Seroprevalence of Toxoplasma gondii in goats in Hunan province, China

Fen Li1,2,3, Shi-Ping Wang1, Chang-Jian Wang4, Shi-Cheng He4, Xiang Wu2, and Guo-Hua Liu2,3,*

1 Xiangya School of Medicine, Central South University, Changsha, Hunan province 410013, PR China
2 College of Veterinary Medicine, Hunan Agricultural University, Changsha, Hunan province 410128, PR China
3 Hunan Co-Innovation Center of Animal Production Safety, Changsha, Hunan province 410128, PR China
4 Animal Disease Prevention and Control Center of Hunan province, 410001, PR China

Received 21 July 2016, Accepted 29 September 2016, Published online 20 October 2016

Abstract – Toxoplasma gondii infections are prevalent in animals and humans worldwide. In the present investigation, the seroprevalence of T. gondii in goats was investigated in Hunan province, subtropical China between March 2014 and December 2015. A total of 1,028 serum samples collected from 14 administrative regions of Hunan province were evaluated by the indirect hemagglutination test (IHAT) for the detection of specific antibodies. Antibodies to T. gondii were detected in 124 serum samples (12%). The T. gondii seroprevalence ranged from 1.7% to 19% among different regions in subtropical China, and the differences were statistically significant (p < 0.01). The results of the present survey indicated that T. gondii infection is prevalent in goats in Hunan, which poses a potential risk for human infection with T. gondii in this province.

Key words: Toxoplasma gondii, Seroprevalence, Goats, Indirect hemagglutination assay, Subtropical China.

Résumé – Séroprévalence de Toxoplasma gondii chez les chèvres dans la province du Hunan, Chine. Les infections par Toxoplasma gondii sont répandues chez les animaux et les humains dans le monde entier. Dans la présente enquête, la séroprévalence de T. gondii chez les chèvres a été étudiée dans la province du Hunan, en Chine subtropicale, entre mars 2014 et décembre 2015. Un total de 1028 échantillons de sérum prélevés dans 14 régions administratives de la province du Hunan ont été évalués par le test d’hémagglutination indirecte (IHAT) pour la détection d’anticorps spécifiques. Les anticorps dirigés contre T. gondii ont été détectés dans 124 échantillons de sérum (12%). La séroprévalence de T. gondii a varié de 1.7% à 19% entre les différentes régions en Chine subtropicale, et les différences étaient statistiquement significatives (p < 0.01). Les résultats de la présente étude indiquent que l’infection par T. gondii est très répandue chez les chèvres dans le Hunan, ce qui pose un risque potentiel pour l’infection humaine par T. gondii dans cette province.

Introduction

Toxoplasmosis is a zoonotic parasitic disease caused by Toxoplasma gondii, which infects humans and has a worldwide distribution [20]. It has been estimated that approximately one third of the world’s population has been infected with T. gondii [8]. It may cause abortion in pregnant women or occasionally toxoplasmic encephalitis or even death in patients with immune-suppression diseases like AIDS, although almost all infected people are asymptomatic [5]. In addition, T. gondii can also infect almost all warm-blooded animals [15].

In goats, the main clinical signs of toxoplasmosis are abortion and perinatal death, causing huge economic losses to the goat industry worldwide [1, 4]. In spite of the high seroprevalence of T. gondii reported in goats around the world [3, 6, 10], little information is available on the seroprevalence of T. gondii in goats in China [9, 18, 19, 21]. In the People’s Republic of China, the goat industry constitutes a large agricultural sector and is important in economic development. In addition, in China, goat meat is the most widely produced and consumed meat. Hunan province is one of the largest producers of goats in China. Although T. gondii infection causes major economic losses in goats, its prevalence in subtropical China might be underestimated and neglected. It has yet to be determined whether T. gondii infection is present in goats...
in Hunan province, subtropical China. Therefore, investigation of T. gondii infection in goats has important implications for the prevention and control of T. gondii infection in animals and humans in this province of subtropical China.

Given this background and the zoonotic significance of T. gondii, the objective of the present investigation was to examine the seroprevalence (animals-level) of T. gondii infection in goats in Hunan province. The results should provide a foundation for the implementation of control strategies against T. gondii infection in goats in this province and elsewhere.

**Materials and methods**

Hunan province is situated in the central eastern part of mainland China, between the northern latitudes of 24°38′–30°08′ and eastern longitudes of 108°47′–114°15′. The surface area is 211,800 square km, with a population of more than 71 million. Hunan’s climate is subtropical: January temperatures average 3–8 °C while July temperatures average around 27–30 °C. The average annual rainfall ranges from 1,200 to 1,700 mm. Hunan province is divided into 14 administrative regions (cities), with the city of Changsha as its capital.

