BIODIVERSITY OF FOODBORNE ZOONOTIC PARASITES IN CHINA

BIODIVERSITÉ DES PARASITES ZOONOTIQUES TRANSMIS PAR LES ALIMENTS EN CHINE

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ABSTRACT

Foodborne zoonotic parasites (FBZPs) pose significant public health challenges due to their complex life cycles and the wide range of hosts they infect. This review focuses on the biodiversity of FBZPs in China, encompassing protozoan and helminthic parasites. Key protozoan parasites include Toxoplasma gondii, Cryptosporidium spp.*, and* Giardia spp.*, each with distinct transmission dynamics and health impacts. Helminthic parasites like* Trichinella *spp. and* Taenia *spp. highlight the zoonotic risks associated with consuming undercooked meat, and* Clonorchis sinensis, Anisakis *spp.,* Echinococcus *spp., and* Paragonimus westermani *illustrate the intricate interplay between human dietary habits and environmental reservoirs. This review underscores the importance of comprehensive surveillance and tailored public health interventions to mitigate the risks posed by these parasites. Enhanced understanding of the biodiversity and transmission mechanisms of FBZPs in China can inform effective strategies for disease control and prevention, ultimately contributing to global health security.*
Keywords: *foodborne zoonotic parasites, biodiversity, China, public health, protozoan parasites, helminthic parasites.*

RÉSUMÉ

Les parasites zoonotiques d'origine alimentaire (PZOA) posent d'importants problèmes de santé publique en raison de leurs cycles de vie complexes et du large éventail d'hôtes qu'ils infectent. Cette revue se concentre sur la biodiversité des PZOA en Chine, englobant les protozoaires et les helminthes. Les principaux protozoaires comprennent *Toxoplasma gondii*, *Cryptosporidium spp*., et *Giardia spp*. chacun ayant une dynamique de transmission et des impacts sur la santé différents. Les helminthes comme *Trichinella* spp. et *Taenia spp*. mettent en évidence les risques zoonotiques associés à la consommation de viande insuffisamment cuite. *Clonorchis sinensis*, *Anisakis spp*., *Echinococcus spp*., et *Paragonimus westermani* illustrent l'interaction complexe entre les habitudes alimentaires humaines et les réservoirs environnementaux. Cette revue souligne l'importance d'une surveillance complète et adaptée en santé publique pour atténuer les risques posés par ces parasites. Une meilleure compréhension de la biodiversité et des mécanismes de transmission des PZOA en Chine peut éclairer des stratégies efficaces de contrôle et de prévention des maladies induites, contribuant ainsi à la sécurité sanitaire mondiale.
Mots-clés : parasites zoonotiques alimentaires, biodiversité, Chine, santé publique, protozoaires, helminthes

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INTRODUCTION

Foodborne zoonotic parasites are a group of parasites that can be transmitted from animals to humans through the consumption of contaminated food and water (Gabriël *et al.* 2022; WHO 2014). These organisms often have complex life cycles involving animal hosts and environmental reservoirs. When humans consume the infective stages of these parasites, typically found in meat, fish, or products that have not been adequately cooked, washed, or treated, they risk contracting the associated diseases, which can range from mild gastrointestinal discomfort to severe systemic illness (Newell *et al.* 2010). Foodborne zoonotic parasites pose a substantial public health risk, such as liver diseases, neurological disorders, and malnutrition. Understanding the biodiversity of foodborne zoonotic parasites is vital for developing effective prevention and control strategies.

China's vast landscape supports a wide range of biodiversity, including numerous species of animals and plants, some of which can harbour parasites that are transmissible to humans (Zhou *et al.* 2008). The agricultural environment, including livestock and crop farming practices, plays a crucial role in the transmission dynamics of zoonotic parasites. China's diverse dietary and cultural practices affect how food is prepared and consumed, influencing the risk of parasite transmission. Managing health care and preventive measures across such a large population with varying levels of access to health services compounds the difficulty of addressing these zoonotic threats. These parasites pose significant public health challenges due to their potential to cause both acute and chronic diseases. The importance of understanding the biodiversity of foodborne zoonotic parasites is underscored by China's large and diverse population.

This review aims to explore the biodiversity of foodborne zoonotic parasitic diseases prevalent in China, focusing on the variety of parasitic species affecting the population, their life cycles, and transmission dynamics. The objective of this review is to provide a detailed, scientifically sound exploration of the rich tapestry of foodborne zoonotic parasites in China. By doing so, it aims to support the development of more effective strategies for disease monitoring, control, and prevention, thereby reducing the burden of these diseases on the Chinese population. China, with its massive population and status as a global travel and trade hub, plays a critical role in the international spread of infectious diseases, including those caused by foodborne parasites. Enhanced understanding and management of these risks within China can contribute significantly to global health security.

OVERVIEW OF FOODBORNE ZOONOTIC PARASITES IN CHINA

Protozoan parasites

Toxoplasma gondii

T. gondii is a protozoan parasite widely studied for its ability to infect virtually all warm-blooded animals, including humans, making it one of the most successful parasites globally. The life cycle of *T. gondii* is complex and involves both the sexual and asexual phases. Sexual reproduction occurs exclusively in felines (wild and domestic) (Lourido 2019). Once ingested by the cat, the parasites form oocysts in the intestinal lining, which are then shed in the cat feces. These oocysts are highly resilient and can survive in the environment under various conditions. Asexual reproduction occurs in intermediate hosts, including humans, livestock, and wildlife. Infection in intermediate hosts usually occurs through the ingestion of oocysts from contaminated soil, water, or food (especially undercooked meat harbouring tissue cysts). These tissue cysts, which are predominantly prevalent in the brain and muscle tissues, can persist throughout the lifetime of the host. The most common route of infection in humans involves the consumption of undercooked or raw meat from infected animals (Tenter *et al.* 2000). In China, due to diverse culinary practices (barbecue, traditional Chinese fondue, hot noodles and raw ham…) that occasionally include the consumption of undercooked meat, this poses a significant risk. Additionally, unwashed raw vegetables, fruits, and untreated water contaminated with cat feces contribute to transmission (Pereira *et al.* 2010). If a woman contracts for the first time during pregnancy, the parasite can cross the placenta and infect the fetus, leading to congenital toxoplasmosis, which can cause miscarriage, neonatal death, or serious congenital defects. Although rare, *T. gondii* transmission can occur through organ transplantation or blood transfusion from infected donors (Ryning *et al.* 1979; Wesołowski *et al.* 2023).

Some systematic reviews and meta-analyses have evaluated seroprevalence in different hosts. Goats *T. gondii* had the highest seroprevalence in Southwestern China (13.3%) and the lowest in Northeastern China (7.3%) (Wei *et al.* 2021). A meta-analysis on the seroprevalence of *T. gondii* in food animals in mainland China from 2010 to 2023 showed that swine exhibited the highest seroprevalence of *T. gondii* at 23.2%. Following this, chickens had a seroprevalence of 19.9%, goats 13.0%, and sheep 11.3%. The lowest seroprevalence was observed in cattle (9.1%) (Yang *et al.* 2024). Cats in Central China, including the provinces of Hunan, Hubei, and Henan, characterized by a subtropical monsoon climate conducive to the survival and sporulation of oocysts in the wild, exhibit a higher seroprevalence than other regions (Ding *et al.* 2017). The first report of *T. gondii* seroprevalence in primary school children in Henan Province showed that the overall seroprevalence was 9.51% (Wang *et al.* 2020). The highest *T. gondii* infection seroprevalence in humans was recorded in Taiwan (23.41%), followed by Tibet (16.75%), and Jilin (12.14%).

