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Seroprevalence of *Toxoplasma gondii* infection in dogs and cats in Zhenjiang City, Eastern China

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PEER REVIEW

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Comments

This study provides fundamental epidemiological background regarding the prevalence of toxoplasmosis infection in dogs and cats, and at the same time it raises the concerns about risk factors associated with human exposure. Presentation of data in this manuscript is easily understandable and I feel the flow is good. Over all, the presentation is good and appealing.
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ABSTRACT

Objective: To determine the seroprevalence of *Toxoplasma gondii* (*T. gondii*) infection in dogs and cats in Zhenjiang City, Jiangsu Province, Eastern China, and to evaluate the main associated risk factors relating to exposure to *T. gondii* in this region.
Methods: Sera from 160 dogs and 116 cats from Zhenjiang City were tested for anti-*T. gondii* antibodies using ELISA. The seropositivity by area of activity, sex and age was analyzed.
Results: Overall, 21 dogs (13.1%) and 24 cats (20.7%) had antibodies to *T. gondii*. The infection rate in stray dogs (38.7%) and cats (28.6%) was significantly higher ($P<0.05$) than in household dogs (6.9%) and cats (18.2%). The seroprevalence in male dogs (14.8%) and cats (21.05%) were slightly higher than their female counterparts (11.4% in dogs and 20.0% in cats), but were not significantly differenent ($P>0.05$). A high proportion of dogs at 3 to 6 years of age were positive to *T. gondii* (20.0%) while cats with relatively high seropositivity rates were at 0 to 1 year of age (33.3%).
Conclusions: The prevalence of *T. gondii* infection in dogs and cats in Zhenjiang City was high, which is probably the main source of *T. gondii* infection in this area.

KEYWORDS

Toxoplasma gondii, Dog, Cat, Seroprevalence, Zhenjiang, China

1. Introduction

Toxoplasma gondii (*T. gondii*) is an important zoonotic intracellular protozoan parasite, which can affect all warm-blooded mammals and birds throughout the world, including humans[1,2]. *T. gondii* is transmitted by ingestion of tissue cysts from undercooked or raw meat, consumption of food or drink contaminated with oocysts, or ingestion of oocysts from the environment by accident[2-4]. Although *T. gondii* infection rarely causes any clinical symptoms in healthy adults, it may lead to severe consequences in an immunocompromised person such as an AIDS patient or a pregnant woman[5].

Felids play a crucial role in the epidemiology of this parasitic disease because they are the only definitive host, shedding and excreting millions of infective oocysts in a short period of time in their faeces[6]. It is generally suggested that cats probably play a major role in

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transmitting *T. gondii* through environments contaminated by faeces.

T. gondii infections in dogs are important because the infection can cause serious illness in dogs. Dogs can be a transport host for *T. gondii* oocysts, and dog meat is consumed by humans in several countries[7].

Investigations of the prevalence of antibodies to *T. gondii* in dogs and cats have been conducted extensively in the world[8-15]. In recent years, there have also been various surveys of *T. gondii* infection in dogs and cats in the People's Republic of China[7,16-22]. However, little is known of *T. gondii* seroprevalence in dogs and cats in Eastern China.

The objectives of the present survey were to determine the seroprevalence of *T.gondii* infection in dogs sand cats in Zhenjiang City, Jiangsu Province, Eastern China, and to evaluate the main associated risk factors relating to exposure to *T. gondii* in this region.

2. Materials and methods

2.1. The study site

The study was conducted in Zhenjiang City, Southwestern Jiangsu Province, covering an area of 3 847 km^2 in Eastern China. Zhenjiang is situated in the lower reaches of the Yangtze River, between 118°58′ E to 119°58′ E and 31°37′ N to 32°19′ N. The city is in the monsoon climate area of north subtropical zone, with clearly-divided four seasons. Its annual average temperature is 15.6 °C, and the annual average precipitation 1 088.2 mm.

