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Canine and feline parasitic zoonoses in China

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Abstract

Canine and feline parasitic zoonoses have not been given high priority in China, although the role of companion animals as reservoirs for zoonotic parasitic diseases has been recognized worldwide. With an increasing number of dogs and cats under unregulated conditions in China, the canine and feline parasitic zoonoses are showing a trend towards being gradually uncontrolled. Currently, canine and feline parasitic zoonoses threaten human health, and cause death and serious diseases in China. This article comprehensively reviews the current status of major canine and feline parasitic zoonoses in mainland China, discusses the risks dogs and cats pose with regard to zoonotic transmission of canine and feline parasites, and proposes control strategies and measures.

Keywords: Parasitic zoonoses, China, Dogs, Cats, Prevalence

Review

Background

Pet dogs and cats are often considered to be the faithful friends and intimate companions of humans, and enjoy life together with humans. This human-animal bond can provide substantial positive benefits with regard to emotional development, socialization and psychological and physiological well-being of humans [1]. However, dogs and cats also act as reservoirs of a large number of pathogens of parasitic zoonoses, such as toxoplasmosis [2], giardiasis [3], toxocariasis [4] and ancylostomiasis [5]. Their roles in transmitting human infections have been recognized worldwide [6,7].

With a major socioeconomic development and a significant increase in living standards, more and more dogs and cats are being raised and kept as family pets and companion animals by Chinese families, and the populations of dogs and cats are approximately 200 and 100 million in China, respectively [8]. In the country, some of the dogs and cats roam freely in urban environments or rural settings, so the presence of these animals in close contact with people constitutes a high potential risk. More importantly, the current status in the lack of zoonotic awareness and enough veterinary resources increases the risk of exposure to parasitic zoonoses, which poses a significant public problem in China.

Unfortunately, up to date there has been no published overview on canine and feline parasitic zoonoses in mainland China in the English literature, except for a few articles published in the Chinese language [9,10]. It is therefore timely to review comprehensively the current status of major canine and feline parasitic zoonoses in mainland China, discuss the risks dogs and cats pose with regard to zoonotic transmission of canine and feline parasites, and propose control strategies and measures.

Zoonotic nematode infections

Toxocariasis

Human toxocariasis results from zoonotic transmission of the round worms, *Toxocara canis* (of dogs) and *T. cati* (of cats). Infection occurs when humans accidently ingest embryonated eggs through contaminated soil, food, fomites or by direct contact with dogs and cats [4], this can result in clinical syndromes such as visceral larva migrans (VLMs), ocular larva migrans (OLMs), eosinophilic meningoencephalitis (EME), covert toxocariasis (CT) and neurotoxocarosis [4,10-12].

Toxocariasis is one of the most common human parasitic infections in the world and high prevalence has been reported in developing countries, such as Indonesia and Brazil [13,14]. However, it is one of the most neglected parasitic infections in China. Only 20-years-

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ago literature was available on the seroprevalence of toxocariasis in humans in Chengdu, Sichuan Province, China [15]. A single retrospective diagnosis of patients ascertained that contact with infected dogs is the risk factor for human infections in China [16].

Widespread prevalence of *Toxocara* spp. in dogs and cats can lead to the contamination of surroundings with *Toxocara* eggs, which threatens public health directly [17,18]. Although only two comprehensive surveys of *Toxocara* infection in dogs were conducted in Hunan province [19] and Heilongjiang province [20] (Table 1), the results indicated that *T. canis* was actually the most common parasite species in dogs in Hunan province (45.2%) [19], and the second most common parasite in dogs in Heilongjiang province (36.5%) [20]. With regard to *Toxocara* of cats, in addition to *T. cati*, we have proven the existence of *T. malaysiensis* in cats in Guangzhou, China, and this parasite is remarkably different from *T. canis*, *T. cati* and *T. leonina* of dogs and cats by molecular characterization [21]. However, a comprehensive epidemiological survey of *Toxocara* infections in cats in China has not yet been performed. Thus, the role of *T. cati* and *T. malaysiensis* as zoonotic parasites has yet to be assessed in future studies.

Ancylostomiasis

Ancylostomiasis caused by blood-feeding hookworms is a neglected tropical disease in a number of countries

Table 1 The prevalence of major canine and feline parasitic zoonoses in mainland China

Disease	Parasite	Prevalence in people	Prevalence in dogs and cats	Reference
Toxocariasis	*Toxocara canis*, *T. cati*	2.1%–17.7% in children in Chengdu; a case reported in Yunnan province	45.2% in dogs in Hunan; 36.5% in dogs in Heilongjiang	[15,16,19,20]
Ancylostomiasis	*Necator americanus*, *Ancylostoma duodenale*, *Ancylostoma caninum*	6.12% in south China	66.3% in dogs in Heilongjiang; 20.3% in dogs in Hunan; Some reported cases in Gansu, Guangdong, Jiangsu and Inner Mongolia in dogs and cats	[9,19,20,24]
Strongyloidiasis	*Strongyloides stercoralis*	11.7% in small village of Yunnan province; some cases reported in Guangxi Zhuang Autonomous Region	Not available	[9,37]
Trichinellosis	*Trichinella spiralis*, *T. nativa*	3.19% in ten endemic provinces; 9 outbreaks by eating dog meat in north China	Canine trichinellosis reported in 11 endemic provinces; feline trichinellosis reported in 10 endemic provinces	[40,42,43]
Echinococcosis	*Echinococcu granulosus*, *E. multilocularis*	~0.4 million in 22 endemic provinces	39.9% in dogs in Qinghai province	[38,44]
Clonorchiasis	*Clonorchis sinensis*	2.4% in 27 endemic provinces; ~12.5 million; 31.90%–57.26% in some villages in Heilongjiang province; 15.2% in some villages of the Korean minority in Liaoning province	41.8% in dogs in Guangdong; 20.5% in cats in Guangdong	[24,38,48,51-54]
Paragonimiasis	*Paragonimus westermani*	1.71% in 24 endemic provinces	Dogs: 14.29% in Hubei; 9.9%–84.62% in Liaoning; 10% in Zhejiang; Cats: 4.5% in Guangxi; 56.25% in Hubei; 2.56%–5.6% in Jiangxi	[24,55]
Giardiasis	*Giardia lamblia*	2.5%; ~30 million	25.2% in dogs in Jilin Province; 13.1% in dogs Henan Province; 11% in pet dogs in Guangzhou	[38,77,78,80]
Toxoplasmosis	*Toxoplasma gondii*	7.9 –12.3% nationwide	21.3% in pet dogs in Guangzhou; 31.3% in stray dogs in Guangzhou; 30.77% in stray cats in Guangzhou; 17.98% in pet cats in Guangzhou; 10.81% in dogs in Lanzhou; 21.3% in cats in Lanzhou	[62,68-71]
Leishmaniasis	*Leishmania infantum* *Leishmania donovani*	More than 400 cases reported in endemic regions in western China	24.8% in dogs in Sichuan Province; 59.43% in dogs in Jiuzhaigou County; 37.21% in dogs in Beichuan County	[85-88,91-93]

