistant to the enzymes present in gastric juices (Prado et al., 2011).

Vertical transmission of *T. gondii* during pregnancy affects the intermediate hosts (sheep and other animals) and even the definitive hosts. The pathogenesis of abortion develops when the parasite proliferates in the placenta and reaches the fetus. When there is no abortion, congenital lesions are initiated and are considered irreversible (Dubey, 1994).

There is yet another likely route of infection by *T. gondii* that has been studied, treating it as a venereal or sexual parasite. Although the subject has been rarely reported, the first papers on the subject were published for sheep in 2010 (Moraes et al., 2010a; Moraes et al., 2010b; Moraes et al., 2010c; Lopes et al., 2013a). The detection of *T. gondii* in semen has also been demonstrated in studies using cattle (Scarpelli et al., 2011), pigs (Moura et al., 2007) and sheep (Lopes et al., 2009). However, all of these species were infected experimentally with the parasite and natural sexual transmission has not been demonstrated.

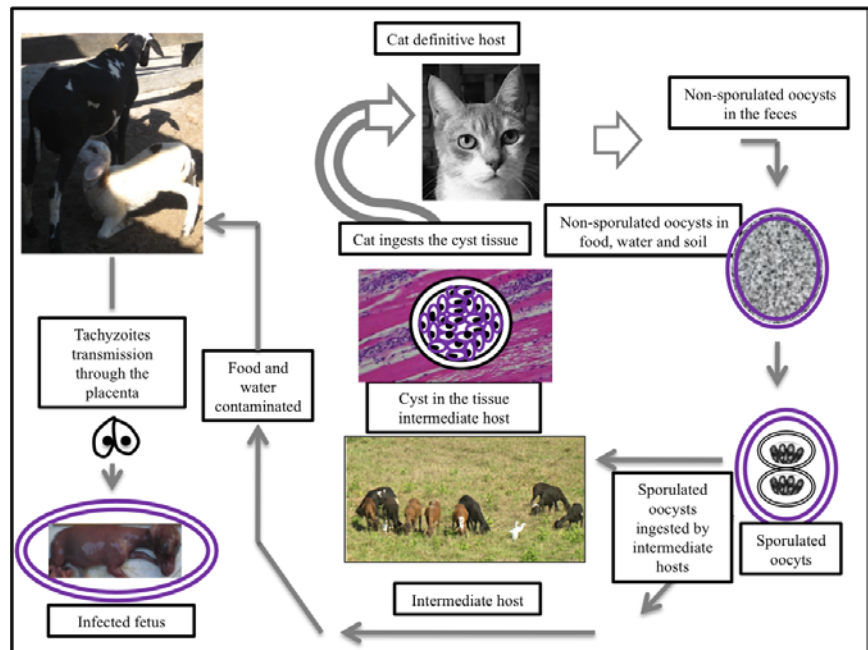


Figure 1: Life cycle of *Toxoplasma gondii*, demonstrates the principal routes of transmission for toxoplasmosis through intermediate hosts are as follows: transplacentally and horizontally.

