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Seroprevalence and associated risk factors of Toxocara infection in Korean, Manchu, Mongol, and Han ethnic groups in northern China

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SUMMARY

Toxocariasis is a very prevalent zoonotic disease worldwide. Recently, investigators have focused more on *Toxocara* spp. seroprevalence in humans. Information regarding *Toxocara* seroprevalence in people from different ethnic backgrounds in China is limited. For this study, blood samples were collected from a total of 802 Han, 520 Korean, 303 Manchu, and 217 Mongol subjects from Jilin and Shandong provinces. The overall *Toxocara* seroprevalence was 16·07% (14·21% Han, 20·58% Korean, 11·22% Manchu, 18·89% Mongol). Living in suburban or rural areas, having dogs at home, exposure to soil, and consumption of raw/undercooked meat were risk factors for *Toxocara* infection. Exposure to soil was identified as the major risk factor for *Toxocara* seropositivity in all of the tested ethnicities. To the best of our knowledge, this is the first report concerning *Toxocara* infection in Manchus and Mongols in China. The present study provided baseline data for effective prevention strategies of toxocariasis in northeast China and recommends improvements in personal hygiene standards to achieve this goal.

Key words: China, Korean ethnicity, Manchu ethnicity, Mongol ethnicity, seroepidemiology, *Toxocara*.

INTRODUCTION

Toxocariasis, a highly underrated and neglected disease, is caused by *Toxocara canis* and *Toxocara cati*, which are important intestinal nematodes of dogs and cats, respectively [1–4]. Of these, *T. canis* is the most common causative agent of human toxocariasis [5–8]. Humans acquire toxocariasis by accidental ingestion of embryonated *T. canis* eggs (from water or soil contaminated by infected cat/dog faeces) or encapsulated larvae (from raw/undercooked meat); toxocariasis usually does not show any symptoms [3, 9, 10]. However, there are four general manifestations of toxocariasis: covert, visceral larva migrans, ocular larva migrans and neurotoxocariosis. Once the infective *T. canis* larvae are ingested, the helminths migrate into internal organs, which may lead to severe illnesses including neurotoxocarosis, visceral larva migrans, and eosinophilic meningoencephalitis [1, 2, 5, 6, 11–14].

Toxocariasis is of increasing concern because of the increasing numbers of pet and stray dogs. Indeed, with the improvement in the standard of living, increasing numbers of people are acquiring pet dogs, which are

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potentially important sources of *T. canis* infections [10, 15, 16]. In addition to the high resistance of *T. canis* eggs to harsh environmental conditions, pet dogs have increased the risk of this infection in humans. Consequently, investigators have focused more on the global seroprevalence of *Toxocara* spp. in humans [10, 13, 17–22]. There are 56 ethnicities in China [23]. However, information concerning *T. canis* seroprevalence in different ethnic groups is limited. To our knowledge, *Toxocara* infection has been reported in several groups: children in Sichuan (11·49%) [24], Shandong, and Jilin provinces (19·3%) [3]; clinically healthy individuals, pregnant women and psychiatric patients in Shandong Province (12·25%) [6]; and asthma patients in Nanjing City [25], but these studies were only related to the Han and Korean ethnic groups.

Because of the possible impact of different cultural backgrounds, customs, and habits, investigation of the risk factors of seroprevalence of *T. canis* infection in different ethnic groups is essential. Most Koreans in China live in Yanbian Korean Autonomous Prefecture, Jilin Province. Dog meat is a popular food for Koreans and is usually eaten either well cooked or raw. Inner Mongolia and northeast China are the most common residences of Mongols. Although Mongols have adapted to modern society, the characteristics that drive people to migrate to where there is water and grass are more or less maintained in this ethnic group. The Han ethnic group is the largest population group in China. Some Hans live together with other ethnic groups and have adopted similar living and dietary habits. For example, in rural areas of northeast China, some Hans also like to eat raw/uncooked meat and drink untreated well or river water. Manchus are now living across the country with similar diets and culture to the Hans. The present study aims to estimate the *T. canis* seroprevalence in four main ethnic groups (Han, Manchu, Mongol, Korean) in Jilin and Shandong provinces (northeastern and eastern China) and assess the risk factors associated with infection in these ethnic groups. This study will provide useful baseline information for planning effective prevention and control of *T. canis* infection in different ethnic groups in China.