Conversely, the lowest infection seroprevalence was observed in Beijing (0.72%), followed by Shanghai (1.59%), Hebei (1.64%), and Liaoning (1.80%) (Su *et al.* 2022). The high seroprevalence of *T. gondii* infection in Taiwan may be attributed to its subtropical monsoon climate and the accumulation of *T. gondii* oocysts in the environment. The high prevalence rate among humans and dogs in Tibet may be associated with economic development and sanitary conditions. In China, the predominant genotype of *T. gondii* isolated from various animals, such as pigs, cats, and dogs, is ToxoDB genotype #9, often referred to as the 'Chinese 1' genotype (Li *et al.* 2015). This genotype has been widely detected in different provinces, including Guizhou, Henan, and Hunan, suggesting its dominant presence in the country. However, other genotypes, such as ToxoDB #10 and ToxoDB #61, have also been identified in certain regions, indicating the genetic diversity of *T. gondii* isolates in China (Gui *et al.* 2018). These findings are important for understanding the epidemiology of toxoplasmosis and its public health implications in China, especially concerning food safety and zoonotic transmission.

Cryptosporidium spp.

Cryptosporidium spp. not only impact animal health but also poses risks to human health due to zoonotic transmission. The life cycle of *Cryptosporidium* is completed within a single host, resulting in diarrhoeal disease that affects both humans and animals. The life cycle initiates with the ingestion of oocysts, leading to the release of sporozoites that infect the epithelial cells of the gastrointestinal tract. These sporozoites develop into trophozoites, undergoing asexual multiplication (merogony) followed by sexual multiplication (gametogony), culminating in the formation of new oocysts excreted in feces. These oocysts can infect other hosts or reinfect the original host, thereby perpetuating the cycle (Tandel *et al.* 2019). In China, both humans and a diverse range of animals, including livestock (cattle, sheep, and goats), wildlife, and pets (particularly young animals), are susceptible to *Cryptosporidium* infection. The transmission of *Cryptosporidium spp.* primarily occurs via the fecal-oral route, especially through the ingestion of contaminated water or food. Dairy and beef cattle serve as reservoirs for zoonotic transmission to humans. Evidence of environmental contamination, including that in urban wastewater and on the surfaces of vegetables and fruits, highlights the risk of foodborne and waterborne outbreaks (Li *et al.* 2019; Liu *et al.* 2011).

The biodiversity of *Cryptosporidium* spp. in China is high. *C. parvum* and *C. hominis* are the most common species infecting humans. Species such as *C. muris*, *C. andersoni*, *C. bovis*, and *C. ryanae* are also prevalent, each adapted to specific hosts but with zoonotic potential (Ma *et al.* 2015; Yang *et al.* 2018). *C. meleagridis*, primarily known to infect birds, has also been reported in humans, indicating potential zoonotic or anthroponotic transmission (Liao *et al.* 2018). *C. felis* and *C. canis*, found in cats and dogs, respectively, underscore the risk from pet animals (Li *et al.* 2021) In rural southwestern China, owning livestock or poultry has been identified as a significant risk factor for *Cryptosporidium* infections. Waterborne transmission through contaminated water sources remains a critical risk factor, particularly in areas with inadequate water treatment facilities (Feng and Xiao 2017; Yang *et al.* 2017b). When pipes are damaged or deteriorated, they may allow contaminants, including *Cryptosporidium oocysts*, to enter the water supply. This issue has been linked to outbreaks where inadequate filtration, poor treatment processes, and contamination from surrounding environments contributed to high levels of *Cryptosporidium* in the water supply (Hayes *et al.* 1989; Hunter *et al.* 2011).

Giardia spp.

Giardia spp. are known to cause giardiasis, a prevalent gastrointestinal illness characterized by diarrhoea, abdominal pain, and malabsorption. The life cycle of *Giardia* is relatively simple, comprising two stages: trophozoites and cysts. The trophozoites represent the active feeding stage within the host intestine, where they proliferate through binary fission. When expelled into the environment with feces, trophozoites can encyst in response to stress factors such as exposure to air or dehydration. These cysts become infectious when ingested by a new host, typically through contaminated water or food, thereby completing their life cycle. Robust cysts can persist for weeks to months in cold, moist environments, rendering them highly effective in spreading infection (Thompson and Monis 2004). *Giardia spp.* are not host-specific and infect a broad range of mammals, including humans, cattle, dogs, and cats. The primary mode of transmission of *Giardia spp.* is the fecal-oral route, predominantly through the ingestion of contaminated water. This can occur through the direct consumption of contaminated surface water or through drinking water that has not been adequately treated. Foodborne transmission is also feasible, typically through the consumption of raw or undercooked food contaminated with cysts. Environmental contamination by animal feces, particularly in areas where livestock or wildlife are present, can also contribute to the spread of *Giardia*, posing significant risks to both human and animal health (Fan *et al.* 2021).

G. duodenalis, the most commonly reported species of *Giardia* in China, exhibits significant genetic variation. This variation is classified into multiple assemblages, which have implications for both epidemiology and public health (Zhang *et al.* 2019). In Sichuan Province, another study explored the presence of *Giardia duodenalis* in adult goats, identifying assemblage E as the predominant strain, with novel genotypes indicating a unique genetic makeup specific to the region (Zhong *et al.* 2018). The identification of both zoonotic and unique genotypes highlights the need for region-specific studies and interventions. Understanding these genetic variations can aid in developing targeted public health strategies to control and prevent *Giardia* infection in humans and animals. Continued surveillance and genetic studies on *Giardia duodenalis* across various regions of China are crucial. These efforts will help to better understand transmission dynamics, identify potential reservoirs of infection, and formulate effective control measures to mitigate the risk of zoonotic transmission.

Sarcocystis spp.

Sarcocystis spp. are a group of intracellular protozoan parasites prevalent in many terrestrial vertebrate species. The life cycle of *Sarcocystis spp.* consists of two major stages: the asexual phase in the intermediate host, and the sexual phase in the definitive host. Intermediate hosts, such as livestock, rodents, or even humans, harbour *Sarcocystis* in their muscle tissues. When a definitive host, usually a predator such as a dog or snake, consumes the infected meat, the parasites undergo sexual reproduction in the intestines of the predator, leading to the formation of oocysts that are eventually shed in feces. These oocysts release sporocysts that can infect new intermediate hosts if ingested, thereby completing their life cycle. The transmission of *Sarcocystis* spp. primarily occurs through the ingestion of food or water contaminated with sporocysts from the feces of definitive hosts. Research has documented the presence of *Sarcocystis spp.* in alpacas, with dogs acting as definitive hosts, completing their life cycle through experimental infections (Wu *et al.* 2022). Other studies have found similar dynamics in Norwegian rats, with king rat snakes as definitive hosts (Hu *et al.* 2022). *Sarcocystis spp.* has been documented in numerous animal hosts across China. *Sarcocystis mansoni* has been identified in alpacas in Henan Province, indicating both the adaptation of this species to non-native hosts and its potential spread due to the introduction of new livestock species into the region (Jiang *et al.* 2021). In Tibetan sheep, the prevalence and morphological diversity of *S. gigantea* have been studied extensively, highlighting the role of traditional grazing systems in the transmission and maintenance of the parasite life cycle (Sun *et al.* 2021). Similar studies in goats from the Kunming area have documented the prevalence and molecular characteristics of *S. capracanis* and *S. hircicanis* (Hu *et al.* 2016). A meta-analysis of the prevalence of *Sarcocystis* infections among ruminants in China showed a high prevalence (65%) (Zhu *et al.* 2022), emphasizing the need for continuous monitoring and control measures to reduce threats to both human health and the livestock industry.