A total of 1,028 blood samples were collected from 54 intensive farms in Hunan province between March 2014 and December 2015. The numbers of goats reared on each farm ranged from approximately 100 to 1,000. The serum samples were collected in the field and were then centrifuged at 1,000 g for 10 min, and the serum was collected, frozen, and stored at −20 °C until it was assayed.

Serum samples were tested for antibodies against T. gondii by the indirect hemagglutination test (IHAT) viable kit (NY/T 573-2002, Lanzhou Veterinary Research Institute, Chinese Academy of Agricultural Sciences) according to the manufacturer’s instructions. The kit is commercially available and has been used for many years in China to detect specific antibodies to T. gondii in goats and other mammals [7, 11, 13, 17]. The serum samples were identified as positive if an agglutination reaction was seen in wells with dilutions of 1:64 or higher.

A multivariable mixed-effects logistic regression model with the farm as a random effect was used. Other variables were introduced as fixed effects in the model. The data were analyzed statistically using the PASW Statistics 18 program (IBM Corporation, Somers, NY); 95% confidence intervals (CI) were given. The value of \( p < 0.05 \) was considered statistically significant in the multivariate analysis.

All animals were handled in strict accordance with good animal practices according to the Animal Ethics Procedures and Guidelines of the People’s Republic of China, and the study was approved by the Animal Ethics Committee of Central South University.

**Results and discussion**

Limited information is available for T. gondii infections in goats in China [9, 18, 19, 21]. No survey of the seroprevalence of T. gondii in goats in tropical China has been reported. IHAT is a simple technique for detecting T. gondii antibodies (IgG and IgM) and has been used extensively in many animals in China [7, 11, 13, 17]. Therefore, the present study used IHAT to detect T. gondii antibodies in goats using a commercially marketed kit.

In the present study, antibodies against T. gondii were detected in 12.1% of goats (124/1028; 95% CI: 10.1–14.1). The T. gondii seroprevalence in goats from different regions ranged from 1.7% (95% CI: 0–5.1) to 18.8% (95% CI: 10.2–27.3) (Table 1), having statistically significant differences (\( p < 0.01 \)). This seroprevalence was similar to that reported in goats in Yunnan province (11.9%) [21] and in northwestern China (14.1%) [9], but was lower than that in northeastern China (16.9%) [19] and Qinghai province (29.5%) [18]. Differences in T. gondii seroprevalence are likely due to differences in animal welfare, climates, and husbandry practices. Results of the present and previous investigations [9, 18, 19, 21] indicate that T. gondii infection is widespread in goats in China.

Female goats (12.4%; 95% CI: 10.3–14.6) had higher T. gondii seroprevalence than males (9.9%; 95% CI: 5.1–14.6) (\( p > 0.05 \)). This finding indicates that T. gondii infection is more likely in females than males. T. gondii seroprevalence in goats was higher in autumn (15.4%; 95% CI: 11.7–19.1), followed by winter (11.4%; 95% CI: 5.3–17.5), but lower in summer (11.3%; 95% CI: 8.4–14) and spring (1.4%; 95% CI: 0–4.2) (Table 2). These results suggest that T. gondii infection in goats is prevalent all year round. This is likely to be associated with the moist and warm climate in tropical China, which is favorable for survival of the oocysts [14]. The highest prevalence of T. gondii was found in goats older than 4 years (18.2%; 95% CI: 9.6–26.8), followed by goats < 1 year old (15.8%; 95% CI: 11.1–20.5). T. gondii prevalence in different ages of goats ranged from 8.3% (95% CI: 5.2–11.3) to 18.2% (95% CI: 9.6–26.8) (Table 2) (\( p > 0.05 \)). The present study indicated that age is a predisposing factor for T. gondii infection, consistent with results in other animals [12, 16]. The seroprevalence of

---

**Table 1. Seroprevalence of Toxoplasma gondii in goats in Hunan province, subtropical China.**

| Region         | No. tested | No. positive | Prevalence (%) | 95% CI    |
|----------------|------------|--------------|----------------|-----------|
| Changsha       | 52         | 3            | 5.8            | 0–12.1    |
| Zhuzhou        | 50         | 3            | 6              | 0–12.6    |
| Xiangtang      | 100        | 12           | 12             | 5.6–18.4  |
| Hengyang       | 60         | 7            | 11.7           | 3.5–19.8  |
| Shaoyang       | 90         | 12           | 13.3           | 6.3–20.4  |
| Yueyang        | 58         | 1            | 1.7            | 0–5.1     |
| Chande         | 70         | 13           | 18.6           | 9.5–27.7  |
| Zhangjiajie     | 80         | 15           | 18.8           | 10.2–27.3 |
| Yiyang         | 60         | 3            | 5              | 0–10.5    |
| Loudi          | 41         | 1            | 2.4            | 0–7.2     |
| Chenzhou       | 85         | 10           | 11.8           | 4.9–18.6  |
| Yongzhou       | 50         | 4            | 8              | 0.5–15.5  |
| Huaihua        | 50         | 9            | 18             | 7.4–28.6  |
| Xiangxi        | 182        | 31           | 17             | 11.6–22.5 |
| Total          | 1028       | 124          | 12.1           | 10.1–14.1 |