with major socio-economic significance [22]. The common hookworms of dogs include *Ancylostoma caninum*, *A. braziliense*, *A. ceylanicum* and *Uncinaria stenocephala*, while *A. tubaeforme*, *A. braziliense*, *A. ceylanicum* and *U. stenocephala* are from cats [5]. *A. ceylanicum* was first isolated and identified in civet cats in Fujian province, China in 1911 [23] and human infection with *A. ceylanicum* was reported in Fujian in 1981, which documented that a high prevalence of *A. ceylanicum* in cats and dogs was the significant risk factor for human infection [23]. The parasites *Necator americanus* and *A. duodenale* are now found to be the most prevalent hookworms distributed in south China, such as Hainan, Guangxi, Fujian provinces and Chongqing Municipal, with a mean prevalence of 6.12% nationwide [24]. In particular, these two most common species are more common in Sichuan [25] and Yunnan [26,27] provinces. The infected people mainly live in less developed rural areas without inadequate sanitary conditions, where dogs and cats are known to roam freely and farmers often walk barefoot [28,29].

Hookworm infections in dogs and cats are endemic in Hunan, Gansu, Guangdong, Heilongjiang, Jiangsu provinces and Inner Mongolia Autonomous Region [9,19,20]. Although it has been documented that *A. caninum* (of dogs) and *A. tubaeforme* (of cats) are the most common species throughout the warmer ranges [30,31], *A. caninum* is also prevalent in the cold regions in China, such as Heilongjiang province, where it has the highest prevalence of 66.3% [20].

Strongyloidiasis

Strongyloidiasis is caused by the nematode *Strongyloides stercoralis*, which is able to infect dogs, cats, monkeys and humans [32]. *S. stercoralis* is prevalent in endemic tropical and subtropical regions [33], especially in rural areas where sanitary conditions are inadequate and *S. stercoralis* filariform larvae contained in feces is able to cause human and dog infection [34,35]. Nonetheless, *S. stercoralis* is a neglected soil-transmitted helminth worldwide [36], with a paucity of epidemiologic data in China.

A few human infections have been reported mainly in tropical regions, such as Guangxi Zhuang Autonomous Region [9], where most cats and dogs usually roam freely in villages and cities. An 11.7% prevalence of *S. stercoralis* was found in a small village of Yunnan province where sanitary conditions were poor [37]. Therefore, it has been speculated that infected dogs and cats may represent a zoonotic risk and, thus, surroundings contaminated by feces of these animals may cause the infection of humans in the country. However, there is no available epidemiologic data on this disease of dogs and cats, and little is known of the dynamics of transmission of strongyloidiasis between dogs and cats and humans in China.

Trichinellosis

Human trichinellosis caused by *Trichinella spiralis* and *T. nativa* is one of the most widespread zoonosis in China [38]. Humans become infected through the consumption of raw or undercooked meat [39]. Between 2004 and 2009, seroepidemiological surveys of human infection with *Trichinella* indicated an average seroprevalence of 3.19%, with the highest seroprevalences mainly in western China, such as 8.43% in Yunnan province, 6.37% in Inner Mongolia Autonomous Region and 5.35% in Sichuan province [40].

In addition to infected pork being the main source of human infection, dog meat has become another important source of human infection with *Trichinella* in China [41]. Resulting from the consumption of dog meat, nine outbreaks of human trichinellosis occurred in north China, where the prevalence of *T. nativa* infection in dogs bred and farmed for human consumption was high [42]. Some *Trichinella* isolates from dogs and cats in northeastern China were identified as *T. nativa* by molecular approaches [43]. Epidemiological surveys have estimated that canine trichinellosis is distributed in 11 provinces/Autonomous Regions/Municipals/Special Administrative Regions (P/A/M/S) [43] (Table 1). *Trichinella* infection in cats has been recorded in 10 P/A/M [43] (Table 1).

Zoonotic cestode infections

Echinococcosis

Echinococcosis is a worldwide parasitic zoonosis caused by infection with adult or larval stages of tapeworms of the genus *Echinococcus*. Among the seven recognized species of *Echinococcus*, both *E. granulosus* and *E. multilocularis* are significant for public health by causing cystic echinococcosis (CE) and alveolar echinococcosis (AE), respectively [44]. Both CE and AE are considered among the most serious parasitic zoonoses in China, and approximately 0.4 million people are infected nationwide [38].