Balantidium coli

B. coli is a protozoan parasite of significant zoonotic potential, primarily affecting pigs as reservoir hosts but capable of infecting a variety of other hosts, including humans. The life cycle of *B. coli* includes two stages, trophozoites and cysts. Trophozoites reside in the host's colon, where they can invade the intestinal mucosa, causing ulceration and dysentery. Trophozoites undergo encystation to form cysts that are excreted in feces. Infection in a new host occurs through the ingestion of cysts from contaminated water or food, after which the cysts excyst in the small intestine to release trophozoites and start the cycle anew. Transmission primarily occurs via the fecal-oral route, through the consumption of contaminated food or water. The cysts are resistant to environmental stresses, which allow them to survive outside the host for extended periods and contribute to the spread of the infection (Ponce-Gordo and García-Rodríguez, 2021). In China, the prevalence of *B. coli* is high in areas with intensive pig farming. Investigations have shown a significant presence of this parasite in various provinces, including Shaanxi and Hunan, highlighting both the widespread nature of this parasite and local variations in prevalence due to differing farming practices and sanitary conditions (Li *et al.* 2020; Yin *et al.* 2015). Human infections with *B. coli* are rare in China, and cases have been reported, highlighting the importance of considering this parasite in the differential diagnosis of dysentery in regions where contact with pigs or consumption of contaminated water may occur (Yu *et al.* 2020). Studies on pigs revealed the presence of two primary genotypes, A and B, with genotype B being the more prevalent variant across different farms and regions. The genetic diversity of *B. coli* was also observed across different age groups of pigs, with both genotypes coexisting in the population (Li *et al.* 2020; Wang *et al.* 2011).

Blastocystis hominis

B. hominis is a common intestinal protist found in humans and a wide variety of animals. The life cycle of *B. hominis* involves several stages, including vacuolar, granular, amoeboid, and cystic forms. The cyst is typically transmitted between hosts. Once ingested, cysts transform into other forms within the host's gastrointestinal tract, primarily in the vacuolar form, which is considered the predominant stage observed in fecal samples. Transmission of *B. hominis* primarily occurs through the fecal-oral route, with cysts at the infectious stage. Contaminated water, food, or direct contact with fecal material are common pathways for the spread of the parasite. The environmental resilience of cysts contributes to the widespread nature of the infection. The biodiversity of *B. hominis* in China is reflected in the variety of subtypes identified across different host species and regions. Studies have shown the presence of multiple genetic subtypes in human and animal populations, indicating significant genetic variability. A study focusing on isolates from different individuals revealed that subtype 1 is particularly prevalent in China, suggesting that it might have a stronger association with pathogenic potential than other subtypes. This finding indicates that certain subtypes are more likely to cause symptoms in infected individuals (Yan *et al.* 2006). This genetic diversity is crucial for understanding the epidemiology and potential impact of *Blastocystis* infections in diverse ecological settings. An epidemiological survey in Huainan City highlighted the prevalence of *B. hominis* among different population groups, including infants, students, and patients with diarrhoea. The infection rates varied, indicating that hygiene practices, age, and health status may influence the likelihood of acquiring *Blastocystis* (Wang *et al.* 2002). A study of *Blastocystis* in animals, such as pigs, cattle, and sheep, in Heilongjiang Province has provided insights into the zoonotic potential of this organism. The identification of subtypes shared between humans and animals underscores the importance of animals as reservoirs of human infections (Wang *et al.* 2018b).

Helminthic parasites

Trichinella spp.

Trichinella spp. are parasitic nematodes that cause trichinellosis, a zoonotic disease affecting a wide range of hosts, including humans. *Trichinella* completes its life cycle within a single host, from larval to adult stage. The larvae were initially ingested by the host from contaminated meat. They then mature into adults in the intestines, reproduce, and their newborn larvae migrate to the muscle tissues where they encyst, becoming infective to the next host that consumes this meat (Dupouy-Camet 2000). A variety of animals, including domestic pigs, wild boars, and rats, act as hosts. Transmission to humans generally occurs through the consumption of undercooked or raw meat containing encysted larvae. In some regions, particularly rural and mountainous areas, traditional practices of feeding pigs raw garbage contribute to maintaining the life cycle of *Trichinella* (Cui and Wang 2011).

The presence of *Trichinella spp.*, including *T. spiralis* and *T. nativa*, has been documented widely across China (Bai *et al.* 2017; Liu and Boireau, 2002; Liu *et al.* 2021). As shown in Figure 1, significant infection rates of *Trichinella spp.* are found in regions such as Yunnan, Henan, Inner Mongolia and Sichuan, and their seropositivity rates were 4.29%, 6.00%, 19.61% and 21.94%, respectively (Zhang *et al.* 2022). These areas feature conditions conducive to the spread of trichinellosis, such as poor pig meat inspection practices and the prevalent use of raw meat in local diets (Cui and Wang 2011; Cui *et al.* 2011; Liu and Boireau, 2002; Zhang *et al.* 2022). In Northeast China, there is *T. nativa* owing to the presence of suitable wild carnivore hosts and a cold climate (Wang *et al.* 2007). In addition, the infection of pigs with trichinellosis is widespread in China, and serological tests have detected signs of infection with trichinellosis in pigs in all 11 provinces (Zhang *et al.* 2022). From the perspective of infection intensity, infections were particularly severe in Guangxi, Henan, Qinghai and Xinjiang (Figure 2). However, it is noteworthy that only Henan among these four regions had reported cases of human infection with *Trichinella spp.* This may be attributed to the fact that the symptoms caused by trichinellosis are relatively mild or that the volume of infection is low, making it easy for cases to be underdiagnosed. The widespread presence and high infection rates of *Trichinella* spp. in China highlight the need for improved meat inspection protocols and public health intervention. Education on safe meat consumption practices with enhanced surveillance of wild and domestic animal populations is crucial for mitigating the risk of trichinellosis.