Table 1: Anti-*Toxoplasma gondii* antibodies in sheep, *Ovis aries*, in Brazil

State - Brazil	Prevalence			Authors
	Sample size	%	Techniques	
Rio Grande do Sul	100	39	RSF ¹	Larsson et al., (1980)
Rio Grande do Sul		18	DAT ²	Zonta et al., (1988)
Paraná	370	47.8	IFAT ³	Freire et al., (1995)
Rio Grande do Sul	144	21-61	LAT ⁴	Martins et al., (1998)
Bahia	240	18.8	LAT	Gondim et al., (1999)
Paraná	228	51.8	IFAT	Garcia et al., (1999)
Pernambuco	173	35.3	IFAT	Silva et al., (2003)
São Paulo	200	31	ELISA	Meireles et al., (2003)
São Paulo	597	34.7	IFAT	Figliuolo et al., (2004)
Rio Grande do Sul	87	44.8	IFAT	Silva e de la rue (2006)
Paraná	157	7	IFAT	Moura et al., (2007)
Paraná	305	51.5	IFAT	Romanelli et al., (2007)
Rio Grande do Norte	102	29.41	ELISA	Clementino et al., (2007)
São Paulo	495	24.2	MAT	Ragozo et al., (2008)
Rio Grande do Norte	409	20.7	IFAT	Soraes et al., (2009)
Distrito Federal	1028	38.2	IFAT	Ueno et al., (2009)
Paraná	167	25.76	ELISA	Soccol et al., (2009)
Rio de Janeiro	112	44.64	MAT	Silva et al., (2010)
Pará	350	44.29	HAI ⁵	Braga-filho et al., (2010)
Minas Gerais	155	46.5	IFAT	Rossi et al., (2011)
Pernambuco	124	48.4	IFAT	Bispo et al., (2011)
Rio de Janeiro	360	38	IFAT	Luciano et al., (2011)
Pernambuco	95	16.9	IFAT	Pereira et al., (2012)
Santa Catarina	360	56.9	IFAT	Sakata et al., (2012)
Espírito Santo	236	38.5	HAI	Tesolini et al., (2012)
Rio Grande do Norte	930	22.1	ELISA	Andrade et al., (2013)
Sergipe	932	28.2	IFAT	Mendonça et al., (2013)
Bahia	795	30.2	IFAT	Guimarães et al., (2013)

¹Reaction Sabin - Feldman, ²Test Hemagglutination Direct, ³Indirect Fluorescent Antibody Test, ⁴Latex Agglutination Test, ⁵Indirect Hemagglutination Test.

Table 2: Anti-*Toxoplasma gondii* antibodies in sheep, *Ovis aries*, around the world

Country	Prevalence			Authors
	Sample size	%	Techniques	
Canada	3872	57.6	ELISA ¹	Waltner-toews et al., (1991)
Pakistan	40	3	LAT ²	Zaki (1995)
Argentina	29	41.4	IFAT ³	West et al., (1998)
France	93	65.6	MAT ⁴	Dumètre et al., (2006)
Spain	203	40.4	MAT	Mainar-jaime e barberán (2007)
Turkey	460	95.7	ELISA	Mor e arslan (2007)
Italy	1170	28.5	ELISA	Fusco et al., (2007)
Mexico	351	29.1	ELISA	Caballero-Ortega et al., (2008)
USA	383	27.1	MAT	Dubey et al., (2008b)
Egypt	300	43.7	MAT	Shaapan et al., (2008)
Finland	1940	24.6	DAT ⁵	Jokelainen et al., (2010)
Iran	156	21.1	MAT	Raeghi et al., (2011)
Iran	56	37.5	PCR ⁶	Asgari et al., (2011)
Greece	1501	48.6	ELISA	Tzanidakis et al., (2012)
Ethiopia	1130	31.6	ELISA	Gebremedhin et al., (2013)
Tunisian (North)	166	1.8	ELISA	Gharbi et al., (2013)
Tunisian (Central)	184	19	ELISA	Gharbi et al., (2013)
Argentina	704	17.3	IFAT	Hecker et al., (2013)
Portugal	119	33.6	MAT	Lopes et al., (2013b)
Spain	503	49.3	ELISA	García-Bocanegra et al., (2013)
Mexico	405	29.9	MAT	Alvarado-Esquivel et al., (2013)
Greece	458	53.7	ELISA	Anastacia et al., (2013)

¹Enzyme Linked ImmunonoSorbent Assay, ²Latex Agglutination Test, ³ Indirect Fluorescent Antibody Test ⁴Test Modified Agglutination, ⁵Agglutination Test Direct, ⁶Reaction Polymerase Chain.

Epidemiology

In Brazil, anti-*T. gondii* antibodies found using serology in sheep had varying percentages of detection (Table 1), from 7% in the State of Paraná (Moura et al., 2007) to 61% on a property in the Rio Grande do Sul region (RS) (Martins et al., 1998).