2.2. Sampling of dogs and cats

Blood samples were collected from the leg veins of dogs and cats between Janurary and December 2013 in Zhenjiang City, respectively.

Stray dogs and cats were randomly selected from the Zhenjiang animal shelter, the selected household dogs and cats were pets admitted to several veterinary clinics. Biometric data for dogs and cats, including age, sex, and lifestyle, were recorded. The analysis information regarding stray dogs and cats was estimated based on body condition and by examining dentition. The information about household dogs and cats was taken from the owners.

Blood samples were kept at 37 °C for 2 h and centrifuged at 2 000 *g* for 5 min. The resulting sera samples were stored at −20 °C until further analysis.

2.3. Determination of antibodies to T. gondii

Antibodies to *T. gondii* were determined using the commercial *T. gondii* IgG ELISA Kit (Combined Company, Shenzhen, Guangdong Province, China) according to the manufacturer's instructions. Positive and negative control sera were provided in the kit. Briefly, the *T. gondii* specific antigen was coated on a 96-well ELISA plate. After incubation of the diluted serum sample (1:100) in the test well and subsequent washing, a conjugate was added. The plate was washed again and then a chromogenic enzyme substrate was added. The optical density (OD) at 450 nm was read using a photometer (BIO-RAD, Hercules, CA, USA). A relative rate percent (IRPC) value was obtained using the following formula:

$$\text{IRPC} = \frac{\text{OD450 (sample)} - \text{mean OD450 (blank control)}}{\text{mean OD450 (negative control)} - \text{mean OD450 (blank control)}}$$

The sera were considered negative to *T. gondii* if the IRPC<2.1, and positive if IRPC>2.1.

2.4. Statistical analysis

Differences in *T. gondii* prevalence between stray and household groups, age groups, and genders were analyzed using a *Chi*-square test. Statistical analysis was performed using Statistic Package for Social Science (SPSS) 16 software for Windows (SPSS Inc., Chicago, Illinois, USA).

2.5. Ethics statement

The collection of serum samples from dogs and cats in the present study was according to the Animal Ethics Procedures and Guidelines of the People's Republic of China.

3. Results

In the present study, a total of 276 serum samples (160 dogs and 116 cats) were collected and analyzed by ELISA to detect the antibodies against the *T. gondii*.

3.1. Seroprevalence in dogs

An overall recorded seroprevalence was 13.1% in dogs. Seroprevalence in stray dogs (38.7%) was significantly higher than that in household dogs (6.9%, $P<0.001$). The seroprevalence in males was 14.8%, whereas in females, the seroprevalence was 11.4%. Although the seroprevalence in males was higher than the females, the difference was not significant ($P>0.05$). The highest prevalence of *T. gondii* infection was 20.0%, which was detected in 3-6 years old dogs (Table 1).

Table 1
Seroprevalence of *T. gondii* infection in dogs.

Variable		*n*	Positive (*n*)	Prevalence (%)
Gender	Male	81	12	14.8
	Female	79	9	11.4
Age (years)	0-1	18	2	11.1
	1-3	44	5	11.4
	3-6	40	8	20.0
	>6	58	6	10.3
Area of activity	House	129	9	6.9
	Stray	31	12	38.7
	Total	160	21	13.1

3.2. Seroprevalence in cats

In this study, the overall seroprevalence in cats was 20.70%. Although cats in both areas were infected with *T. gondii*, the seroprevalence of infection in stray cats (28.60%) was significantly higher ($P<0.05$) than that of in household cats (18.20%). The prevalence in males was 21.05%, 20.00% in females and the difference was not significant ($P>0.05$). The highest prevalence of *T. gondii* infection was 33.30%, which was detected in 0-1 year old cats (Table 2).

Table 2
Seroprevalence of *T. gondii* infection in cats.

