



Seroprevalence of *Toxoplasma gondii* infection in domestic goats in Durango State, Mexico

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ABSTRACT

Little is known concerning the seroprevalence of *Toxoplasma gondii* infection in goats in Mexico. Antibodies to *T. gondii* were determined in 562 goats in Durango, Mexico using the modified agglutination test. Goats were raised in 12 farms in two geographical regions: semi-desert ($n = 70$) and mountains ($n = 492$). Overall, antibodies to *T. gondii* were found in 174 (31%) of 562 goats, with titers of 1:25 in 18, 1:50 in 12, 1:100 in 10, 1:200 in 30, 1:400 in 32, 1:800 in 40, 1:1600 in 17, and 1:3200 or higher in 15. Seroprevalence of *T. gondii* increased with age, and varied with breed and geographic region; goats raised in the semi-desert region (Nubian breed) had a significantly higher seroprevalence (32.7%) than those raised in the mountains (mixed breed) (18.6%). Seropositive goats were found in all 12 (100%) farms sampled. This is the first report of *T. gondii* infection in goats in Durango State, Mexico. Results indicate that infected goats are likely an important source of *T. gondii* infection in humans in Durango State.

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1. Introduction

Infections with *Toxoplasma gondii* in domestic goats (*Capra hircus*) occur widely around the world (Dubey, 2010). Toxoplasmosis is an important cause of caprine abortions and the ingestion of undercooked meat and unpasteurized milk from infected goats could be source of infection in humans (Dubey, 2010). The ingestion of unpasteurized goat milk was linked epidemiologically to serious illness in humans (Sacks et al., 1982; Chiari and Neves, 1984; Skinner et al., 1990).

We have been studying the epidemiology of *T. gondii* infections in humans (Alvarado-Esquivel et al., 2009, 2010, 2011) and other animals in Durango State, México

(Alvarado-Esquivel et al., 2007, 2011, in press; Dubey et al., 2007, 2009). Information regarding *T. gondii* infection in goats in Durango State, Mexico is lacking. Meat of goat is widely consumed in Mexico, and a number of typical Mexican dishes are made of this meat. In addition, unpasteurized goat milk and its products are consumed in Mexico. Therefore, we sought to determine the seroprevalence of *T. gondii* infection in goats raised in two geographical regions in Durango State, Mexico.

2. Materials and methods

2.1. Goats surveyed

Five hundred and sixty two domestic goats were sampled from 12 farms in two municipalities of Durango State (Table 1) in January 2011. The number of goats per farm

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Table 1
Seroprevalence of *T. gondii* infection in domestic goats in Durango.

Region	Municipality	Farms surveyed	Goats tested No.	Seroprevalence of <i>T. gondii</i> infection	
				No.	%
Semi-desert	Simón Bolívar	SB-1	108	36	33.3
		SB-2	31	13	41.9
		SB-3	25	2	8
		SB-4	50	9	18
		SB-5	57	24	42.1
		SB-6	143	49	34.3
		SB-7	13	7	53.8
		SB-8	33	8	24.2
		SB-9	32	13	40.6
		All	492	161	32.7 ^a
Mountains	Pueblo Nuevo	PN-1	42	4	9.5
		PN-2	20	6	30
		PN-3	8	3	38
		All	70	13	18.6
All		562	174	31	

^a Significantly higher seroprevalence in goats in the semi-desert region than those in the mountainous region ($P=0.02$).

ranged from eight to 143 (median 32.5). Nine farms were located in the municipality Simón Bolívar in the semi-desert region and three farms in the municipality Pueblo Nuevo in the mountains region. Goats from the semi-desert region ($n=492$) were mixed breed, and aged 10–72 (median 48) month old. These goats included 478 (97.2%) females and 14 (2.8%) males. Goats from the mountains were pure breed (Nubian), and aged seven to 48 (median 24) months old. These goats included 67 (95.7%) females and three (4.3%) males.

2.2. Serological examination

Blood samples were transported to the laboratory on the day of collection. Sera were collected from whole blood by centrifugation and stored at -20°C until tested. Goat sera were tested for *T. gondii* antibodies using twofold serial dilutions from 1:25 to 1:3200 with the modified agglutination test (MAT) as described by Dubey and Desmonts (1987). A titer of 1:25 was used as cut-off for seropositivity in MAT. The antigen was prepared at the Laboratory of Parasitology, National Reference Centre on Toxoplasmosis (Reims, France), as described by Desmonts and Remington (1980).

2.3. Statistical analysis

Statistical analysis was performed using Epi Info software version 3.5.1 (Centers for Disease Control and Prevention: <http://wwwn.cdc.gov/epiinfo/>). The Yates' corrected Chi square test was used for comparison of the frequencies among groups. We used this test to prevent overestimation of statistical significance for small data. A P value of <0.05 was considered statistically significant.