Toxoplasma gondii has been isolated in all parts of the world. In sheep, infections with this parasite have a worldwide distribution (Dubey, 2010) with prevalences (Table 2) ranging from 1.8% in North Tunisian (Gharbi et al., 2013) to 95.7% in Turkey (Mor and Arslan, 2007).

The disparity in results between different regions of the same country or between countries from serological infection by *T. gondii* in sheep might primarily be due to the different serological methods employed for the diagnosis, the cultural patterns of the populations, their food habits, age distribution, urban or rural origins, or other factors (Amendoeira, Costa and Spalding 1999; Luciano et al., 2011). The presence of cats on farms or properties with sheep might be another factor that influences infection rates by *T. gondii* because cats are another possible source of transmission (Martins et al., 1998).

Clinical manifestation

Manifestation of the clinical signs of toxoplasmosis in animals, as well as in humans, depends primarily on the immune response of the infected host and on the virulence of the sample of *T. gondii* (Amendoeira et al., 1999). According to Millar et al. (2008), farm animals such as sheep are more susceptible to infection when compared with other species.

Sheep infected with *T. gondii* are clinically asymptomatic; however, immune-compromised sheep that acquire the infection during pregnancy might develop reproductive disorders. *T. gondii* infection is a major cause of fetal death, mummification, stillbirth, abortion or of animals being born debilitated (Dubey, 1990).

According to Buxton et al. (1998), the clinical signs of toxoplasmosis are observed when pregnant sheep are infected for the first time. Typical clinical signs include the production of stillborn and/or weak lambs, in addition to mummified fetuses.

Abortion in sheep is cited by many researchers from different regions of the world (Van den Brom et al., 2012) as a principal sign of infections by *T. gondii*. Additionally, this symptom is the primary cause of economic losses in the sheep industry due to the high prevalence of parasite infection that exists (Moreno et al., 2012).

In addition to the clinical signs that the reproductive agent *T. gondii* can cause, other clinical signs of toxoplasmosis in animals are fever, dyspnea, and neurological signs (Soccol et al., 2009). The signs described above and that are associated with the clinical and physical examination of the animal, in addition to complementary diagnostic methods, can contribute to the identification of the disease.

Diagnosis

Diagnosis of *T. gondii* in sheep can be made by means of direct tests, such as histopathology, immunohistochemistry, PCR and bioassay, as well as by means of indirect tests (serum) based on the detection of anti-*T. gondii* antibodies, or by a combination of these methods (Dubey, 2010; Glor et al. 2013).

For establishing a serological survey of *T. gondii*, serological tests are essential because they will report the actual situation and the degree of infection in the animals studied (Braga-Filho et al., 2010). Moreover, various serological tests exist that can be used for the detection of both IgG or IgM (Ragozo et al., 2008; Soccol et al., 2009; Silva et al., 2010; Raeghi et al., 2011; Pereira et al., 2012; Silva et al., 2013).

The indirect fluorescent antibody test (IFAT) is the most commonly used and is therefore considered as the gold standard for diagnosis, as cited by various authors (Silva et al., 2003; Figliuolo et al., 2004; Soraes et al., 2009; Ueno et al., 2009). However, the modified agglutination test (MAT) is also widely used for the diagnosis of toxoplasmosis in animals and humans because it detects IgG with the additional advantage of not requiring a specific conjugate, and it also does not require sophisticated equipment for diagnosis (Dubey 2008a; 2010). In sheep, the MAT has been used for diagnostic serology in France (Dumètre et al., 2006), Spain (Mainar-Jaime & Barberán 2007), Egypt (Shaapan et al., 2008), the United States (Dubey et al., 2008b), Iran (Raegui et al., 2011), and Brazil (Silva et al., 2013), among other countries.