---
**T. gondii** increases with growth in goats, indicating that there may be a cumulative likelihood for exposure to **T. gondii** infection with age.

Humans can become infected by **T. gondii** through ingestion of oocyst-contaminated food, water, or undercooked meat. The present results reveal the presence of **T. gondii** infection in goats in tropical China, indicating contamination of the environment by **T. gondii** oocysts, which poses a risk of human infection with **T. gondii**. As a result, further work is required to assess whether the soil and water on goat farms or in other regions in tropical China are also contaminated by **T. gondii** oocysts [2]. In addition, toxoplasmosis can lead to abortion, stillbirth, and mummification in pregnant goats [1, 4]. However, the present dataset could not determine whether or not **T. gondii** infection can significantly increase the risk of abortion in goats in tropical China. Therefore, further studies are necessary to investigate a potential effect of **T. gondii** on reproduction in goats.

**Conclusions**

The results of the present survey indicate that **T. gondii** infection is prevalent in goats in subtropical China. Therefore, it is imperative to implement integrated control strategies and measures to prevent and control **T. gondii** infection in goats. This is the first time that infection with **T. gondii** has been reported in Hunan province.

**Acknowledgements.** This research was supported by the National Natural Science Foundation of China (Grant Nos. 31372431 and 81171597) and the Outstanding Young Scientific Research Project of the Education Department of Hunan Province (Grant No. 14B092).

**References**

1. Abu-Dalbouh MA, Ababneh MM, Giadinis ND, Lafi SQ. 2012. Ovine and caprine toxoplasmosis (**Toxoplasma gondii**) in aborted animals in Jordanian goat and sheep flocks. Tropical Animal Health and Production, 44(1), 49–54.

2. Du F, Zhang Q, Yu Q, Hu M, Zhou Y, Zhao J. 2012. Soil contamination of **Toxoplasma gondii** oocysts in pig farms in central China. Veterinary Parasitology, 187(1–2), 53–56.

3. García-Bocanegra I, Cabezón O, Hernández E, Martínez-Cruz MS, Martínez-Moreno Á, Martínez-Moreno J. 2013. **Toxoplasma gondii** in ruminant species (cattle, sheep, and goats) from southern Spain. Journal of Parasitology, 99(3), 438–440.

4. Gebremedhin EZ, Agonafir A, Tessema TS, Tilahun G, Medhin G, Vitale M, Di Marco V. 2013. Some risk factors for reproductive failures and contribution of **Toxoplasma gondii** infection in sheep and goats of Central Ethiopia: a cross-sectional study. Research in Veterinary Science, 95(3), 894–900.

5. Hill DE, Dubey JP. 2013. **Toxoplasma gondii** prevalence in farm animals in the United States. International Journal for Parasitology, 43(2), 107–113.

6. Iovu A, Györke A, Mircean V, Gavrea R, Cozma V. 2012. Seroprevalence of **Toxoplasma gondii** and **Neospora caninum** in dairy goats from Romania. Veterinary Parasitology, 186(3–4), 470–474.

7. Jiang HH, Zhang WB, Zhao L, Zhou DH, Song HQ, Xu CM, Deng SZ, Zhu XQ. 2014. Seroprevalence of **Toxoplasma gondii** infection in pigs in Jiangxi province, Southeastern China. Foodborne Pathogens and Diseases, 11(8), 362–365.

8. Liu Q, Wang ZD, Huang SY, Zhu XQ. 2015. Diagnosis of toxoplasmosis and typing of **Toxoplasma gondii**. Parasites & Vectors, 8, 292.

9. Liu ZK, Li JY, Pan H. 2015. Seroprevalence and risk factors of **Toxoplasma gondii** and **Neospora caninum** infections in small ruminants in China. Preventive Veterinary Medicine, 118(4), 488–492.

10. Lopes AP, Dubey JP, Neto F, Rodrigues A, Martins T, Rodrigues M, Cardoso L. 2013. Seroprevalence of **Toxoplasma gondii** infection in cattle, sheep, and pigs from the North of Portugal for human consumption. Veterinary Parasitology, 193(1–3), 266–269.