3. Results

Overall, antibodies to *T. gondii* were found in 174 (31%) of 562 goats, with titers of 1:25 in 18, 1:50 in 12, 1:100 in 10, 1:200 in 30, 1:400 in 32, 1:800 in 40, 1:1600 in 17,

and 1:3200 or higher in 15. Seropositive goats were found in all 12 (100%) farms sampled. In goats from the semi-desert, antibodies to *T. gondii* were found in 161 (32.7%) of 492 goats, with titers of 1:25 in 10, 1:50 in 10, 1:100 in 9, 1:200 in 30, 1:400 in 31, 1:800 in 40, 1:1600 in 17, and 1:3200 or higher in 14. In goats from the mountains, antibodies to *T. gondii* were found in 13 (18.6%) of 70 goats, with titers of 1:25 in eight, 1:50 in two, 1:100 in one, 1:400 in one, and 1:3200 in one. A significantly ($P=0.02$) higher seroprevalence of *T. gondii* infection was observed in goats raised in the semi-desert region (32.7%) than those from the mountains region (18.6%) (Table 1). Seropositivity to *T. gondii* in goats increased significantly ($P=0.04$) with age (Table 2). The seroprevalence of *T. gondii* infection was significantly ($P=0.02$) higher in mixed (32.7%), than in pure breed (18.6%) goats.

4. Discussion

In the present study seropositive goats were found on all 12 farms in two municipalities. The municipality of Simon Bolívar explored in this study belongs to the "Laguna region" which is the most important region for production of goat milk in Mexico. This Laguna region use to have around 450,000 goats and produces more than 3000 tons of meat and more than 45 million liters of goat milk yearly (http://w4.siap.gob.mx/sispro/IndModelos/PRector/33_RLA/PE.Caprinos.pdf). We found that the seroprevalence of *T. gondii* varied with geographic region and breed. It is not clear why goats raised in the semi-desert region (Nubian breed) had a significantly higher seroprevalence than those raised in the mountains (mixed breed). Goat herds in Durango are raised free-range and are moved frequently from one pastureland to the other in search for food. However, goats from the semi-desert region may graze in a larger area than those in the Mountains and this behavior might increase the probability for exposure to *T. gondii*. Although we have not tested feral cats for exposure to *T. gondii*, antibodies to *T. gondii* were found in 21% of 105 (Alvarado-Esquivel et al., 2007) and 9.3% of 150 (Dubey

Table 2
General characteristics of the 562 goats studied and seroprevalence of *T. gondii* infection.

Characteristics	Goats tested No.	Seroprevalence of <i>T. gondii</i> infection		P value
		No.	%	
Age (months)				
7–12	12	5	41.7	0.04
18	17	4	23.5	
24	89	18	20.2	
30	46	13	28.3	
36	135	34	25.2	
40	6	2	33.3	
48	117	45	38.5	
60	124	45	36.3	
72	16	8	50	
Gender				
Male	17	6	35.3	0.89
Female	545	168	30.8	
Breed				
Pure	70	13	18.6	0.02
Mixed	492	161	32.7	

et al., 2009) domestic cats from Durango, Mexico. These seropositive cats would have shed oocysts in the environment. Concerning breed, pure bred goats are likely to have low parasite exposure because they receive better care than the mixed breed goats, and better hygiene may contribute to reduce the risk of *T. gondii* infection.

Two previous seroprevalence studies in goats in Mexico have been reported. However, in those previous studies assays other than MAT were used. García-Vázquez et al. (1990) studied 211 goats from two states (San Luis Potosi and Morelos) in central Mexico, and found a 44% seroprevalence using indirect fluorescent antibody assay. In the second study, the same research group analyzed sera of 707 goats from nine farms, and found that five of the nine farms had seropositive goats and the average seroprevalence was 3.2% by enzyme-linked immunosorbent assay (García-Vázquez et al., 1993). Worldwide prevalence of *T. gondii* infection in goats was recently reviewed by Dubey (2010). Since then, Chikweto et al. (in press) reported *T. gondii* antibodies in 42.8% of 180 goats from Grenada and Carriacou, West Indies by using MAT. Anderlini et al. (2011) found antibodies in 39% of 454 goats from Alagoas, Brazil using an indirect immunofluorescence antibody test.

In the present study, we might have underestimated the prevalence of *T. gondii* using a cut-off of 1:25 because viable *T. gondii* has been isolated from 2 goats with MAT titers of <1:10 (Dubey et al., 2011). Ragozo et al. (2009) isolated viable *T. gondii* from tissues of 12 of 26 seropositive (MAT, 1:25 or higher) goats from Brazil. Mercier et al. (2010) isolated *T. gondii* from 10 goats from Dienga, Gabon, Africa; these goats had MAT titers of 1:800. Although there is no proper validation of MAT for the detection of *T. gondii* antibodies in goats these bioassay studies suggest the specificity of MAT.

In the present study, the youngest goats found to be seropositive were seven month old and thus would have lost their colostrally derived antibodies. In general seropositivity increased with age of the goat indicating post-natal exposure to *T. gondii* oocysts.

We conclude that seropositivity to *T. gondii* is common among goats in farms in Durango. Although, we did not test milk or meat from goats in the present study, viable *T. gondii* has been isolated from naturally infected goat meat by others (Ragozo et al., 2009; Dubey et al., 2011), and *T. gondii* has been isolated from milk of experimentally infected goats (Dubey, 1980), indicating that goats can be source of *T. gondii* infection for humans. This is the first seroprevalence study of *T. gondii* infection in goats in Durango State, Mexico.

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