CE and AE are prevalent in 22 provinces, and the main endemic areas include western and northwestern provinces and autonomous regions, such as Xinjiang, Gansu, Ningxia, Inner Mongolia, Qinghai, Tibet, and Sichuan [44] (Table 1). In northwestern China, dogs are the most important definitive host transmitting *E. granulosus* to humans [45] (Table 1), owing to the traditional practice of feeding dogs by herdsmen with offal (e.g., lungs and liver) of sheep and yaks during slaughtering seasons and their close relationship with local people. Moreover, it is documented that domestic dogs are also the predominant definitive host in the semidomestic cycle and are responsible for human AE in China [45-47].

Dogs are generally highly susceptible to *E. multilocularis* and a large number of owned and stray dogs in rural regions are usually poorly fed and live freely in the country. Therefore, dogs may get infected with the parasite from small mammals in the field, and AE is therefore easily transmitted to humans via eggs in the feces of dogs.

Zoonotic trematode infections

Clonorchiasis

Clonorchiasis is a parasitic zoonosis caused by the oriental liver fluke *Clonorchis sinensis*. Humans and other mammals become infected with *C. sinensis* through ingestion of raw or undercooked freshwater fish and shrimp infected by *C. sinensis* metacercariae [48,49].

This infectious disease is regarded as one of the major parasitic zoonoses in some parts of Asia, including Korea, Japan, northern Vietnam, Thailand and China [48,50]. Human clonorchiasis has been reported in 27 provinces and autonomous regions in China [24], with approximately 12.5 million people being infected nationwide [38] (Table 1). Southern China's Guangdong province has the largest number of infected populations (~5.5 million), which results from the local custom of consumption of raw and undercooked fish [48]. In the northeast, the prevalence of *C. sinensis* in some villages of Zhaoyuan County in Heilongjiang province ranged from 31.90% to 57.26% [51], and 15.2% of the Korean minority were infected with *C. sinensis* in some villages in Liaoning province [52].

In addition to humans, cats and dogs serve as definitive hosts for *C. sinensis*, and they are considered to be the most important reservoir hosts for human infection in the endemic regions of China [53,54] (Table 1).

Paragonimiasis

Paragonimus westermani, the lung fluke, is of major socioeconomic importance in Asia [55]. Humans become infected by consuming raw or undercooked stream crabs that are infected by *P. westermani*, drinking water contaminated by metacercaria or undercooked meat from a paratenic host [56]. The recent national survey indicated that paragonimiasis is endemic in 24 P/A/M, and the nationwide prevalence is estimated to be 1.71% [24] (Table 1). People in some P/A/M such as Hubei, Zhejiang and Fujian provinces have the higher prevalence [57-59].

Many carnivorous animals such as cats and dogs serve as definitive hosts of *P. westermani*, and cats and dogs are considered to be the most important reservoir hosts for human infections in endemic regions in China [60]. Some recent surveys have indicated that cat and dog infections are extremely severe in rural areas in Fujian and Hubei provinces [55] (Table 1) where most cats and dogs usually roam freely in villages and, thus, freely drink contaminated water or ingest crabs or crayfish infected with lung flukes [55,58].

Zoonotic protozoan infections

Toxoplasmosis

Toxoplasmosis is an important zoonotic parasitic disease in humans and many species of birds and mammals, which is caused by the opportunistic protozoan *Toxoplasma gondii* [61]. It has been estimated that up to one third of the world's population has been infected [61]. In China, the prevalence of human toxoplasmosis appears to be increasing, from 7.9% to 12.3% between 2001 and 2008 [38,62,63] (Table 1).

As the definitive hosts for *T. gondii*, cats can pass oocysts in their feces leading to contamination of *T. gondii* oocysts in soil [2,64]. In China, owing to excretion of *T. gondii* oocysts in the environment by stray cats in parks, the possibility of human infection has increased [64]. As a risk factor for *T. gondii* infection in humans, the potential role of dogs has been recognized because of mechanical transmission of oocysts [61]. A recent study has also found that taking care of pet animals was a risk factor associated with *T. gondii* infections in humans [65]. People owning dogs and cats as pets also showed a high risk of infection, with the prevalence ranging from 5.3% to 34.8% in China [66,67]. Our recent serologic surveys using ELISA revealed that *T. gondii* infection in dogs in Guangzhou, southern China is high, especially in stray dogs, which have a prevalence of 21.3% and 31.3%, respectively [68]. Moreover, it was found that the prevalence of stray and household cats in Guangzhou China was 30.77% and 17.98%, respectively [69]. In Lanzhou, northwest China, a *T. gondii* prevalence of 10.81% in pet dogs [70] and 21.3% in pet cats was reported [71], indicating the widespread prevalence of *T. gondii* in China.

Giardiasis

Giardiasis caused by *Giardia* spp. is one of the most common human parasitic diseases that can cause public health problems in most developing countries as well as some developed countries [72,73]. In China, *G. lamblia* (syn. *G. duodenalis* and *G. intestinalis*) has been documented in every mainland province [38,74] (Table 1). However, there is still no detailed data on human infections nationwide, and thus *G. lamblia* infection is underestimated, despite it being documented that HIV positive individuals are susceptible to co-infections with *Giardia* (1.3% from 302 HIV positive individuals) in a rural village of Fuyang, Anhui province [75].