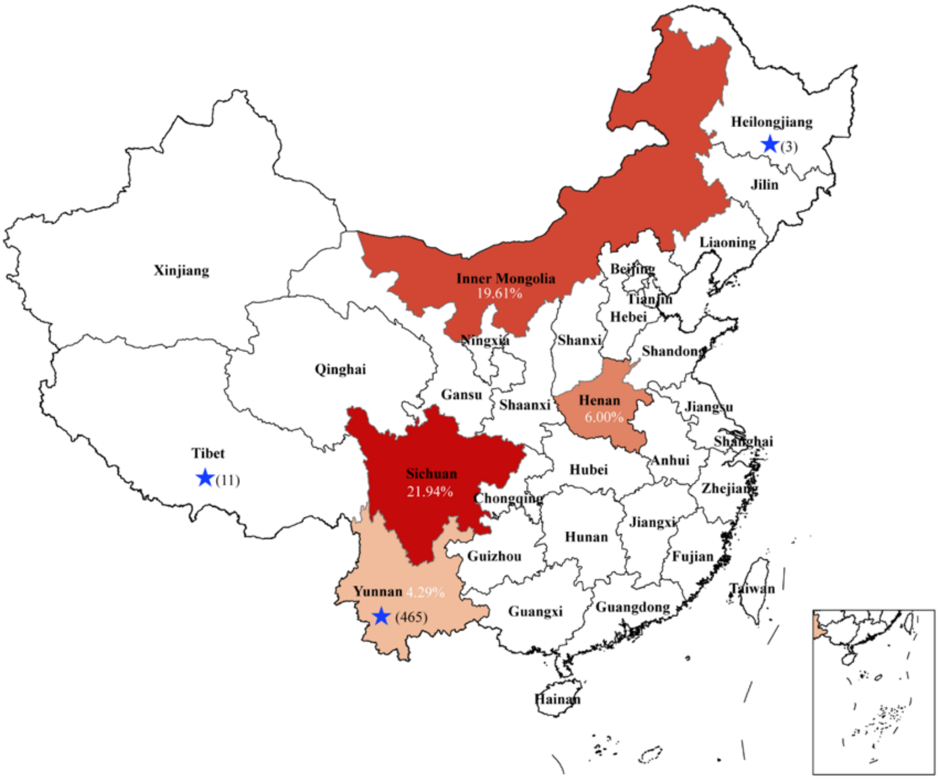

Figure 1. Area distribution of human trichinellosis in China, 2009-2020.
The colour shades are used to visualise the different seroprevalence of human trichinellosis in provinces/municipalities (P/Ms) of China, 2009-2020. Specific prevalence rates are presented as percentages. And the number of human cases of trichinellosis in Heilongjiang Province, Yunnan Province and Tibet Autonomous Region are clearly labelled with specific values in the figure. In particular, the white background of a province means that there is a lack of relevant statistics for that province and the data have not yet been included or published.

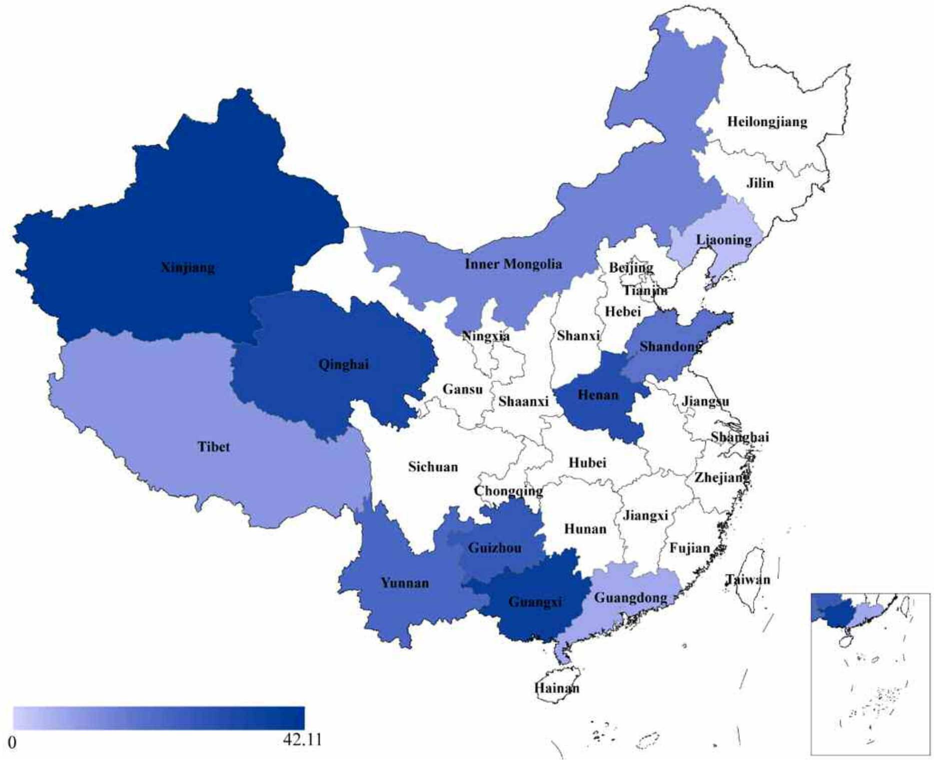

Figure 2. *Area distribution of swine trichinellosis in China, 2009-2020.*
The colour shades are used to visualise the different seroprevalence of swine trichinellosis in provinces/municipalities (P/Ms) of China, 2009-2020. In particular, the white background of a province means that there is a lack of relevant statistics for that province and the data have not yet been included or published.

Anisakis spp.
Anisakis spp. are parasitic nematodes that are found in marine environments. *Anisakis spp.* have an indirect life cycle that involves multiple hosts. Adult worms live in the stomachs of marine mammals, such as dolphins and whales. Eggs are released into the sea through the feces of the host. Upon hatching, the larvae are ingested by crustaceans and then eaten by fish or squids, thereby transferring the larvae to these secondary hosts. Humans and other mammals can become accidental hosts by consuming infected raw or undercooked fish, thereby leading to anisakiasis. In China, studies have shown *Anisakis* infections in various fish species sold in the market, indicating a broad range of intermediate hosts. For example, an epidemiological survey in the Yellow Sea identified *A. pegreffii* (25%) from eight different fish species, including *Astroconger myriaster*, *Clupea pallasi*, *Coryphaena hippurus*, *Lophius titulon*, *Mugil cephalus*, *Pneumatophorus japonicus*, *Scomberomorus niphonius* and *Sebastiscus marmoratus* (Zhang *et al.* 2007). *A. pegreffii* was the predominant species accounting for 84.8% of all larvae examined in the East China Sea and *A. simplex sensu stricto* is also identified from fish (Kong *et al.* 2015). The identification of *Anisakis spp.* among various fish species in the Yellow Sea and East China Sea highlights the need for comprehensive public health measures. This should include stricter surveillance of fish markets, improved inspection protocols, and consumer education on safe fish consumption practices to mitigate the risk of anisakiasis in China.

Gnathostoma spp.
Gnathostoma spp. are parasitic nematodes that cause gnathostomiasis, a zoonotic disease affecting both humans and animals. The life cycle of *Gnathostoma spp.* typically involves multiple intermediate hosts before reaching a definitive host. The early life stages include eggs expelled by the definitive host into freshwater environments, where they hatch into larvae. These larvae are then ingested by small crustaceans (the first intermediate host), such as copepods. The larvae develop within these copepods until they are eaten by larger secondary intermediate hosts, which are usually fishes, eels, frogs, or snakes. Humans become incidental hosts by consuming undercooked or raw meat from these secondary hosts harbouring infective larvae. Humans usually acquire *Gnathostoma* infection through dietary habits, including the consumption of raw or undercooked freshwater fish or eels, which may contain third-stage larvae of the parasite. This is the principal route of transmission that causes human gnathostomiasis (Herman Joanna and Chiodini Peter 2009). The biodiversity of *Gnathostoma* species in China is notable, with various species being identified across different regions, highlighting their ecological adaptation and medical significance. *G. doloresi* and *G. hispidum* have been identified in areas close to freshwater bodies where intermediate hosts, such as fish, are commonly found (Cho *et al.* 2007; Sun *et al.* 2016).

Ascaris suum
A. suum is a parasitic nematode primarily affecting pigs, but it can also infect humans, causing ascariasis. The life cycle of *Ascaris suum* involves several stages, and typically occurs in a single host. The eggs are excreted in the feces of infected pigs and need to be incubated in the environment for approximately 2-4 weeks to become infective. Once ingested by another pig, eggs hatch in the intestines, releasing larvae that migrate through the liver and lungs. After reaching the lungs, the larvae are coughed and swallowed, returning to the intestine to mature into adult worms. This migration is crucial, as it contributes to significant morbidity in infected pigs, often complicating infection dynamics (Holland 2021). The primary route of transmission of *A. suum* is the fecal-oral route. There is growing evidence that *A. suum* can also infect humans, particularly in regions where humans are in close contact with pigs or pig fecal matter. This zoonotic potential complicates control measures for ascariasis in regions where both pigs and humans are commonly infected (Zhou *et al.* 2012). This parasite is found throughout China, with a notable prevalence in pig-producing areas. For instance, in Sichuan Province, which is a major hub for pork production, the prevalence (mean seroprevalence being > 60%) of *A. suum* can vary significantly across different farms, reflecting the diverse management practices and environmental conditions that influence the parasite's life cycle and transmission (Zheng *et al.* 2020).