MATERIALS AND METHODS

Sample collection and laboratory tests

This study was approved by the Ethics Committee of Jilin Agricultural University (Approval No. JAUAEC2013-003). A total of 1842 blood samples were collected from Han ($n = 802$), Korean ($n = 520$), Manchu ($n = 303$), and Mongol ($n = 217$) subjects in Jilin and Shandong urban and rural areas by medically trained staff between June 2013 and August 2015. The purpose and procedures of the study were explained to all participants, and written informed consent was obtained from each of them. Volunteers/guardians provided informed consent on behalf of all child participants. The sera were collected with agreement from the volunteers. Blood samples (5 ml) were taken from the elbow vein of each participant using a plain tube. Serum samples were separated by centrifuging at 4000 rpm for 8 min. The sera were collected in Eppendorf tubes and stored at 4 °C for 24–72 h until transportation in an ice box to the Laboratory of Veterinary Parasitology, College of Animal Science and Technology, Jilin Agricultural University, Changchun, Jilin Province, where they were kept at −20 °C until analysed.

Serological tests

All the serum samples were tested for *Toxocara* IgG antibodies using a commercially available enzyme immunoassay *Toxocara* kit (Diagnostic Automation Inc., USA). The positive and negative controls were supplied in the kit and used in each test. When the absorbance reading was $\geqslant 0{\cdot}3$ OD units, the sample was considered to be positive. Doubtful samples were retested. All the operations were performed according to the manufacturer's instructions [6, 13].

Statistical analysis

The variation in seroprevalence of *Toxocara*-infected participants (y) of different variables including age ($x1$), gender ($x2$), residential place ($x3$), residential area ($x4$), ethnicity ($x5$), cat at home ($x6$), dog at home ($x7$), water sources ($x8$), consumption of raw/undercooked meat ($x9$), and exposure to soil ($x10$) were analysed by χ^2 test using SAS version 9.1 (SAS Institute Inc., USA). Each variable was included in a binary logic model as an independent variable by multivariate regression analysis. $P < 0{\cdot}05$ was considered statistically significant. Odds ratios (ORs) and their 95% confidence intervals (CIs) were estimated to examine the strength of the association between *Toxocara* positivity and the selected condition.

RESULTS

Seroprevalence in different ethnic groups

The overall seroprevalence of *Toxocara* in the present study was 16·07%. The seroprevalence ranged from a

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minimum of 11·22% in Manchus to a maximum of 20·58% in Koreans (Table 1). In the Han ethnic group, the seroprevalences of *Toxocara* in Weihai, Qingdao, and Changchun cities were 14·32%, 13·81%, and 14·50%, respectively (Table 1). The highest (18·75%) seroprevalence of *Toxocara* infection was found in the 30–39 years age group (Table 1). Females have a higher seroprevalence (16·67%) than males (11·35%; Table 1). In the Korean ethnic group, *Toxocara* seroprevalences were 24·42%, 15·26%, and 22·12% in Weihai, Qingdao, and Changchun cities, respectively (Table 1). Koreans aged 50–59 years had the highest (24·05%) seroprevalence (Table 1). In the Manchu ethnic group, *Toxocara* seroprevalences were 16·67%, 14·61%, and 11·49% in Weihai, Qingdao, and Changchun cities, respectively (Table 1). *T. canis* seroprevalences in Manchus living in urban and suburban/rural areas were 8·24% and 20·30%, respectively (Table 1). The seroprevalences in different age groups varied from 5·41% to 23·81% (Table 1). In the Mongol ethnic group, *Toxocara* seroprevalences in Weihai, Qingdao, and Changchun were 18·06%, 20·69% and 12·93%, respectively (Table 1). *Toxocara* seroprevalence in different age groups varied from 7·41% to 25·00% (Table 1).

Risk factor analysis

For the study populations, the effects of age, gender, city, residential area, ethnicity, cat at home, dog at home, water sources, consumption of raw/undercooked meat, and exposure to soil contaminated with *Toxocara* eggs based on seropositivity were considered in the evaluation by the forward stepwise logistic regression analysis using Fisher's scoring technique; this was described by the equation

$$y = 0{\cdot}5049 \times 4 + 0{\cdot}4729 \times 7 + 0{\cdot}3555 \times 9 + 1{\cdot}2599 \times 10 - 2{\cdot}2364.$$

Four variables, including living in suburban or rural areas, dog at home, exposure to soil, and consumption of raw/undercooked meat were found to be potential risk factors for *Toxocara* infection, for which the ORs were 1·657 (95% CI 1·209–2·272), 1·605 (95% CI 1·192–2·161), 1·427 (95% CI 1·106–1·840), and 3·525 (95% CI 2·523–4·925), respectively.