Most *Giardia* spp. are host adapted (narrow hosts range), but *G. lamblia* is considered to be a zoonotic agent that causes giardiasis in humans and most mammals including dogs and cats [74,76]. Until recently, in addition to some reports of prevalence of *Giardia* in dogs in China [77,78] (Table 1), there were only two recent studies on genotyping or subtyping of *Giardia* isolates from humans and animals [79,80]. By sequence analysis of the triosephosphate isomerase (tpi) gene of *Giardia duodenalis*, the Assemblages A and B were found in 12 and 6 human specimens, respectively in Henan province, China [79]. A very recent survey of *G. duodenalis* prevalence in pet dogs in Guangzhou, China revealed an 8.61% (18/209) prevalence using microscopy examination and 11% (23/209) using PCR [80]. The *G. duodenalis* prevalence was significantly higher in diarrheic dogs and young dogs than in non-diarrheic dogs and adult dogs. Assemblage D (18/23) and zoonotic Assemblage A (5/23) were found based on sequence analysis of the 23 PCR-positive samples, which indicated the potential risk of *G. duodenalis* transmission from pet dogs to humans in China, at least in Guangzhou [80].

Leishmaniasis
Leishmaniasis is one of the most important vector-borne diseases in the world caused by *Leishmania* spp. [81,82]. Humans and animals can become infected with *Leishmania* spp. through transmission of flagellated promastigotes by the insect vectors, phlebotomine sand flies [83]. In China, leishmaniasis caused by *Leishmania donovani* is still an important parasitic disease [84], and serological surveys reported that human cases occurred in western China, such as Sichuan, Shaanxi, Shanxi, Sichuan and Gansu provinces, and Inner Mongolia and Xinjiang and Autonomous Regions [85,86]. In particular, Xinjiang Autonomous Region is the most prevalent area in the country [87,88] (Table 1).

Canine leishmaniasis (CanL) is caused by *Leishmania infantum* (syn. *Leishmania chagasi*), which is mainly prevalent in regions of Europe, Africa, Asia and Latin America [89]. The domestic dog is the main reservoir for human infection [89,90]. In China, information regarding prevalence of CanL is very limited, and the only three available surveys were conducted in western China's Sichuan province by PCR and serological tests [91-93] (Table 1). While it has confirmed that infected dogs are the major source of human infection with *Leishmania* spp. and some sporadic CanL reports have suggested that dog infections are mainly distributed in endemic western areas in the country [85,91], it is unclear whether dog infection contributed to the re-emergence of human leishmaniasis in western China due to lack of information on CanL prevalence in these endemic areas.

Zoonotic ectoparasite infections
Sarcoptic mange caused by *Sarcoptes scabiei* is the most common ectoparasite infection in various animals including companion animals [94]. Also, scabies caused by *S. scabiei* in humans is one of the most common human health problems [94]. This global parasitic zoonosis is an emerging/re-emerging infectious disease seriously threatening human and animal health, causing significant public health concern [94]. Scabies is also prevalent in developing countries such as Brazil, where it has been shown to be a significant public health problem [95]. However, survey of scabies prevalence in China is scant, apart from several reports of canine and feline sarcoptic mange [96,97]. Obviously, scabies and sarcoptic mange are underestimated in China, dogs and cats pose potential health hazards by transmitting *S. scabiei* between themselves and humans.

Zoonotic risks
With an increasing number of dogs and cats, indirect or direct contact with animals is very common, therefore a large number of parasitic zoonosis can potentially be transmitted to humans from dogs and cats. In China, there are more than 1.3 billion people of 56 nationalities, each practices different hygiene habits, culture and customs. Some of the eating habits or customs are risk factors leading to the prevalence of parasitic zoonoses. For example, the prevalence of echinococcosis in vast western and northwestern pastoral regions in China is closely related to the unique practice of feeding dogs, while occurrence of trichinellosis in north China is partly owing to the custom of eating raw or undercooked meats of various kinds. In addition, pet ownership is an important risk factor for the occurrence of many parasitic zoonoses, such as toxocariasis [7], toxoplasmosis [2] and ectoparasite infections [94]. However, in China, most pet owners have not been educated about the presence of this risk factor, thus increasesing the possibility of exposure to parasitic zoonoses.

Since the faecal-oral route (via water or food) is a major transmission model for soil-transmitted helminth infections, widespread contamination of environment or drinking water with parasite eggs, oocysts, or infective larvae may induce the occurrence of parasitic zoonoses, in particular in rural areas where stray dogs and cats enjoy water sources together with humans.

Perspectives for control
As a result of uncontrolled populations of dogs and cats existing in close proximity to the increasing densities of human populations, effective control of canine and feline parasitic zoonoses is an extremely tough task in China. Given that a large number of canine and feline parasitic zoonoses have not been given high priority and the owners of dogs and cats also lack the related knowledge, the most common and important control strategies and approaches are to improve the public awareness of canine and feline parasitic zoonoses using various educational media, such as TV and radio, and to educate people to change their unhealthy eating habits, in

particular for some ethnic groups. Furthermore, regulating the populations of dogs and cats, especially stray dogs and cats, promoting the significance of deworming dogs and cats, and improving the sanitation and hygiene of dogs and cats are among the recommended strategies and measures that can be taken to control canine and feline parasitic zoonoses in China.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
XQZ and JC conceived and designed the review, and critically revised the manuscript. JC drafted the manuscript. MJX, DHZ, HQS and CRW contributed to drafting the manuscript. All authors read and approved the final manuscript.