The Elisa test has been widely used for the serological diagnosis of *T. gondii* in sheep (Soccol et al., 2009; Andrade et al., 2013; García-Bocanegra et al., 2013; Charbi et al., 2013; Gebremedhin et al., 2013). According to Glor et al. (2013), an Elisa kit might represent a valuable tool for collecting information on toxoplasmosis infections during sheep production, and additionally, for diagnosis in slaughterhouses, helping to control this widespread zoonosis.

Other tests, such as the latex agglutination test (LAT) described by Gondim et al. (1999) and the Sabin-Feldman reaction (RSF) described by Larsson et al. (1980), also detect the anti-*T. gondii* antibody in serum independent of a specific conjugate and can be used for diagnosis in animals and people.

The bioassay in mice is one of the primary methods used to detect *T. gondii* cysts in tissue for confirming suspected cases of infection by the parasite. It is considered to be a very sensitive diagnostic test, but it is also very costly, difficult and slow (Rosa et al., 2001; Tsutsui et al., 2007). One study evaluated the presence of *T. gondii* in commercial cuts of pork (ham, loin, rib and shoulder) through bioassay and PCR in experimentally inoculated animals; the bioassay test was more sensitive than PCR (Tsutsui et al., 2007).

The first report of the detection of *T. gondii* DNA was conducted in the 1980s by Burg et al. (1989) using the B1 gene. Since then, studies have been performed with tissues such as brain, cardiac and skeletal muscle, and liver (Esteban-Redondo and Innes, 1998; Argassi et al., 2011) as well as blood (Spalding et al., 2003) for identification of the parasite using PCR.

Samples of brain, tongue, and liver and from neck, intercostal and femoral muscle from 78 sheep and goats were tested in Iran using nested PCR, and the researchers detected *T. gondii* DNA in 21.8% of the tongue, 19.2% of the brain and 17.9% of the muscle tissue samples. The data confirmed the high rate of toxoplasmosis infection in small ruminants in the country. In addition, the researchers warned the population after studying the infection of the human population in the region by the parasite (Argassi et al., 2011).

Hematological and biochemical parameters, although not conclusive, can assist in the diagnosis of *T. gondii*. However,

studies of these parameters in sheep naturally infected with *T. gondii* are scarce in the literature consulted (Silva et al., 2011). The data published for sheep indicate that chronic parasitism influences changes in hematological and biochemical parameters, primarily lymphopenia, neutrophilia and decreased values of alanine transaminase (ALT).

The diagnosis of *T. gondii* infection using histopathology and immunohistochemistry (IHC) testing for the identification of the parasite and about its being widely used for the diagnosis of *T. gondii* will be discussed separately in the wake of this review.

Anatomo-histopathological and immunohistochemical aspects

Immunohistochemistry combined with the clinical history and examination of any anatomo-histopathological data allows for a definitive diagnosis of *T. gondii* disease in most cases (Dagleish, Chianini and Benavides, 2010). Aborted fetuses of sheep infected with *T. gondii* have a fresh appearance and are autolyzed and/or mummified. Necrotic lesions are considered rare and abortion in sheep occurs between 60 to 120 days of gestation in 70% of cases (Pereira-Bueno et al., 2004).

The tissue cysts of *T. gondii* may develop to various sizes (70-100 μm) and have been visualized in the histopathology of

mononuclear inflammatory infiltrates both focally and multifocally. Nevertheless, it was not possible to observe the parasitic cysts of *T. gondii* in these tissues (Silva et al., 2013).

In Rio Grande do Sul, Brazil, ovine fetuses that were seropositive for toxoplasmosis showed histopathological changes characterized by severe congestion in the brain as well as areas of malacia with the presence of tachyzoites. In the lung, we found extensive areas of atelectasis, lymphocytic interstitial pneumonia, and fibrinous interalveolar exudates. In addition, congestion and focal centrilobular necrosis have been reported in the liver, while in the heart, focal lymphocytic myocarditis was found (Motta et al., 2008). Buxton (1990) reported on the microscopic examination of the brains of sheep, finding focal gliosis surrounded by necrotic cells and the mineralization associated with meningitis. Pereira-Bueno et al. (2004) described non-suppurative myocarditis and encephalomyelitis in fetal sheep, in addition to multifocal interstitial hepatitis.