For the Han group, logistic regression analysis showed that gender (OR 1·56, 95% CI 1·04–2·35, $P = 0{\cdot}0306$), dog at home (OR 1·73, 95% CI 1·11–2·71, $P = 0{\cdot}0151$), and exposure to soil (OR 2·96, 95% CI 1·92–4·58, $P < 0{\cdot}0001$) were significantly associated with *Toxocara* infection (Table 2). Meanwhile, exposure to soil (OR 1·68, 95% CI 1·09–2·60, $P = 0{\cdot}0187$) and consumption of raw/undercooked meat (OR 1·78, 95% CI 1·16–2·74, $P = 0{\cdot}0080$) were identified as being associated with *Toxocara* infection in Koreans (Table 2). Furthermore, residential area (OR 2·84, 95% CI 1·42–5·57, $P = 0{\cdot}0023$), water sources (OR 2·94, 95% CI 1·49–5·78, $P = 0{\cdot}0013$), and exposure to soil (OR = 3·67, 95% CI 1·68–7·98, $P = 0{\cdot}0006$) were identified as the major risk factors for *Toxocara* seropositivity in Manchus (Table 2). In the present study, exposure to soil (OR 2·87, 95% CI 1·27–6·49, $P = 0{\cdot}0090$) was the only factor associated with *Toxocara* seropositivity in Mongols (Table 2).

DISCUSSION

The overall *T. canis* seroprevalence in the study populations was 16·07% (95% CI 14·39–17·75). This rate is higher than the 11·49% reported in children in Chengdu, China [24], 12·25% in clinically healthy individuals, pregnant women, psychiatric patients in Shandong Province, Eastern China [6], 6·4% in pregnant women in southern Brazil [10], 12·03% in the Roma and non-Roma populations of Eastern Slovakia [22], 15·5% in Brazilian schoolchildren [21], and 4·7% in psychiatric patients in Mexico [13]. However, the rate is lower than the 19·3% reported in children in Shandong and Jilin provinces [3], 48·4% in a large urban setting in northeast Brazil [19], 50·6% in southern Brazil [20], 40·6% in mountain aboriginal adults in Taiwan [17], and 86·75% among primary schoolchildren in the capital area of the republic of the Marshall Islands [18]. Many factors, including diagnostic methods, geographical conditions, the timing of sample collection, sample sizes, sanitation, and life style of the evaluated population, might have contributed to the differences observed in seroprevalence rates.

In the present study, Koreans showed the highest *T. canis* seroprevalence of the four ethnic groups studied, but the differences in the rates were not statistically significant in different ethnic groups ($P > 0{\cdot}05$). However, this result is in contrast with the findings of a previous study in which Koreans were reported to have lower seroprevalence than Hans [6]; this difference could be attributed to the different sample sizes, different sampling times, and individual ethnic differences.

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Table 1. *Socio-demographic and risk factors associated with* Toxocara *seropositivity in different ethnic groups*

	Han ethnicity				Korean ethnicity				Manchu ethnicity				Mongol ethnicity			
Variable	No. tested	No. positive	%	*P* value	No. tested	No. positive	%	*P* value	No. tested	No. positive	%	*P* value	No. tested	No. positive	%	*P* value
Age group (years)																
⩽19	90	13	14·44	0·7074	58	11	18·97	0·9204	53	7	13·21	0·3025	27	2	7·41	0·1707
20–29	61	10	16·39		55	12	21·82		27	3	11·11		28	4	14·29	
30–39	112	21	18·75		63	13	20·64		37	2	5·41		30	7	23·33	
40–49	219	30	13·70		145	26	17·93		90	12	13·33		59	5	8·48	
50–59	137	17	12·41		79	19	24·05		54	7	12·96		36	9	25·00	
⩾60	183	23	12·57		120	26	21·67		42	10	23·81		37	7	18·92	
Gender																
Male	370	42	11·35	0·0316	224	51	22·77	0·2823	137	21	15·33	0·4061	95	18	18·95	0·2409
Female	432	72	16·67		296	56	18·92		166	20	12·05		122	16	13·12	
Location																
Changchun	131	19	14·50	0·9796	113	25	22·12	0·0668	148	17	11·49	0·5567	116	15	12·93	0·4673
Qingdao	210	29	13·81		190	29	15·26		89	13	14·61		29	6	20·69	
Weihai	461	66	14·32		217	53	24·42		66	11	16·67		72	13	18·06	
Residential area																
Urban	487	64	13·14	0·2794	300	59	19·67	0·5488	170	14	8·24	0·0023	123	20	16·26	0·7838
Suburban or rural	315	50	15·87		220	48	21·81		133	27	20·30		94	14	14·89	
Cat at home																
Yes	174	24	13·79	0·8573	122	24	19·67	0·7775	59	12	20·34	0·0885	47	8	17·02	0·7731
No	628	90	14·33		398	83	20·85		244	29	11·89		170	26	15·29	
Dog at home																
Yes	164	33	20·12	0·0151	99	23	23·23	0·5019	69	12	17·39	0·2861	33	8	24·24	0·1411
No	638	81	12·70		421	85	26·48		234	29	12·39		184	26	14·13	
Consumption of raw/ undercooked meat																
Yes	330	49	14·85	0·6672	242	62	25·62	0·0080	136	22	16·18	0·2245	87	16	18·39	0·3667
No	472	65	13·77		278	45	16·19		167	19	11·38		130	18	13·85	
Exposure to soil																
Yes	401	82	20·45	<0·0001	273	67	24·54	0·0187	161	32	19·88	0·0006	115	25	21·74	0·0090
No	401	32	7·98		247	40	16·19		142	9	6·34		102	9	8·82	
Source of drinking water																
Tap	536	76	14·18	0·9675	352	68	19·32	0·3041	187	16	8·56	0·0013	156	29	18·59	0·0583
Well+river	266	38	14·29		168	39	23·21		116	25	21·55		61	5	8·20	
Total	802	114	14·21		520	107	20·58		303	41	11·22		217	34	18·89	