Angiostrongylus cantonensis
A. cantonensis, also known as the rat lungworm, is a parasitic nematode that causes angiostrongyliasis, a zoonotic disease primarily affecting the central nervous system. Definitive hosts are rats, where adult worms reside in the pulmonary arteries and the heart. The female worms release larvae (first-stage larvae, L1) into the rat's bloodstream, which are then expelled through feces. The intermediate hosts are primarily snails and slugs. The larvae are ingested by these molluscs, where they develop into third-stage larvae (L3), the infectious stage for rats and accidental hosts, including humans. Human infection generally occurs when individuals consume raw or undercooked snails or slugs that carry the infective L3 larvae. In some cases, the consumption of contaminated vegetables or water can also lead to infection. The larvae migrate to the brain, causing eosinophilic meningitis, but do not complete their life cycle in humans (Zhang *et al.* 2008). The first national survey on the natural location of *A. cantonensis* identified its presence across 19 provinces in mainland China, with a higher prevalence detected in Fujian (36.6%), Jiangxi (19.9%), Zhejiang (16.0%), Hunan (5.0%), Guangdong (6.3%), Guangxi (39.1%) and Hainan (25.0%). This wide distribution is linked to the presence of the snail *Pomacea canaliculata*, a main intermediate host that facilitates the parasite's life cycle and transmission (Zhang *et al.* 2009). Addressing this public health challenge requires a multifaceted approach, including surveillance, public education, and environmental management, to reduce the risk of angiostrongyliasis.

Capillaria philippinensis
C. philippinensis is a parasitic nematode causing intestinal capillariasis, with a presence noted in various regions, including China. The life cycle of *Capillaria philippinensis* includes both definitive and intermediate hosts. Adult worms reside in the intestines of birds, mammals, and humans. Females lay eggs that pass through the feces. If these eggs reach the water, they can be ingested by freshwater fish, where they hatch into larvae. These larvae mature in fish until they reach the infection stage. When birds or mammals consume infected fish, the cycle continues. The primary route of transmission in humans is through the ingestion of raw or undercooked freshwater fish that harbour infective larvae. In humans, this parasite can cause severe gastrointestinal disturbances and can be fatal if not promptly treated. A documented case of *C. philippinensis* in Hainan Province highlights its presence and challenges in diagnosing this infection. The patient experienced chronic diarrhoea and severe weight loss due to the parasite, which was initially misdiagnosed (Fan *et al.* 2012).

Toxocara canis
T. canis, a zoonotic nematode of significant public health concern, is primarily transmitted through direct contact with infected canids or ingestion of contaminated soil, water, or undercooked meat from paratenic hosts. Epidemiological studies indicate notable prevalence variations among populations and regions, influenced by environmental and dietary factors. In humans, seroprevalence rates have been documented between 11% and 52%, with rural and agriculturally active communities exhibiting the highest exposure risks due to close proximity to infected soil or domestic animals. Among food-producing animals, chickens demonstrate a prevalence ranging from 12.7% in experimental studies to as high as 93.3% in serological surveys conducted on semi-free-range broilers in Brazil, underscoring the role of poultry in the transmission cycle. Similarly, pigs and sheep show variable infection rates, with sheep prevalence correlating with age and exposure to contaminated grazing areas (Xu and Han 2024). These findings underscore the importance of targeted epidemiological surveillance and stringent food safety measures to mitigate the risk of *T. canis* infection in humans and animals alike.

Taenia spp.
Taenia spp. are represented by several species, including *T. solium*, *T. saginata,* and *T. asiatica*, each with specific life cycles and hosts. Pigs are intermediate hosts for *T. solium* and *T. asiatica*, where the larvae form cysts primarily in the muscles and sometimes in the liver. The cattle serve as intermediate hosts for *T. saginata*, harbouring cysts in their muscles. Adult tapeworms reside in the intestines of humans. Transmission to humans occurs through the consumption of undercooked or raw meat from infected intermediate hosts. Surveys and studies in regions such as the Tibetan area of Sichuan Province have shown a high prevalence (22.5%) of taeniasis, with *T. saginata* being notably dominant. These studies indicate significant public health concerns associated with taeniasis, driven by poor sanitation and traditional consumption of undercooked meat (Li et al. 2006). *T. asiatica* is particularly significant in China, found mostly in the Southern and Eastern provinces. This species is closely associated with the

consumption of raw pork liver, a common practice in some ethnic communities. The presence of *T. asiatica* alongside *T. solium* and *T. saginata* illustrates a diverse taeniid fauna within China, influenced by dietary habits and the regional prevalence of intermediate hosts, such as pigs and cattle (Ito *et al.* 2019). The persistent presence of *Taenia spp.* in China can be attributed to several interlinked factors. Poor hygiene and lack of regulation in slaughterhouses contribute to the persistence of *Taenia spp.* These parasites often remain in infected meat that is improperly handled or inadequately inspected. Inadequate meat inspection and failure to properly cook or freeze infected meat can lead to human infections when undercooked meat is consumed (e.g. pork in the case of *T. solium*). And in rural China, many pigs are raised in close proximity to human latrines or unsanitary waste disposal systems. This increases the likelihood of pigs ingesting eggs of *Taenia spp.* that are excreted by infected individuals. Infected pigs then become hosts for the larvae, which can eventually be transmitted to humans through the consumption of undercooked pork or exposure to contaminated water and food. These traditional farming and hygiene practices, combined with insufficient public health controls in some areas, have helped sustain the prevalence of *Taenia spp.* in the region.

Echinococcus spp.

Echinococcus species in China, specifically *E. granulosus* and *E. multilocularis*, play significant roles in zoonotic diseases, such as cystic and alveolar echinococcosis. The life cycle of *Echinococcus spp.* includes definitive and intermediate hosts. Typically, dogs and other canids are definitive hosts, where adult tapeworms reside in the intestines. Eggs are shed in the feces of these hosts. Usually intermediate hosts livestock like sheep for *E. granulosus* and small mammals (e.g. rodents) for *E. multilocularis*. The larvae (oncospheres) hatch from ingested eggs, penetrate the intestinal wall, and form hydatid cysts in the liver, lungs, and other organs. Humans become accidental intermediate hosts by ingesting eggs, leading to cyst formation in organs, which is severe and can be fatal if untreated. Transmission to humans and intermediate hosts occurs through the ingestion of food, water, or soil contaminated with feces from infected definitive hosts (Romig *et al.* 2017). *Echinococcus spp.* are primarily found in pastoral and farming regions in western and northwestern China, where practices such as free-ranging livestock and close contact between domestic animals and wild canids facilitate the life cycle of these parasites. For example, research from 2013 to 2014 documented a prevalence of 4.03% in Yushu and Guoluo counties in Qinghai Province (Han *et al.* 2019). The highest human prevalence rates are observed in these areas due to environmental, biological, and social factors influencing the transmission dynamics of these parasites (Fu *et al.* 2021). A new species of *Echinococcus shiquicus* was found from the Tibetan fox *Vulpes ferrilata* and the plateau pika (Zhu *et al.* 2020).

Spirometra spp.