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References
1. Paul M, King L, Carlin EP: **Zoonoses of people and their pets: a US perspective on significant pet-associated parasitic diseases.** *Trends Parasitol* 2010, **26**:153–154.
2. Elmore SA, Jones JL, Conrad PA, Patton S, Lindsay DS, Dubey JP: ***Toxoplasma gondii*: epidemiology, feline clinical aspects, and prevention.** *Trends Parasitol* 2010, **26**:190–196.
3. Ballweber LR, Xiao L, Bowman DD, Kahn G, Cama VA: **Giardiasis in dogs and cats: update on epidemiology and public health significance.** *Trends Parasitol* 2010, **26**:180–189.
4. Smith H, Holland C, Taylor M, Magnaval JF, Schantz P, Maizels R: **How common is human toxocariasis? Towards standardizing our knowledge.** *Trends Parasitol* 2009, **25**:182–188.
5. Bowman DD, Montgomery SP, Zajac AM, Eberhard ML, Kazacos KR: **Hookworms of dogs and cats as agents of cutaneous larva migrans.** *Trends Parasitol* 2010, **26**:162–167.
6. Reaser JK, Clark EE Jr: **Meyers NM: All creatures great and minute: a public policy primer for companion animal zoonoses.** *Zoonoses Public Health* 2008, **55**:385–401.
7. Deplazes P, van Knapen F, Schweiger A, Overgaauw PA: **Role of pet dogs and cats in the transmission of helminthic zoonoses in Europe, with a focus on echinococcosis and toxocarosis.** *Vet Parasitol* 2011, **24**:41–53.
8. Dong HP, Liu ZW, Chen H, Zhang LX: **The situation and treatment of parasitic zoonoses of pets.** *Hennan J Ani Sci Vet Med* 2007, **28**:8–10. In Chinese.
9. Zhang XC, Zhao N: **Important pet-related parasitic zoonoses.** *Chin J Com Med* 2010, **20**:65–70. In Chinese.
10. Finsterer J, Auer H: **Neurotoxocarosis.** *Rev Inst Med Trop Sao Paulo* 2007, **49**:279–287.
11. Rubinsky-Elefant G, Hirata CE, Yamamoto JH, Ferreira MU: **Human toxocariasis: diagnosis, worldwide seroprevalences and clinical expression of the systemic and ocular forms.** *Ann Trop Med Parasitol* 2010, **104**:3–23.
12. Chen J, Zhou DH, Nisbet AJ, Xu MJ, Huang SY, Li MW, Wang CR, Zhu XQ: **Advances in molecular identification, taxonomy, genetic variation and diagnosis of *Toxocara* spp.** *Infect Genet Evol* 2012, **12**:1344–1348.
13. Noordin R, Smith HV, Mohamad S, Maizels RM, Fong MY: **Comparison of IgG-ELISA and IgG4-ELISA for *Toxocara* serodiagnosis.** *Acta Trop* 2005, **93**:57–62.
14. De Andrade Lima Coêlho R, De Carvalho LB Jr, Perez EP, Araki K, Takeuchi T, Ito A, Aoki T, Yamasaki H: **Prevalence of toxocariasis in northeastern Brazil based on serology using recombinant *Toxocara canis* antigen.** *Am J Trop Med Hyg* 2005, **72**:103–107.
15. Luo ZJ, Chen SW, Liao L, Luo CH, Mao M, Li Q, Yang CL: **A survey of serum antibodies against *Toxocara* larvae for preschool children in Chengdu area.** *Chin J Zoon* 1993, **1**:2–4. In Chinese.
16. Li XR, Dong YX, Duan YH, Zeng GX, Wang FY, Wang YB: **a reported case of *Toxocara canis*.** *Livestock Poultry Industry* 2009, **242**:93. In Chinese.
17. Dado D, Izquierdo F, Vera O, Montoya A, Mateo M, Fenoy S: **Galván AL, García S, García A, Aránguez E, López L, Del Águila C.** *Miró G: Detection of zoonotic intestinal parasites in public parks of Spain. Potential epidemiological role of microsporidia. Zoonoses Public Health* 2012, **59**:23–28.
18. Mattia S, Colli CM, Adami CM, Guilherme GF, Nishi L, Rubinsky-Elefant G, Marchioro AA, Gomes ML, Falavigna-Guilherme AL: *Seroprevalence of Toxocara infection in children and environmental contamination of urban areas in Paraná State*. J Helminthol: Brazil; 2012 [Epub ahead of print].
19. Dai RS, Li ZY, Li F, Liu DX, Liu W, Liu GH, He SW, Tan MY, Lin RQ, Liu Y, Zhu XQ: **Severe infection of adult dogs with helminths in Hunan Province, China poses significant public health concerns.** *Vet Parasitol* 2009, **160**:348–350.
20. Wang CR, Qiu JH, Zhao JP, Xu LM, Yu WC, Zhu XQ: **Prevalence of helminthes in adult dogs in Heilongjiang Province, the People's Republic of China.** *Parasitol Res* 2006, **99**:627–630.
21. Li MW, Zhu XQ, Gasser RB, Lin RQ, Sani RA, Lun ZR, Jacobs DE: **The occurrence of *Toxocara malaysiensis* in cats in China, confirmed by sequence-based analyses of ribosomal DNA.** *Parasitol Res* 2006, **99**:554–557.
22. Rabelo EM, Hall RS, Loukas A, Cooper L, Hu M, Ranganathan S, Gasser RB: **Improved insights into the transcriptomes of the human hookworm Necator americanus–fundamental and biotechnological implications.** *Biotechnol Adv* 2009, **27**:122–132.
23. Chen QX, Lin XM, Yang CC: **Studies on the biology and epidemiology of *Ancylostoma ceylanicum* infection from man and animal in Fujian, China.** *J Xiamen Univ* 1981, **4**:476–486. In Chinese.
24. Xu LQ, Chen YD, Sun FH, Cai L, Fang RY, Wang LP, Liu X, Feng Y, Li H: **A national survey on current status of the important parasitic diseases in human population.** *Chin J Parasitol Parasit Dis* 2005, **23**:332–340. In Chinese.
25. Xie H, Tian HC, Wang XG, Liu CH, Zhen DF, Tan K, Liu WL, Hu M, Tang ZJ, Chen YL, Zhang FN: **Surveillance of geohelminthiasis in national surveillance area in Sichuan, 2006–2009.** *J Prev Med Infect* 2011, **7**:495–499. In Chinese.
26. Steinmann P, Zhou XN, Li YL, Li HJ, Chen SR, Yang Z, Fan W, Jia TW, Li LH, Vounatsou P, Utzinger J: **Helminth infections and risk factor analysis among residents in Eryuan county, Yunnan province, China.** *Acta Trop* 2007, **104**:38–51.
27. Kotze AC, Steinmann P, Zhou H, Du ZW, Zhou XN: **The effect of egg embryonation on field-use of a hookworm benzimidazole-sensitivity egg hatch assay in Yunnan Province.** *People's Republic of China. PLoS Negl Trop Dis* 2011, **5**:1203.
28. Wang DB: **A survey on current status of hookworm infections in human in Kaihua county in China.** *Zhenjiang Prev Med* 2011, **1**:78–79. In Chinese.
29. Xie H, Tian HC, Wang XG, Liu CH, Zhen DF, Tan K, Liu WL, Hu M, Tang ZJ, Chen YL, Zhang FN: **Surveillance of geohelminthiasis in national surveillance area in Sichuan, 2006–2009.** *J Prev Med Infect* 2011, **7**:495–499. In Chinese.
30. Traub RJ, Hobbs RP, Admas PJ, Behnke JM, Harris PD, Thompson RC: **A case of mistaken identity - reappraisal of the species of canid and felid**