Variable		*n*	Positive (*n*)	Prevalence (%)
Gender	Male	76	16	21.05
	Female	40	8	20.00
Age (years)	0-1	12	4	33.30
	1-3	72	12	16.70
	3-10	32	8	25.00
Area of activity	House	88	16	18.20
	Stray	28	8	28.60
	Total	116	24	20.70

4. Discussion

In the present study, the overall seroprevalence of *T. gondii* infection in dogs in Zhenjiang City was 13.1%, which was lower than that observed in Guangzhou City (21.3%) and Xuzhou City (40.3%)[23,24], higher than that observed in Lanzhou City (10.8%)[18], Sichuan Province (3.5%) and Shanghai Municipality (3.2%)[25,26], and similar to that observed in Henan Province (12.3%) in China[7].

The overall prevalence of *T. gondii* infection in cats in Zhenjiang City was 20.7%, which was higher than that reported in some other countries, such as in Peru (11.0%) and Thailand (10.1%)[8,13], higher than that in Shanghai Municipality (17.2%)[21], but lower than that observed in Guangzhou City (25.2%), Lanzhou City (21.3%), Beijing Municipality (57.8%) and Yunnan Province(25.1%) in China[20,22,27,28].

The differences in seroprevalences of *T. gondii* in dogs and cats are probably due to the differences in ecological and geographical factors, serologic tests used and the living conditions of dogs and cats.

In this study, female dogs and cats had lower prevalence than the males, although the difference was not significant ($P>0.05$). The gender thus was not significantly associated with the presence of anti *T. gondii* antibodies in the current study ($P>0.05$). This was consistent with reports from some other countries or cities[7,11,16].

Free-living animals such as stray cats, dogs, and foxes can be surveyed as indicators of the environmental spread of *T. gondii*[29]. Stray cats are especially important as they shed environmentally resistant oocysts in their feces, and they are increasing in numbers gradually. In this study, seroprevalence of *T. gondii* infection in stray dogs and cats was significantly higher than that in household dogs and cats ($P<0.05$), which was consistent with the reports from some other countries or cities[23,27,30]. Differences in their hunting habits, living conditions and animal welfare may attribute to the differences in *T. gondii* seroprevalence between household dogs and cats and stray dogs and cats.

Conflict of interest statement

We have no conflict of interest related with this report.

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Comments

Background

T. gondii is an obligate intracellular parasite that causes a pathological status known as toxoplasmosis, which has a huge impact on human and animal health. With the improvement in people's living standards and the awareness of good animal welfare, the number of pet dogs and cats has increased substantially. It's very important to estimate the prevalence of *T. gondii* in dogs and cats.

Research frontiers

Application of epidemiological surveys to evaluate the status of *T. gondii* infection with regard to the role of dogs and cats as pet animals in Zhenjiang City, Eastern China, in relation with associated risk factors.

Related reports

According to Yan *et al.* 2012, Zhang *et al.* 2010, Wu *et al.* 2011, Li *et al.* 2012, Qian *et al.* 2012, and Tian *et al.* 2014, surveys have been carried out to determine the status of toxoplasmosis in dogs and cats, but more surveys are required considering the environmental variations in countries like China.

Innovations & breakthroughs

The location targeted in this study, economically is one of the fastest growing cities in China. The popularity of pets, especially dogs and cats is rising; concerns about zoonotic diseases like toxoplasmosis are likely to be encountered. In this study the authors addressed the risk factors associated with the prevalence of *T. gondii* infection in dogs and cats for the first time in that area, which has reflected important information about the disease.

Applications

As an important zoonotic disease, with a life cycle that involves many species of hosts, this study targeted two of the most important hosts, dogs and cats. Such studies have provided significant epidemiological information that would help evaluate the status of toxoplasmosis.

Peer review

This study provides fundamental epidemiological background regarding the prevalence of toxoplasmosis infection in dogs and cats, and at the same time raises the concerns about risk factors associated with human exposure. Presentation of data in this manuscript is easily understandable and I feel the flow is good. Over all, the presentation is good and appealing.

References

[1] Zhou P, Chen Z, Li HL, Zheng H, He S, Lin RQ, et al. *Toxoplasma gondii* infection in humans in China. *Parasit Vectors* 2011; **4**: 165.