Spirometra spp., particularly *S. erinaceieuropaei* and *S. decipiens*, found in China are parasitic tapeworms that cause sparganosis, a notable parasitic disease affecting humans and animals. *Spirometra spp.* has a complex life cycle involving multiple hosts: first intermediate hosts: typically aquatic crustaceans, like copepods, which ingest the parasite's eggs. Inside these hosts, the eggs hatch into procercoid larvae. Second intermediate host: a wide range of vertebrates, including frogs, snakes, and occasionally mammals, where procercoids develop into plerocercoid larvae, the stage that is infectious to the next host. Definitive hosts: cats and dogs, where plerocercoids mature into adult tapeworms in the intestines. Humans are accidental hosts and can be infected by the plerocercoid stage but do not support the adult stage of the parasite (Okino *et al.* 2017). *Spirometra spp.* are particularly prevalent in Southern China, notably in provinces like Guangdong. This region accounts for 16.1% of all human sparganosis cases reported nationwide. The region's dietary habits, including the consumption of raw or minimally processed frog and snake meat, facilitate the transmission of sparganosis (Wang *et al.* 2018a). Studies have identified *S. erinaceieuropaei* and *S. decipiens* as the primary species involved in infections. The mitochondrial genomes of *S. erinaceieuropaei* from China exhibit near-identical sequences, supporting their close evolutionary relationship (Liu *et al.* 2012). Notably, *S. decipiens* has been found in various hosts, including snakes, with no marked genetic differentiation observed across populations (Gong *et al.* 2021).

Diphyllobothrium spp.

Diphyllobothrium species in China, specifically *D. latum* and *D. nihonkaiens*, is a fish-borne zoonotic parasite that causes diphyllobothriasis in humans. The parasite's eggs are passed in the feces of infected humans or other mammals. The eggs hatch in freshwater, releasing coracidia, which are then ingested by copepods, turning into procercoid larvae. Fishes eat the infected copepods, and the procercoid larvae develop into plerocercoids in the fish's muscle tissue. Humans or other mammals become infected by consuming raw or undercooked fish containing plerocercoid larvae, which mature into adult tapeworms in the intestines. Molecular identification techniques have confirmed its presence and variability in the northeast of China, where consumption of raw freshwater fish is frequent (Guo *et al.* 2012). Among the 20 cases of *Diphyllobothrium* infections reported in mainland China, species identification through molecular analysis confirmed both *D. latum* and *D. nihonkaiense* as aetiological agents. *D. nihonkaiense* appears to be a dominant species in certain regions, like Heilongjiang Province (Zhang *et al.* 2015). *D. nihonkaiense* has been found in cases linked to the consumption of imported Pacific salmon. This highlights the zoonotic potential and necessity for improved monitoring of fish-borne diseases (Cai *et al.* 2017).

Hymenolepis spp.

Hymenolepis spp. including *Hymenolepis nana (Rodentolepis nana)* and *Hymenolepis diminuta* are tapeworms infecting humans, particularly in areas with poor hygiene and sanitation. It can complete its life cycle without an intermediate host. Eggs released in the feces of the definitive host can directly infect other hosts when ingested. The primary route of transmission is through the ingestion of food or water contaminated with feces containing eggs. It is found widely across China, with varying prevalence rates depending on regional hygiene practices, proximity to rodent populations, and socioeconomic conditions. In Guangdong, high prevalence rates (25.62%) of *H. diminuta* are observed in rodent populations, with *Rattus norvegicus* and *Rattus flavipectus* serving as primary reservoirs (Jun 2004). The prevalence of *H. nana* (6.1%) and *H. diminuta* (14.9%) among rodents in Heilongjiang province is particularly notable, providing insight into zoonotic potential and public health risks (Yang *et al.* 2017a).

Clonorchis sinensis

C. sinensis, also known as the Chinese liver fluke, is a parasitic worm that primarily affects the liver of humans and other mammals. Their eggs are excreted in the feces of infected hosts and must reach freshwater to develop. Freshwater snails ingest the eggs, which develop into sporocysts, then rediae, and finally cercariae. Cercariae are released into the water and penetrate the skin of freshwater fish, where they encyst as metacercariae in the fish's flesh. Humans and other mammals become infected by consuming raw or undercooked fish containing metacercariae. Once ingested, the metacercariae excyst in the duodenum and ascend through the biliary tract to mature into adult flukes in the bile ducts. The primary route of contamination is dietary, through the consumption of raw or undercooked freshwater fish contaminated with metacercariae (Lun *et al.* 2005). *C. sinensis* is endemic with a significant prevalence (5.33%) in China, particularly in the southeastern regions, such as Guangdong and Guangxi provinces, and along major river basins where freshwater fish are abundant (Huang *et al.* 2017). The parasite has a broad range of intermediate fish hosts, with specific species varying by local ecological conditions. Studies have shown that certain fish families, such as the *Cyprinidae*, are particularly susceptible to infection (Huang *et al.* 2017; Lun *et al.* 2005). Effective control measures, including surveillance, public education, and environmental management, are crucial to reducing the prevalence and impact of this parasitic infection. According to the results of the latest survey on clonorchiasis, a total of 18 provinces/municipalities in China are infected with *Clonorchis* (Chen *et al.* 2020). Among them, Guangxi, Guangdong, Heilongjiang, Jilin, Jiangxi and Guizhou have relatively high prevalence rates (Figure 3), which is broadly similar to previous reports of infection (Lun *et al.* 2005). However, of particular concern is the increase in the prevalence of clonorchiasis infection in Jiangxi Province. In addition, there are several reports in the literature of high levels of infection in Jiangxi (Huang *et al.* 2020), which further highlights the importance of strengthening surveillance and control in this region in the future (Ge J 2020).

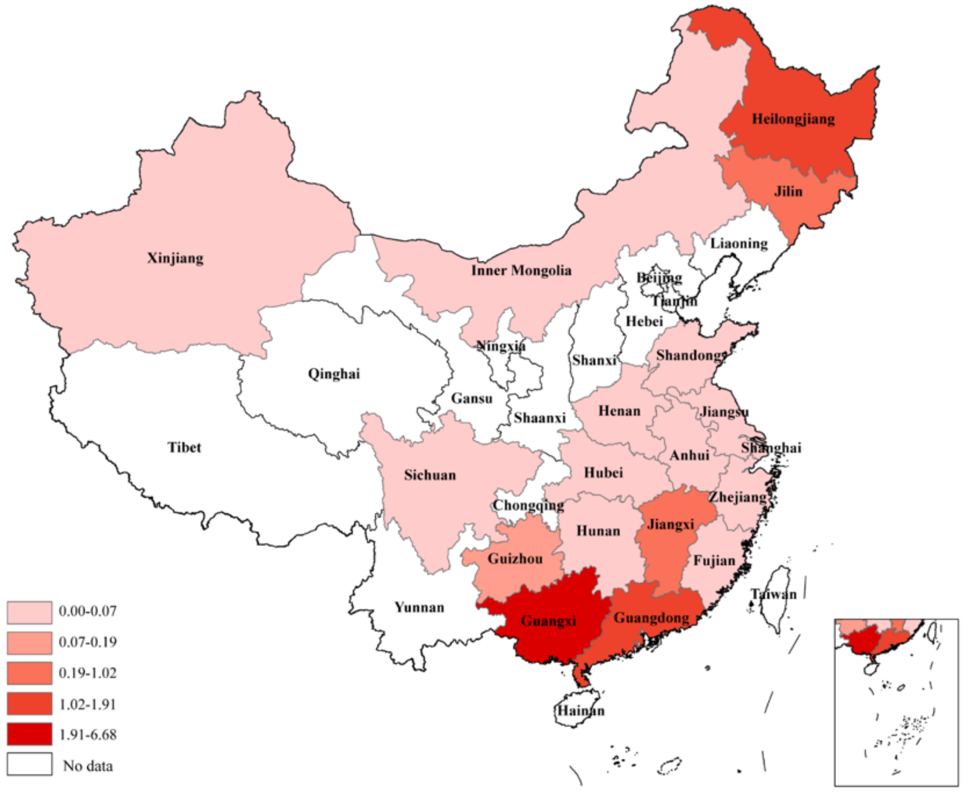

Figure 3. *Area distribution of human clonorchiasis in China, 2015.*
The colour shades are used to visualise the different prevalence of clonorchiasis infection in provinces/municipalities (P/Ms) of China, 2015. In particular, the white background of a province means that there is a lack of relevant statistics for that province and the data have not yet been included or published.