Table 2. *Odds ratio of the risk factors associated with seropositivity to* Toxocara *in different ethnic groups in northern China*

Ethnicity	Variables	OR	95% CI	*P* value
Han	Gender			
	Male	Reference		
	Female	1·56	1·04–2·35	0·0316
	Dog at home			
	No	Reference		
	Yes	1·73	1·11–2·71	0·0151
	Exposure to soil			
	No	Reference		
	Yes	2·96	1·92–4·58	<0·0001
Korean	Exposure to soil			
	No	Reference		
	Yes	1·68	1·09–2·60	0·0187
	Consumption of raw/ undercooked meat			
	No	Reference		
	Yes	1·78	1·16–2·74	0·0080
Manchu	Residential area			
	Urban	Reference		
	Suburban or rural	2·84	1·42–5·57	0·0023
	Water sources			
	Tap	Reference		
	Well + river	2·94	1·49–5·78	0·0013
	Exposure to soil			
	No	Reference		
	Yes	3·67	1·68–7·98	0·0006
Mongol	Exposure to soil			
	No	Reference		
	Yes	2·87	1·27–6·49	0·0090

OR, Odds ratio; CI, confidence interval.

It is well known that dogs are the most important definitive host of *T. canis*. The parasite's eggs can survive not only in the faeces and fur of domestic dogs but also in soil and water after their faeces have been discharged into these areas [6, 21, 26]. Hence, dogs at home and exposure to contaminated soil were undoubtedly risk factors for *T. canis* infection in humans [3, 6]. The present study has shown that exposure to soil is associated with *T. canis* infection in all four ethnic groups, which suggests that the problem of polluted soil is widespread in these areas.

However, only in the Han ethnic group were having dogs at home (OR 1·73, 95% CI 1·11–2·71, $P = 0·0151$) associated with *T. canis* infection (Table 2). Actually, dogs at home and contact with dogs are not necessarily risk factors unless there is lack of essential measures (e.g. not washing hands) after having contact with dogs' faeces. The high *T. canis* burden in the Manchu ethnic group would be partially explained by this phenomenon. Manchus passionately raise dogs, especially in suburban and rural areas, where the majority of the people use untreated water from wells or rivers for drinking. The seroprevalence of *T. canis* was rather high in Manchus for those raising dogs and those living in rural areas. Furthermore, Han women handle raw meat and vegetables more frequently and spend more time with their pets than men, which may account for their significantly higher *T. canis* seroprevalence than the rate observed in males ($P = 0·0316$). In China, the increasing number of pet dogs and inadequate inspection and quarantine measures enhance the potential toxocariasis risk for humans. In addition, the old Korean tradition of consuming dog meat and the habit of consuming raw/ undercooked meat, which may contain encapsulated larvae, across the groups can also be associated with the *Toxocara* infection in humans [6, 21, 27–29]. Improved and integrated strategies and measures are required for the effective prevention and control of toxocariasis in these ethnic groups in northern China.

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CONCLUSION

The present study has shown that the overall seroprevalence of *Toxocara* infection in the various ethnic groups examined from Jilin and Shandong provinces, northern China, was 16·07%. The lowest seropositivity (11·22%) was recorded in the Manchu group, while the highest seropositivity (20·58%) was recorded in Koreans. The study revealed the seroprevalence of *Toxocara* infection in Manchus and Mongols for the first time. Living in suburban or rural areas, dogs at home, exposure to soil, and consumption of raw/undercooked meat are risk factors of *Toxocara* infection. Moreover, more attention should be given to the Han women and Manchus who come in contact with unboiled water. Hence, establishment of good health habits including washing hands before meals and after contact with soil, regular deworming of dogs, and eating well-cooked meat should be promoted. Investigation of soil contamination between cities should be further studied.

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DECLARATION OF INTEREST

None.

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