Figure 2 illustrates histopathological tissue sections of liver and heart from sheep naturally infected with anti-*T. gondii* antibodies. In Figure 2A, a mild focal neutrophilic infiltration of the liver can be observed, whereas in Figure 2B, in lung tissue, an inflammatory infiltrate of mononuclear cells and congestion, changes that are commonly found in infections by *T. gondii* in sheep and other species, can be observed (Motta et al., 2008; Dubey, 2010; Silva et al., 2013).

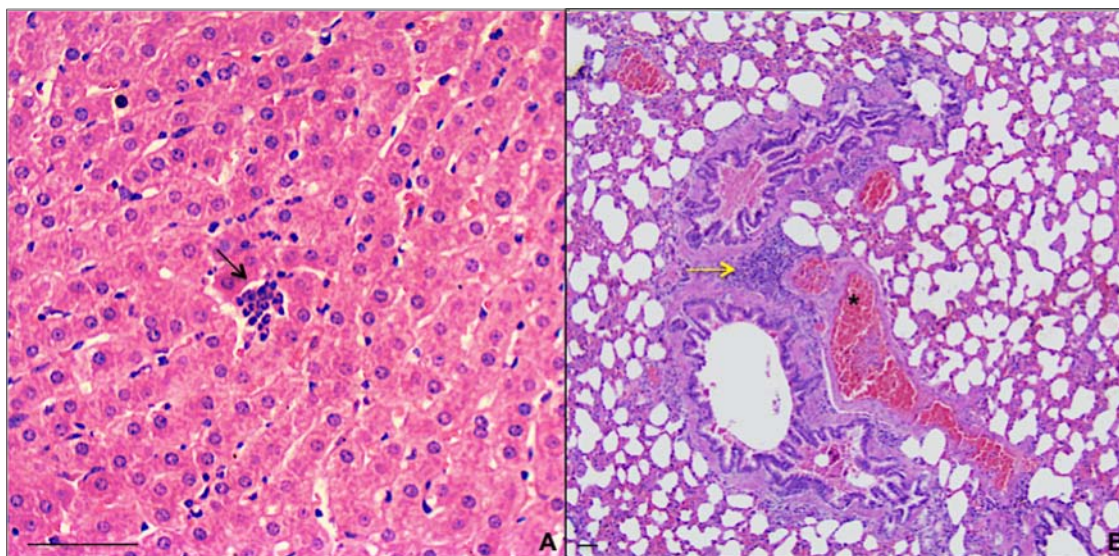


Figure 2: Liver and lung of sheep seropositive for anti-*T. gondii* antibodies. In A - Liver with mild focal neutrophilic inflammatory infiltrate (black arrow) and B - Lung with mononuclear inflammatory infiltrate (yellow arrow) and congestion (*) (H&E). Bar 50 μm .

tissues of the lung, liver and kidney, but they are most easily found in muscle and neural tissue, including the brain, eyes, heart and skeletal muscle (Dubey, 2010). Although cysts are "visualized" microscopically in the tissues of infected animals, several researchers have reported difficulty in finding cysts using histopathology (Motta et al., 2008; Silva et al., 2013).

In Rio de Janeiro, Brazil, a survey conducted using 26 sheep seropositive for *T. gondii* and slaughtered for human consumption, examined cardiac tissue, lung, kidney, brain, liver and muscle tissue histopathologically and found areas of congestion ranging from mild to moderate, followed by polymorphonuclear and

Sheep infected with *T. gondii* may demonstrate evidence for antigens to anti-*T. gondii* using IHC on sections of liver, heart and brain. In these organs, the immunoreaction can be found around blood vessels and in some cases within them, as well as in parenchymal cells, which exhibit a rounded shape (Silva et al., 2013).