Paragonimus spp.

Paragonimus spp., commonly known as lung flukes, represent a significant group of parasitic flatworms responsible for the zoonotic disease paragonimiasis. The life cycle of *P. westermani* involves two intermediate hosts and a definitive host. The cycle begins when eggs are excreted in the sputum or feces of an infected host. Once in water, the eggs embryonate and release miracidia, which infect freshwater snails (first intermediate host). Within the snail, the miracidia undergo several developmental stages, eventually becoming cercariae. These cercariae leave the snail and infect freshwater crabs or crayfish (second intermediate host), where they encyst as metacercariae. Humans or other mammals (definitive hosts) become infected by consuming raw or undercooked infected crustaceans. *Paragonimus* is predominantly found in the southern and eastern regions, where conditions are favourable for its intermediate hosts, including various species of freshwater snails and crabs (Chen *et al.* 2001; Ryu *et al.* 2000). *P. westermani*, *P. skrjabini*, and *P. heterotremus* are the most clinically significant, with the first two widely distributed across the country and the latter more regionally confined to southern provinces (Zhou *et al.* 2021). The prevalence of this parasite in China is associated with cultural dietary habits, particularly the consumption of raw or undercooked freshwater crabs, which is common in some local cuisines. In Jiangxi Province, the prevalence in snails (first intermediate hosts) was 0.21%, and in crabs (second intermediate hosts) reached 54.3%, indicating persistent local transmission cycles (Yan *et al.* 2004). In Sichuan, serological surveys of human populations reported infection rates of approximately 1.32%, while crab infections averaged 13.83% (Chen *et al.* 2015). *P. westermani* displays significant genetic diversity, which has been attributed to its complex life cycle and range of intermediate hosts (Doanh *et al.* 2009). China remains a hotspot for paragonimiasis, with significant public health implications tied to its biodiversity of *Paragonimus* spp. and their hosts. Further monitoring and control measures, including public education on safe dietary practices and habitat management, are critical to mitigating its impact.

Fasciolopsis buski

F. buski is a significant zoonotic parasite found in China, known for causing fasciolopsiasis, a serious intestinal infection. The life cycle of *Fasciolopsis buski* involves two primary hosts: snails and mammals. Adult flukes reside in the intestines of mammals such as pigs and humans. Eggs are excreted with feces into freshwater bodies where they hatch into miracidia, which infect suitable snail hosts like *Segmentina hemisphaerula*. Inside the snail, the miracidia develop into cercariae, which are then released into the water. These cercariae encyst on aquatic plants like metacercariae, which are the infective stage for mammals. When humans or pigs consume these contaminated plants, the metacercariae excyst in the duodenum, develop into adult flukes, and complete the life cycle (Kuntz and Lo 1967). *F. buski* primarily infects pigs and humans, with pigs often acting as a significant reservoir host. The parasite's transmission to humans typically occurs through the consumption of raw or undercooked aquatic plants such as water chestnut, water caltrop, and lotus, which harbour the encysted metacercariae.

Surveys have shown that children are disproportionately affected, with prevalence rates reaching up to 57% in certain endemic regions of mainland China (Graczyk *et al.* 2001). The distribution of *F. buski* in China is largely influenced by the presence of suitable snail hosts and aquatic plants. The parasite is endemic in regions where these conditions are met, particularly in rural and semi-urban areas with significant pig farming and poor sanitation practices. Notably, central China, including regions like Jiangsu and Guangdong, are known endemic areas for *F. buski*. In these regions, the incidence of infection is correlated with agricultural practices that involve the use of contaminated water for crop irrigation (Ma *et al.* 2017).

Opisthorchis spp.

Opisthorchis spp., particularly *O. viverrini* and *O. felineus*, are significant zoonotic parasites found in China. These liver flukes cause opisthorchiasis, a serious disease that can lead to cholangiocarcinoma, a type of bile duct cancer. The life cycle of *Opisthorchis spp.* involves multiple hosts. The adult flukes reside in the bile ducts of definitive hosts, including humans, cats, and dogs. Eggs are excreted in the host's feces into freshwater bodies, where they are ingested by the first intermediate host, freshwater snails of the genus *Bithynia*. Inside the snail, the miracidia hatch and develop into sporocysts, rediae, and cercariae. The cercariae are then released into the water, where they infect the second intermediate host, a freshwater fish, encysting as metacercariae in the fish's muscles. Humans and other definitive hosts become infected by consuming raw or undercooked infected fish. Once ingested, the metacercariae excyst in the duodenum, migrate to the bile ducts, and mature into adult flukes, completing the life cycle (Harinasuta and Harinasuta, 1984). Transmission occurs primarily through the consumption of raw or undercooked fish containing metacercariae. In China, traditional dietary practices involving raw fish dishes contribute significantly to the transmission of these parasites (Petney *et al.* 2013). The distribution of *Opisthorchis spp.* is influenced by the presence of suitable snail and fish hosts and local dietary practices. The prevalence of *O. viverrini* infection varies with environmental conditions and land use practices, such as irrigation in rice paddies, which create ideal habitats for the snail hosts (Petney *et al.* 2013). In China, *O. viverrini* is predominantly found in Southern and Southeastern regions, where freshwater fish are a dietary staple. *O. felineus* infections have been reported sporadically in northern China. Cases of infection are rare in China, and data on prevalence in China are limited (Qian *et al.* 2024).

Echinostoma spp.

Echinostoma spp. are important zoonotic parasites found in China, known to cause echinostomiasis. The life cycle of *Echinostoma spp.* involves several hosts. Adult flukes reside in the intestines of definitive hosts, such as birds and mammals. Eggs are excreted with the host's feces into freshwater bodies, where they hatch into miracidia. These miracidia infect suitable first intermediate hosts, typically freshwater snails. Inside the snail, the miracidia develop into sporocysts, rediae, and eventually cercariae. The cercariae are then released into the water, where they encyst as metacercariae on aquatic plants or second intermediate hosts, such as fishes and amphibians. Humans and other definitive hosts become infected by consuming these contaminated plants or hosts. Once ingested, the metacercariae excyst in the duodenum and develop into adult flukes, completing the life cycle (Ahn and Ryang 1986). *E. revolutum* is one of the most widely distributed and studied among the *Echinostoma spp*. It has been found in various regions across China and is known for its morphological complexity and genetic diversity (Georgieva *et al.* 2014; Li *et al.* 2022).

DISCUSSION

The diverse array of foodborne zoonotic parasites in China poses a significant public health challenge, reflecting the country's rich ecological landscapes and agricultural diversity that harbour a myriad of parasitic species. This extensive biodiversity complicates the control and prevention of zoonotic diseases due to the intricate life cycles, diverse hosts, and multiple transmission pathways involved. Addressing this complexity necessitates a multifaceted approach to control and prevention strategies.