hookworms (*Ancylostoma*) present in Australia and India. *Parasitology* 2007, **134**:113–119.
31. Palmer CC, Traub RJ, Roberston ID, Hobbs RP, Elliot A, While L, Ress R, Thompson RC: **The veterinary and public health significance of hookworm in dogs and cats in Australia and the status of *A. ceylanicum*.** *Vet Parasitol* 2007, **145**:304–313.
32. Gonçalves AL, Machado GA, Gonçalves-Pires MR, Ferreira-Júnior A, Silva DA, Costa-Cruz JM: **Evaluation of strongyloidiasis in kennel dogs and keepers by parasitological and serological assays.** *Vet Parasitol* 2007, **147**:132–139.
33. Lam CS, Tong MK, Chan KM, Siu YP: **Disseminated strongyloidiasis: a restrospective study of clinical course and outcome.** *Eur J Clin Microbiol Infect Dis* 2006, **25**:14–18.
34. Robertson ID, Thompson RC: **Enteric parasitic zoonoses of domesticated dogs and cats.** *Microbes Infect* 2002, **4**:867–873.
35. Traub RJ, Robertson ID, Irwin P, Mencke N, Thompson RC: **The role of dogs in transmission of gastrointestinal parasites in a remote tea-growing community in northeastern India.** *Am J Trop Med Hyg* 2002, **67**:539–545.
36. Bethony J, Brooker S, Albonico M, Albonico M, Geiqer SM, Loukas A, Diemert D, Hotez PJ: **Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm.** *Lancet* 2006, **367**:1521–1532.
37. Steinmann P, Zhou XN, Du ZW, Jiang JY, Wang LB, Wang XZ, Li LH, Marti H, Utzinger J: **Occurrence of *Strongyloides stercoralis* in Yunnan Province, China, and comparison of diagnostic methods.** *PLoS Negl Trop Dis* 2007, **1**:75.
38. Zhou P, Chen N, Zhang RL, Lin RQ, Zhu XQ: **Food-borne parasitic zoonoses in China: perspective for control.** *Trends Parasitol* 2009, **24**:190–196.
39. Gottstein B, Pozio E, Nöckler K: **Epidemiology, diagnosis, treatment, and control of trichinellosis.** *Clin Microbiol Rev* 2009, **22**:127–145.
40. Cui J, Wang ZQ, Xu BL: **The epidemiology of human trichinellosis in China during 2004–2009.** *Acta Trop* 2011, **118**:1–5.
41. Liu MY: **Trichinellosis in China and the updates on research advances.** *Meat Hyg* 2005, **6**:14–16. In Chinese.
42. Liu M, Boireau P: **Trichinellosis in China: epidemiology and control.** *Trends Parasitol* 2002, **18**:553–556.
43. Wang ZQ, Cui J, Shen LJ: **The epidemiology of animal trichinellosis in China.** *Vet J* 2007, **173**:391–398.
44. Wang Z, Wang X, Liu X: **Echinococcosis in China, a review of the epidemiology of *Echinococcus* spp.** *Ecohealth* 2008, **5**:115–126.
45. Li TY, Qiu JM, Yang W, Craig PS, Chen XW, Xiao N: **Echinococcosis in Tibetan populations, western Sichuan province, China.** *Emerg Infect Dis* 2005, **11**:1866–1873.
46. Wang Q, Qiu JM, Yang W, Schantz PM, Raoul F, Craig PS, Giraudoux P, Vuitton DA: **Socioeconomical and behavioral risk factors of human alveolar echinococcosis in Tibetan communities, Sichuan, China.** *Am J Trop Med Hyg* 2006, **74**:856–862.
47. Craig PS, Giraudoux P, Shi D, Bartholomot B, Barnish G, Delattre P, Quere JP, Harraga S, Bao G, Wang Y, Lu F, Ito A, Vuitto DA: **An epidemiological and ecological study of human alveolar echinococcosis transmission in south Gansu, China.** *Acta Trop* 2000, **77**:167–177.
48. Lun ZR, Gasser RB, Lai DH, Li AX, Zhu XQ, Yu XB, Fang YY: **Clonorchiasis: a key foodborne zoonosis in China.** *Lancet Infect Dis* 2005, **5**:31–41.
49. Huang SY, Zhao GH, Fu BQ, Xu MJ, Wang CR, Wu SM, Zou FC, Zhu XQ: **Genomics and molecular genetics of *Clonorchis sinensis*: current status and perspectives.** *Parasitol Int* 2012, **61**:71–76.
50. Hong ST, Fang Y: ***Clonorchis sinensis* and clonorchiasis, an update.** *Parasitol Int* 2012, **61**:17–24.
51. Ge T, Wang YB: **Investigation and analysis on prevalence condition of *Clonorchis* infection in Zhaoyuan country of Heilongjiang province.** *Chin J Pest Control* 2009, **1**:3–4.
52. Rim HJ: **Clonorchiasis: an update.** *J Helminthol* 2005, **79**:269–281.
53. Tang JD, Lin RQ, Zhu XQ: ***Clonorchis sinensis* infection in animals in China.** *Chin J Zoon* 2007, **23**:177–179. In Chinese.
54. Lin RQ, Tang JD, Zhou DH, Song HQ, Huang SY, Chen JX, Chen MX, Zhang H, Zhu XQ, Zhou XN: **Prevalence of *Clonorchis sinensis* infection in dogs and cats in subtropical southern China.** *Parasit Vectors* 2011, **4**:180.
55. Liu Q, Wei F, Liu W, Yang S, Zhang X: **Paragonimiasis: an important food-borne zoonosis in China.** *Trends Parasitol* 2008, **24**:318–323.
56. Procop GW: **North American paragonimiasis (Caused by *Paragonimus kellicotti*) in the context of global paragonimiasis.** *Clin Microbiol Rev* 2009, **22**:415–446.