According to a study conducted in sheep seropositive for anti-*T. gondii* antibodies, when titers higher than 1:50 are detected by the MAT, it is not necessary to choose any specific organ for detecting the parasite with IHC because the distribution of the parasite is random. However, if an animal exhibits a titer \leq

1:50, cardiac tissue should be preferentially selected because the chances of finding the parasite will be higher (Silva et al., 2013). The liver appears to be a good choice for organ detection of *T. gondii* in sheep using IHC (Silva et al., 2013), as well as the brain (Motta et al., 2008), lung and heart (Benavides et al., 2011).

As mentioned previously, IHC assists in the definitive diagnosis of the disease (Dagleish, Chianini and Benavides, 2010). Therefore, it is important to send an appropriate sample to the laboratory for the diagnosis to be as accurate as possible.

In the immunohistochemical reaction in Figure 3, as described in Figure 3A, it stained positive for the anti-*T. gondii* antigen in sections from the brain, while in Figure 3B, it was from the liver. In these images, the immunoreaction exhibits a round shape, while in the brain a marking was observed around the blood vessels and in some cases within them.

Janeiro, Bahia-Oliveira et al. (2003) and Ribeiro et al. (2008) conducted epidemiological studies to search for anti-*T. gondii* antibodies in humans and they found prevalences of 84% and 75%, respectively.

The city of Erechim, Rio Grande do Sul, Brazil, is noteworthy because it has been cited as one of the cities with the highest prevalence of infection by *T. gondii* in humans (Silveira et al., 2001). In Paraná, an outbreak of acute toxoplasmosis was diagnosed after the ingestion of raw sheep meat by 17 people at a party (Bonametti et al., 1997). These studies demonstrate the importance of diagnosis of the parasite because sheep meat is consumed in various regions of Brazil and the world, and this constitutes a risk for the population that consumes sheep meat, where the meat is not inspected or where control and hygiene standards are not adopted, because it is a zoonosis.

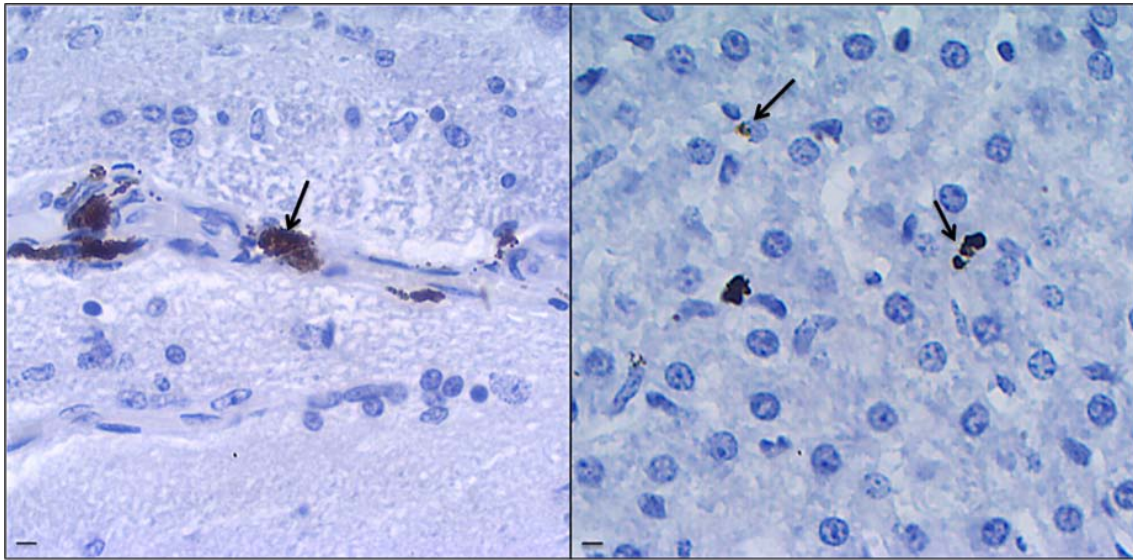


Figure 3: Immunostained sections of different tissues from sheep seroreactive for *Toxoplasma gondii*. A- Brain showing immunoreactivity of the anti-*T. gondii* antigen (arrow) and in B, in liver tissue (arrow). Bar 20 μ m.