[2] Dubey JP. *Toxoplasmosis of animals and humans*. 2nd ed. Boca Raton: CRC Press; 2010.

[3] Dubey JP. Toxoplasmosis-a waterborne zoonosis. *Vet Parasitol* 2004; **126**(1-2): 57-72.

[4] Dehkordi FS, Borujeni MR, Rahimi E, Abdizadeh R. Detection of *Toxoplasma gondii* in raw caprine, ovine, buffalo, bovine, and camel milk using cell cultivation, cat bioassay, capture ELISA, and PCR methods in Iran. *Foodborne Pathog Dis* 2013; **10**(2): 120-125.

[5] Dubey JP, Jones JL. *Toxoplasma gondii* infection in humans and animals in the United States. *Int J Parasitol* 2008; **38**(11): 1257-1278.

[6] Dubey JP, Prowell M. Ante-mortem diagnosis, diarrhea, oocyst shedding, treatment, isolation, and genetic typing of *Toxoplasma gondii* associated with clinical toxoplasmosis in a naturally infected cat. *J Parasitol* 2013; **99**(1): 158-160.

[7] Liu Y, He G, Cheng Z, Qi Y, Liu J, Zhang H, et al. Seroprevalence of *Toxoplasma gondii* in dogs in Shandong, Henan, and Heilongjiang Provinces, and in the Xinjiang Uygur Autonomous Region, People's Republic of China. *J Parasitol* 2012; **98**(1): 211-212.

[8] Cerro L, Rubio A, Pinedo R, Mendes-de-Almeida F, Brener B, Labarthe N. Seroprevalence of *Toxoplasma gondii* in cats (*Felis catus*, Linnaeus 1758) living in Lima, Peru. *Rev Bras Parasitol Vet* 2014; **23**(1): 90-93.

[9] Nguyen TT, Choe SE, Byun JW, Koh HB, Lee HS, Kang SW. Seroprevalence of *Toxoplasma gondii* and *Neospora caninum* in dogs from Korea. *Acta Parasitol* 2012; **57**(1): 7-12.

[10] Rosypal AC, Hill R, Lewis S, Braxton K, Zajac AM, Lindsay DS. *Toxoplasma gondii* and *Trypanosoma cruzi* antibodies in dogs from Virginia. *Zoonoses Public Health* 2010; **57**(7-8): e76-e80.

[11] Langoni H, Fornazari F, da Silva RC, Monti ET, Villa FB. Prevalence of antibodies against *Toxoplasma gondii* and *Neospora caninum* in dogs. *Braz J Microbiol* 2013; **44**(4): 1327-1330.

[12] Cedillo-Peláez C, Díaz-Figueroa ID, Jiménez-Seres MI, Sánchez-Hernández G, Correa D. Frequency of antibodies to *Toxoplasma gondii* in stray dogs of Oaxaca, México. *J Parasitol* 2012; **98**(4): 871-872.

[13] Sukhumavasi W, Bellosa ML, Lucio-Forster A, Liotta JL, Lee AC, Pornmingmas P, et al. Serological survey of *Toxoplasma gondii*, *Dirofilaria immitis*, feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) infections in pet cats in Bangkok and vicinities, Thailand. *Vet Parasitol* 2012; **188**(1-2): 25-30.

[14] Dubey JP, Ness SL, Kwok OC, Choudhary S, Mittel LD, Divers TJ. Seropositivity of *Toxoplasma gondii* in domestic donkeys (*Equus asinus*) and isolation of *T. gondii* from farm cats. *Vet Parasitol* 2014; **199**(1-2): 18-23.

[15] Györke A, Opsteegh M, Mircean V, Iovu A, Cozma V. *Toxoplasma gondii* in Romanian household cats: evaluation of serological tests, epidemiology and risk factors. *Prev Vet Med* 2011; **102**(4): 321-328.