The intricate interplay of environmental, agricultural, and cultural factors demands a comprehensive response to alleviate the burden of these diseases. This approach should encompass heighted public health education, improved sanitation practices, and stringent regulatory measures to safeguard food safety. Critical interventions include enhancing water and food sanitation infrastructure and advocating for good hygiene practices through public health campaigns to combat the transmission of parasites like *E. histolytica* and *Giardia spp*. Targeted strategies to manage intermediate hosts, such as snails for *A. cantonensis*, and ensuring access to clean water sources are vital in reducing the incidence of various parasitic infections. Public awareness initiatives on the risks associated with consuming raw or undercooked meat and fish can help mitigate infections from parasites such as *T. gondii*, *Trichinella spp.*, and *Anisakis spp.* additionally, implementing improved livestock management practices, including regular veterinary monitoring and proper waste disposal, can effectively control the spread of parasites such as *Cryptosporidium spp.* and *A. suum*.

Over the past few decades, there has been a significant rise in the number of cat owners in urban China. For example, it was estimated that approximately 100 million cats were considered pets in 2010 in China, with a growth rate of 10% over the subsequent years (Chen *et al.* 2016). This increase in pet ownership, particularly of cats, which are known to be the definitive hosts of *T. gondii*, raises concerns about the potential long-term implications for public health. As more people interact with domestic cats, the risk of exposure to *T. gondii* oocysts in the environment also increases. Consequently, this could lead to a higher seroprevalence of toxoplasmosis in urban populations, as the parasite's transmission through feline feces becomes more widespread. The increasing trend in cat ownership in China suggests that, in the future, the prevalence of toxoplasmosis among humans, particularly in urban areas, may rise, potentially posing a public health challenge.

Wildlife plays a critical role in the ecology of foodborne zoonotic parasites, often acting as reservoirs that maintain and spread these parasites within ecosystems. The wide range of wildlife species, from small mammals to birds and aquatic animals, serves as both intermediate and definitive hosts, allowing zoonotic parasites to thrive in diverse environments. These wildlife reservoirs provide a critical bridge for parasites to cross from natural habitats to human populations, either directly or through contact with domestic animals. This reservoir role enhances the risk of zoonotic spillover events, which can lead to new outbreaks of parasitic diseases in humans. To mitigate these risks, it is essential to understand the interactions between wildlife and zoonotic parasites, particularly the factors that allow these parasites to persist in wildlife populations and subsequently spill over into human communities. Effective control and surveillance strategies must consider wildlife management as a key element to disrupt the life cycle of zoonotic parasites and reduce the potential for transmission to humans. Wildlife plays a significant role in the ecology of foodborne zoonotic parasites, particularly in the context of live animal markets, where various species—including domestic and semi-wild animals—are sold. This issue became more prominent after the COVID-19 crisis, where the potential for zoonotic diseases to spread through these markets gained widespread attention. Post-COVID-19, significant regulatory changes were implemented in China, particularly in the management of wild live animal markets. China introduced stricter regulations on the trade and consumption of wild animals. This included a temporary ban on the sale of wild animals for food, as these markets were seen as potential hotspots for zoonotic disease transmission. China enhanced traceability systems, ensuring that animals, particularly those sold in live animal markets, could be tracked from their origin to their sale. Veterinary inspections have been systematically strengthened to ensure that animals are not carriers of zoonotic diseases, including foodborne parasites. Relevant legal frameworks, such as the "Wildlife Protection Law" and "Animal Epidemic Prevention Law," provide the basis for these regulatory changes. Public health communication regarding these risks has also been a focus. The Chinese government, in collaboration with local authorities, launched multimedia campaigns targeting markets where live wild animals were sold. These campaigns often involved using digital platforms, radio, and television to broadcast educational content on the risks associated with the consumption of unregulated wildlife. The Chinese CDC worked on producing and distributing a series of instructional videos, which discussed diseases like echinococcosis, showing citizens how to take preventive actions, such as wearing protective gear when handling animals, cleaning utensils, and avoiding unregulated markets. In urban areas with high human-wildlife interaction (like those with significant numbers of live animal markets or areas near wildlife habitats), the outreach efforts were designed to target at-risk populations with tailored health tips.

The lack of comprehensive molecular characterization across all regions and species in China presents a significant barrier to fully understanding the genetic diversity and potential cryptic species of zoonotic parasites. Region-specific epidemiological data fail to provide a holistic view of parasite distribution and prevalence across the country's varied ecological and socio-economic landscapes. To address these gaps, there is a critical need for extensive and standardized data collection efforts to elucidate the true distribution and prevalence of zoonotic parasites. Continuous surveillance is essential to monitor the prevalence and genetic diversity of these parasites, informing targeted interventions and policy development. A thorough understanding of parasite life cycles and transmission dynamics is crucial to tailor effective public health interventions. Investment in the development of vaccines for livestock and potentially for human use can help prevent infections by specific parasites. Increased funding for research on zoonotic parasites is imperative to support sustained and comprehensive studies.

Collaboration with neighbouring countries is vital for managing and controlling the spread of zoonotic parasites, particularly in border regions with frequent cross-border animal movements. Establishing joint surveillance programs to monitor zoonotic parasite infections in human and animal populations across borders enables early detection and response to outbreaks. Creating a network of laboratories for sharing diagnostic tools, resources, and expertise enhances parasite detection and research capabilities. Developing and implementing coordinated emergency response plans for zoonotic disease outbreaks, with clear delineation of roles and responsibilities among countries, is crucial. Conducting joint field operations in border areas, including vaccination campaigns, vector control measures, and public health interventions, helps control and prevent parasite spread. Active participation in global health initiatives, such as the World Health Organization's (WHO) initiatives on zoonotic diseases and the Global Outbreak Alert and Response Network, facilitates real-time data sharing and international collaboration during emergencies. Contributing data to One Health platforms that integrate information from human, animal, and environmental health sectors enables a comprehensive understanding of the interconnected factors influencing zoonotic disease transmission and aids in effective disease control strategies.

In conclusion, a thorough comprehension of the biodiversity of foodborne zoonotic parasites in China is crucial for formulating efficacious public health strategies (Figure 4). Addressing the intricate interplay of environmental, agricultural, and cultural factors necessitates a comprehensive approach to alleviate the burden of these diseases. Facilitating collaboration among research institutions, government agencies, and international organizations to exchange data and resources is imperative. Increased funding for research on zoonotic parasites is essential to support continuous and in-depth studies. Adopting a One Health approach involving collaboration among public health authorities, veterinarians, and the community is indispensable for making significant strides in controlling zoonotic parasitic infections.

Figure 4. *Overview of the strategies to control foodborne zoonotic parasites in China.*
The biodiversity of foodborne zoonotic parasites in China presents significant challenges for public health. These parasites, transmitted from animals to humans, are influenced by a myriad of environmental, agricultural, and cultural factors. To effectively reduce the burden of zoonotic parasitic infections, promoting collaboration between research institutions, government agencies, and international organizations is essential. Sustained and comprehensive studies require adequate funding. Adopting a One Health approach is crucial for integrated efforts across different sectors. In summary, combating foodborne zoonotic parasites in China demands a comprehensive and collaborative approach. By understanding the interplay of various factors, promoting collaboration, increasing research funding, and adopting a One Health approach, significant progress can be made in controlling these infections and safeguarding public health.

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AUTHOR CONTRIBUTIONS

M. Liu, X. Jin and P. Boireau performed the literature review and wrote the manuscript. All authors reviewed and approved the manuscript.

COMPETING INTERESTS

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