Zoonosis

The agent *T. gondii* was isolated in humans for the first time by Wolf et al. (1939). Since then, toxoplasmosis infection has been considered to be the most cosmopolitan of all zoonosis (Silva et al., 2003) because infection varies greatly from region to region (Dubey, 2010).

The clinical spectrum of *T. gondii* infection varies from an asymptomatic state to severe illness. The parasite can affect the host's lymph nodes, eyes, central nervous system, liver, and heart (Alvarado-Esquivel et al., 2011). Primary infections with *T. gondii* acquired during pregnancy are usually asymptomatic for the pregnant woman but can lead to serious neonatal complications. Screening of *T. gondii* infections during antenatal care should be considered as the main strategy to minimize congenital toxoplasmosis (Mwambe et al., 2013).

Studies of the seroprevalence of *T. gondii* in humans have been described in over eighty countries (Dubey, 2010) with prevalences ranging from 4% in Korea (Ryu et al, 1996) to 92% in pregnant women in the State of Mato Grosso in west-central Brazil (Figueiró-Filho et al., 2005). In the State of Rio de

Prevention and control measures

Diagnosis by means of laboratory tests, when it is rapid and reliable, can be a control measure because it confirms the toxoplasmosis infection in the herd and can be implemented to reduce the impact of infection and protect the economic viability of the livestock (Dubey, 2010).

A study conducted in the U.S. in the early 1990s with pigs revealed that when cats are removed from direct contact with animals, the chances of infection by *T. gondii* decreased (Dubey et al., 1995).

Until now, it has been considered to be impossible to eradicate toxoplasmosis in an infected host, mainly because the parasite is obligatorily intracellular and rapidly encysts, which makes the entry of anti-parasitic drugs difficult (Velarde et al., 2009). There is a live vaccine on the market for less cystogenic sheep that reduces neonatal mortality rates (Buxton and Innes, 1995; Wilkins & O'Connell, 1983).

Freezing meat in a domestic freezer for at least one night before consumption by animals and/or humans seems to be an easy and economical method for reducing the chances of transmission of *T. gondii* (Dubey, 2008a).

Disinfectants can be used to destroy *T. gondii*, however, there are few options, including ethanol and acetic acid (concentration 95%/5% for 24 h) and ammonium hydroxide (5% for 30 min) (Dubey, Miller and Frenkel, 1970). Another way to destroy the oocysts is by high pressure processing (Lindsay et al., 2008).

It is very important that doctors, veterinarians and people working in the health and environmental industries work together for the development of control strategies, new therapies and effective vaccines for the control of *T. gondii* infection in animals, peoples and, especially in cats (Innes, 2010). In addition, education and public health programs are fundamental to disease control (Foulon, 1992).

Control measures and prevention are essential for the control of toxoplasmosis in humans and animals, thus avoiding

unnecessary losses and outbreaks caused by lack of sanitary management for animals.

Conclusion

Although some of the mysteries concerning the transmission of *T. gondii* have been resolved, we cannot forget that a parasite is very "intelligent" and that the prevention of oocysts shed by "street cats" is not easy (Dubey, 2009). It is noteworthy that what must be accomplished is the raising of awareness in people so that there is a more efficient control of infections by *T. gondii*, not only in sheep but also in other species. Early diagnosis is also an important factor, as it can prevent infections in sheep, because it is a sexually transmitted disease. Apart from that, avoiding the consumption of meat if it is infected with the parasite will minimize the risk of transmission.

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