[16] Duan G, Tian YM, Li BF, Yang JF, Liu ZL, Yuan FZ, et al. Seroprevalence of *Toxoplasma gondii* infection in pet dogs in Kunming, Southwest China. *Parasit Vectors* 2012; **5**: 118.

[17] Liu CW, Yang N, He JB, Mu MY, Yang M, Sun N, et al. Seroprevalence of *Toxoplasma gondii* infection in police dogs in Shenyang, Northeastern China. *Korean J Parasitol* 2013; **51**(5): 579-581.

[18] Wu SM, Huang SY, Fu BQ, Liu GY, Chen JX, Chen MX, et al. Seroprevalence of *Toxoplasma gondii* infection in pet dogs in Lanzhou, Northwest China. *Parasit Vectors* 2011; **4**: 64.

[19] Yang N, Mu M, Li H, Hu J, Gao W, Yang S, et al. Seroprevalence of *Toxoplasma gondii* infection in pet dogs in Shenyang, Northeastern China. *J Parasitol* 2013; **99**(1): 176-177.

[20] Tian YM, Huang SY, Miao Q, Jiang HH, Yang JF, Su C, et al. Genetic characterization of *Toxoplasma gondii* from cats in Yunnan Province, Southwestern China. *Parasit Vectors* 2014; **7**: 178.

[21] Wang Q, Jiang W, Chen YJ, Liu CY, Shi JL, Li XT. Prevalence of *Toxoplasma gondii* antibodies, circulating antigens and DNA in stray cats in Shanghai, China. *Parasit Vectors* 2012; **5**: 190.

[22] Wu SM, Zhu XQ, Zhou DH, Fu BQ, Chen J, Yang JF, et al. Seroprevalence of *Toxoplasma gondii* infection in household and stray cats in Lanzhou, Northwest China. *Parasit Vectors* 2011; **4**: 214.

[23] Zhang H, Zhou DH, Chen YZ, Lin RQ, Yuan ZG, Song HQ, et al. Antibodies to *Toxoplasma gondii* in stray and household dogs in Guangzhou, China. *J Parasitol* 2010; **96**(3): 671-672.

[24] Yan C, Fu LL, Yue CL, Tang RX, Liu YS, Lv L, et al. Stray dogs as indicators of *Toxoplasma gondii* distributed in the environment: the first report across an urban-rural gradient in China. *Parasit Vectors* 2012; **5**: 5.

[25] Li B, Zhong N, Peng W, Shang L, Jin H, Liu Q. Seroprevalence of *Toxoplasma gondii* infection in dogs in Sichuan Province, Southwestern China. *J Parasitol* 2012; **98**(1): 209-210.

[26] Wang Q, Jiang W, Chen YJ, Jing ZY. Prevalence of *Toxoplasma gondii* antibodies and DNA in dogs in Shanghai, China. *J Parasitol* 2011; **97**(2): 367-369.

[27] Zhang H, Zhou DH, Zhou P, Lun ZR, Chen XG, Lin RQ, et al. Seroprevalence of *Toxoplasma gondii* infection in stray and household cats in Guangzhou, China. *Zoonoses Public Health* 2009; **56** (9-10): 502-505.

[28] Qian W, Wang H, Su C, Shan D, Cui X, Yang N, et al. Isolation and characterization of *Toxoplasma gondii* strains from stray cats revealed a single genotype in Beijing, China. *Vet Parasitol* 2012; **187**(3-4): 408-413.

[29] Duarte A, Castro I, Pereira da Fonseca IM, Almeida V, Madeira de Carvalho LM, Meireles J, et al. Survey of infectious and parasitic diseases in stray cats at the Lisbon Metropolitan Area, Portugal. *J Feline Med Surg* 2010; **12**(6): 441-446.

[30] Haddadzadeh HR, Khazraiinia P, Aslani M, Rezaeian M, Jamshidi S, Taheri M, et al. Seroprevalence of *Toxoplasma gondii* infection in stray and household cats in Tehran. *Vet Parasitol* 2006; **138**(3-4): 211-216.