11. Miao Q, Wang X, She LN, Fan YT, Yuan FZ, Yang JF, Zhu XQ, Zou FC. 2013. Seroprevalence of **Toxoplasma gondii** in horses and donkeys in Yunnan province, Southwestern China. Parasites & Vectors, 6, 168.

12. Qin SY, Cong W, Liu Y, Li N, Wang ZD, Zhang FK, Huang SY, Zhu XQ, Liu Q. 2014. Molecular detection and genotypic characterization of **Toxoplasma gondii** infection in bats in four provinces of China. Parasites & Vectors, 7, 558.

13. Qian WF, Yan WC, Wang TQ, Zhai K, Han LF, Lv CC. 2015. Prevalence and genetic characterization of **Toxoplasma gondii** in pet dogs in Central China. Korean Journal of Parasitology, 53(1), 125–128.

---

**Table 2. Seroprevalence of **Toxoplasma gondii** in goats by gender, season, and age in Hunan province, subtropical China.**

| Factor | Category | No. tested | No. positive | Prevalence (%) | 95% CI |
|--------|----------|------------|--------------|----------------|-------|
| Gender | Male     | 152        | 15           | 9.9            | 5.1–14.6|
|        | Female   | 876        | 109          | 12.4           | 10.3–14.6|
| Season | Spring   | 70         | 1            | 1.4            | 0–4.2 |
|        | Summer   | 489        | 55           | 11.3           | 8.4–14 |
|        | Autumn   | 364        | 56           | 15.4           | 11.8–19.1|
|        | Winter   | 105        | 12           | 11.4           | 5.3–17.5|
| Age    | <1 year  | 228        | 36           | 15.8           | 11.1–20.5|
|        | 1 ≤ years <2 | 420 | 49 | 11.7 | 8.6–14.7|
|        | 2 ≤ years <3 | 303 | 25 | 8.3  | 5.2–11.3|
|        | ≥4 years | 77         | 14           | 18.2           | 9.6–26.8|
| Total  |           | 1028       | 124          | 12.1           | 10.1–14.1|
14. VanWormer E, Fritz H, Shapiro K, Mazet JA, Conrad PA. 2013. Molecules to modeling: Toxoplasma gondii oocysts at the human-animal-environment interface. Comparative Immunology Microbiology and Infectious Diseases, 36(3), 217–231.

15. Witkowski L, Czopowicz M, Nagy DA, Potarniche AV, Aoanei MA, Imomov N, Mickiewicz M, Welz M, Szaluś-Jordanow O, Kaba J. 2015. Seroprevalence of Toxoplasma gondii in wild boars, red deer and roe deer in Poland. Parasite, 22, 17.

16. Xu MJ, Liu QY, Fu JH, Nisbet AJ, Shi DS, He XH, Pan Y, Zhou DH, Song HQ, Zhu XQ. 2012. Seroprevalence of Toxoplasma gondii and Neospora caninum infection in dairy cows in subtropical southern China. Parasitology, 139(11), 1425–1428.

17. Xu P, Li X, Guo L, Li B, Wang J, Yu D, Zhao Q, Liu XG. 2014. Seroprevalence of Toxoplasma gondii infection in Liaoning cashmere goat from northeastern China. Parasite, 21, 22.

18. Xu P, Li X, Tang F, Liu YH, Kou X, Zhao ML, Li B, Guo L, Liu XG, Zhao Q. 2015. Seroprevalence and risk factors for Toxoplasma gondii in sheep and goats in Jinhzhou, Northeastern China. Tropical Biomedicine, 32(3), 563–567.

19. Zhao GH, Zhang MT, Lei LH, Shang CC, Cao DY, Tian TT, Li J, Xu JY, Yao YL, Chen DK, Zhu XQ. 2011. Seroprevalence of Toxoplasma gondii infection in dairy goats in Shaanxi province, Northwestern China. Parasites & Vectors, 4, 47.

20. Zhou P, Chen Z, Li HL, Zheng H, He S, Lin RQ, Zhu XQ. 2011. Toxoplasma gondii infection in humans in China. Parasites & Vectors, 4, 165.

21. Zou F, Yu X, Yang Y, Hu S, Chang H, Yang J, Duan G. 2015. Seroprevalence and risk factors of Toxoplasma gondii infection in buffaloes, sheep and goats in Yunnan province, Southwestern China. Iranian Journal of Parasitology, 10(4), 648–651.

Cite this article as: Li F, Wang S-P, Wang C-J, He S-C, Wu X & Liu G-H: Seroprevalence of Toxoplasma gondii in goats in Hunan province, China. Parasite, 2016, 23, 44.