57. Yang YX, Yu XH, Luo ZS, Peng LB, Yun LJ: **An epidemiological survey of paragonimiasis prevalence in the three gorges dam area after the second impoundment.** *Chin Trop Med* 2011, **5**:548–550. In Chinese.
58. Xu GZ, Qian BZ, Ye LP, Zhang JN, Lu F, Sun YW: **Epidemiological survey on paragonimiasis in Ningbo City,Zhejiang Province.** *Chin J Parasitol Parasit Dis* 2008, **6**:449–451. In Chinese.
59. Li YS: **Investigation on final host and geographic distribution of Paragonimus in Fujian province.** *Shanghai Lab Anim Sci* 2004, **24**:153–156. In Chinese.
60. Yan QR, Yan T, Zhou XM, Li YS, Zhu CC, Shi LB, Ma XM, Hu NY: **Epidemiological survey on the infection of *Paragonimus westermani* in Jiangxi Province.** *Chin J Parasitol Parasit Dis* 2004, **22**:250–252. In Chinese.
61. Dubey JP: *Toxoplasmosis of Animals and Humans*. Boca Raton, New York: CRC Press Inc; 2010:1–313. Second.
62. Zhou P, Chen Z, Li HL, Zheng H, He S, Lin RQ, Zhu XQ: ***Toxoplasma gondii* infection in humans in China.** *Parasit Vectors* 2011, **4**:165.
63. Xiao Y, Yin J, Jiang N, Xiang M, Hao L, Lu H, Sang H, Liu X, Xu H, Ankarklev J, Lindh J, Chen Q: **Seroepidemiology of human *Toxoplasma gondii* infection in China.** *BMC Infect Dis* 2010, **10**:4.
64. Du F, Feng HL, Nie H, Tu P, Zhang QL, Hu M, Zhou YQ, Zhao JL: **Survey on the contamination of *Toxoplasma gondii* oocysts in the soil of public parks of Wuhan, China.** *Vet Parasitol* 2012, **184**:141–146.
65. Jones JL, Kruszon-Moran D, Sanders-Lewis K, Wilson M: ***Toxoplasma gondii* infection in the United States, 1999–2004, decline from the prior decade.** *Am J Trop Med Hyg* 2007, **77**:405–410.
66. Zhao LQ, Liu SQ: **Serological surveillance of *Toxoplasma* infection in Haizhu district in 2004.** *J Trop Med* 2007, **7**:495–496. In Chinese.
67. Zhang Y, Li H: **Seroepidemiological investigation of *Toxoplasma gondii* infection among population in Lanzhou area.** *Chin J Parasit Dis Con* 2005, **18**:432–433. In Chinese.
68. Zhang H, Zhou DH, Chen YZ, Lin RQ, Yuan ZG, Song HQ, Li SJ, Zhu XQ: **Antibodies to *Toxoplasma gondii* in stray and household dogs in Guangzhou, China.** *J Parasitol* 2010, **96**:671–672.
69. Zhang H, Zhou DH, Zhou P, Lun ZR, Chen XG, Lin RQ, Yuan ZG, Zhu XQ: **Seroprevalence of *Toxoplasma gondii* infection in stray and household cats in Guangzhou, China.** *Zoonoses Public Health* 2009, **56**:502–505.
70. Wu SM, Huang SY, Fu BQ, Lin GY, Chen JX, Chen MX, Yuan ZG, Zhou DH, Weng YB, Zhu XQ, Ye DH: **Seroprevalence of *Toxoplasma gondii* infection in pet dogs in Lanzhou.** *Northwest China. Parasit Vectors* 2011, **4**:64.
71. Wu SM, Zhu XQ, Zhou DH, Fu BQ, Chen J, Yang JF, Song HQ, Weng YB, Ye DH: **Seroprevalence of *Toxoplasma gondii* infection in household and stray cats in Lanzhou, northwest China.** *Parasit Vectors* 2011, **4**:214.
72. Yason J: **A, Rivera W L: Genotyping of *Giardia duodenalis* isolates among residents of slum area in Manila.** *Philippines. Parasitol Res* 2007, **101**:681–687.
73. Nkrumah B, Nguah SB: ***Giardia lamblia*: a major parasitic cause of childhood diarrhoea in patients attending a district hospital in Ghana.** *Parasit Vectors* 2011, **4**:163.
74. Feng Y, Xiao L: **Zoonotic potential and molecular epidemiology of *Giardia* species and giardiasis.** *Clin Microbiol Rev* 2011, **24**:110–140.
75. Tian LG, Chen JX, Wang TP, Cheng GJ, Steinmann P, Wang FF, Cai YC, Yin XM, Guo J, Zhou L, Zhou XN: **Co-infection of HIV and intestinal parasites in rural area of China.** *Parasit Vectors* 2012, **5**:36.
76. Ballweber LR, Xiao L, Bowman DD, Kahn G, Cama VA: **Giardiasis in dogs and cats: update on epidemiology and public health significance.** *Trends Parasitol* 2010, **26**:180–189.
77. He HX, Zhang XC, Yu JJ, Chen JB: **A survey of *Giardia* infection in dogs in Jilin province. *Heilongjiang*.** *J Ani Sci Vet Med* 2001, **11**:19. In Chinese.
78. Qi M, Wang Q, Zhang M, Sun YR: **A survey of *Giardia* infection in dogs in Zhengzhou Area.** *J Ani Sci Vet Med* 2011, **11**:69–71. In Chinese.
79. Wang R, Zhang X, Zhu H, Zhang L, Feng Y, Jian F, Ning C, Qi M, Zhou Y, Fu K, Wang Y, Sun Y, Wang Q, Xiao L: **Genetic characterizations of Cryptosporidium spp. and Giardia duodenalis in humans in Henan, China.** *Exp Parasitol* 2011, **127**:42–45.
80. Li J, Zhang P, Wang P, Alsarakibi M, Zhu H, Liu Y, Meng X, Li J, Guo J, Li G: *Genotype identification and prevalence of Giardia duodenalis in pet dogs of Guangzhou*. Vet Parasitol: Southern China; 2012 [Epub ahead of print].
81. Solano-Gallego L, Koutinas A, Miró G, Cardoso L, Pennisi MG, Ferrer L, Bourdeau P, Oliva G, Baneth G: **Directions for the diagnosis, clinical staging, treatment and prevention of canine leishmaniosis.** *Vet Parasitol* 2009, **165**:1–18.

82. Barratt JL, Harkness J, Marriott D, Ellis JT, Stark D: **Importance of nonenteric protozoan infections in immunocompromised people.** *Clin Microbiol Rev* 2010, **23**:795–836.
83. Wittner M: **Tanowitz H B: Leishmaniasis in infants and children.** *Semin Pediatr Infect Dis* 2000, **11**:196–201.
84. Li T, He S, Zhao H, Zhao G, Zhu XQ: **Major trends in human parasitic diseases in China.** *Trends Parasitol* 2010, **26**:264–270.
85. Guan LR, Qu JQ, Chai JJ: **Leishmaniasis in China–present status of prevalence and some suggestions on its control.** *Di Fang Bing Tong Bao* 2000, **15**:49–52. In Chinese.
86. Wang JY, Feng Y, Gao CH, Jin CF, Chen SB, Zhang CJ: **Asymptomatic Leishmania infection in human population of Wenxian County, Gansu Province.** *Chin J Parasitol Parasiti Dis* 2007, **25**:62–64. In Chinese.
87. Gu DA: **Present situation and perspective of leishmaniasis and its vector sandfly control.** *Int J Med Parasit Dis* 2006, **33**:236–238. In Chinese.
88. Kai SR, *et al*: **The consideration of leishmaniasis prevention and control in Kashi area of Xinjiang Autonomous Region.** *Di Fang Bing Tong Bao* 2008, **23**:23–26. In Chinese.
89. Baneth G, Koutinas AF, Solano-Gallego L, Bourdeau P, Ferrer L: **Canine leishmaniosis - new concepts and insights on an expanding zoonosis: part one.** *Trends Parasitol* 2008, **24**:324–330.
90. Soares MR, de Mendonça IL: **do Bonfim JM, Rodrigues JA, Werneck GL, Costa CH: Canine visceral leishmaniasis in Teresina, Brazil: Relationship between clinical features and infectivity for sand flies.** *Acta Trop* 2011, **117**:6–9.
91. Wang JY, Ha Y, Gao CH, Wang Y, Yang YT, Chen HT: **The prevalence of canine *Leishmania infantum* infection in western China detected by PCR and serological tests.** *Parasit Vectors* 2011, **4**:69.
92. Shang LM, Peng WP, Jin HT, Xu D, Zhong NN, Wang WL, Wu YX, Liu Q: **The prevalence of canine *Leishmania infantum* infection in Sichuan Province, southwestern China detected by real time PCR.** *Parasit Vectors* 2011, **4**:173.
93. Sun K, Guan W, Zhang JG, Wang YJ, Tian Y, Liao L, Yang BB, Chen DL, Chen JP: **Prevalence of canine leishmaniasis in Beichuan County, Sichuan, China and phylogenetic evidence for an undescribed Leishmania sp. in China based on 7SL RNA.** *Parasit Vectors* 2012, **5**:75.
94. Alasaad S, Walton S, Rossi L, Bornstein S, Abu-Madi M, Soriguer RC, Fitzgerald S, Zhu XQ, Zimmermann W, Ugbomoiko US, Pei KJ: **Heukelbach J; Sarcoptes-World Molecular Network: Sarcoptes-World Molecular Network (Sarcoptes-WMN): integrating research on scabies.** *Int J Infect Dis* 2011, **15**:294–297.
95. Heukelbach J, Wilcke T, Winter B, Feldmeier H: **Epidemiology and morbidity of scabies and *pediculosis capitis* in resource-poor communities in Brazil.** *Br J Dermatol* 2005, **153**:150–156.
96. Zeng FM: **Diagnosis and treatment for *Sarcoptes scabiei* in dog.** *Contemporary Anim Husbandry* 2010, **11**:48. In Chinese.
97. Zhang LY: **Diagnosis and treatment for *Sarcoptes scabiei* in dog.** *Chin Anim Health* 2011, **5**:65. In Chinese.

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