PAKISTAN JOURNAL OF ZOOLOGICAL SCIENCES

IJSMART® PUBLISHING COMPANY

RESEARCH ARTICLE

Clonorchis Sinensis and Its Pathobiological Impact on Human Health: A Comprehensive Review

Asra Nawab[1], Dr. Ghulam Murtaza[2,*], iqra Moomina[1] , Bareera Fatima[1], Shazia Parveen[1] and Nimra Akhtar [1]

[1]University of Gujrat, Hafiza Hayat Campus, Gujrat 50700, Pakistan

*Correspondence: drghulam.murtaza@uog.edu.pk

Article Info

Academic Editor:

Muhammad Naeem

Received: 20, October, 2025
Accepted: 26, November, 2025
Published: 24 December, 2025

Citation: Nawab A, Murtaza G, Moomina I, Fatima B, Parveen S., Akhtar N. Clonorchis sinensis and its pathobiological impact on human health: a comprehensive review. *PAK J ZOOL SCI*. 2025;1(3):1–8.

Abstract Clonorchiasis remains an important food-borne parasitic disease associated with hepatobiliary complications and long-term health consequences. Despite its public health significance, infections are often underdiagnosed due to mild or nonspecific symptoms. This review aims to summarize the epidemiology, life cycle, clinical manifestations, diagnostic approaches, and current strategies for the prevention and treatment of clonorchiasis. After ingestion, the parasite migrates to the bile ducts where it matures and can persist for many years. Mild infections may remain asymptomatic, whereas moderate to severe infections can cause hepatobiliary disorders such as abdominal pain, fatigue, bile duct obstruction, jaundice, and hepatomegaly. *Clonorchis sinensis* can infect a variety of mammals including humans, cats, dogs, pigs, and other piscivorous animals, which serve as reservoir hosts. Chronic infections may remain undetected for decades, contributing to delayed diagnosis and mismanagement. Accurate diagnosis can be achieved through microscopic, serological, and molecular methods. Prevention and control strategies include improved sanitation, food safety practices, public health education, and chemotherapy. Early diagnosis, effective treatment with antiparasitic drugs such as praziquantel, and strengthened preventive measures are crucial for controlling clonorchiasis in endemic regions. Enhanced public awareness and implementation of comprehensive health strategies can substantially reduce the burden of this neglected parasitic infection.

Keywords: Clonorchiasis, hepatobiliary disease, hepatic inflammation, human infection, pathogenesis, cholangiocarcinoma, foodborne trematode

Introduction

Clonorchiasis is an important food-borne parasitic disease that continues to pose a significant public health burden in many parts of the world [1]. Parasitic infections remain highly prevalent in developing and endemic regions, affecting millions of people and contributing to chronic morbidity and long-term health complications [2]. Among the trematode parasites infecting humans, *Clonorchis sinensis*, commonly known as the Chinese liver fluke, is widely distributed in East Asia, particularly in China [3], Korea, Vietnam, and the eastern regions of Russia [4]. Humans acquire infection primarily through the consumption of raw or undercooked freshwater fish containing infective metacercariae [5]. Epidemiological surveys indicate that *C. sinensis* remains one of the most prevalent food-borne trematode infections in endemic regions [6]. For example, the 8th National Survey on the Prevalence of Intestinal Parasitic Infections conducted in Korea in 2012 reported a

 https://doi.org/10.65139/pjzs.v1i3.35

prevalence of 2. 6%, representing the highest prevalence among the parasites surveyed [7]. Chronic infection with *C. sinensis* can lead to a range of hepatobiliary complications, including inflammation of the bile ducts, fibrosis, gallstones, and bile duct obstruction [8]. Importantly, *Clonorchis sinensis* and *Opisthorchis viverrini* have been classified as Group 1 carcinogens by the International Agency for Research on Cancer (IARC) due to their strong association with cholangiocarcinoma (CCA), a malignant tumor of the bile ducts. In contrast, Schistosoma haematobium is also categorized as a Group 1 carcinogen but is specifically associated with urinary bladder cancer rather than cholangiocarcinoma. Despite ongoing control programs, clonorchiasis remains prevalent in several endemic regions, highlighting the need for improved epidemiological surveillance, early diagnosis, and effective prevention strategies [9]. In this study, we aim to review the epidemiology, pathogenesis, diagnosis, and control strategies of Clonorchis sinesis infection, with an emphasis on identifying gaps in current knowledge and improving disease management in endemic areas.

History and Epidemiology

Clonorchis sinensis was first identified in humans in 1877 by Kenso Ishisaka in Japan and was initially named Distoma sinense by Cobbold [10, 11]. Subsequent studies in the early 20th century clarified its life cycle: Harujiro Kobayashi identified cyprinid fish as the second intermediate host in 1912, and Masatomo Muto identified freshwater snails (Parafossarulus spp.) as the first intermediate host in 1918. The endemic nature of clonorchiasis in Korea and Taiwan was documented in 1915 [11]. The parasite’s life cycle involves three hosts: humans and other fish-eating mammals (e.g., cats, dogs, and pigs) as definitive hosts; freshwater snails as the first intermediate host; and cyprinid fish as the second intermediate host, where infective metacercariae encyst [12, 13].

Clonorchiasis is a major food-borne parasitic disease widely distributed across East Asia, particularly in China, Korea, Vietnam, and the Russian Far East [14, 15]. Globally, an estimated 15–35 million people are infected, with 200–600 million at risk [4, 16, 17]. China bears the highest disease burden, especially in provinces such as Guangdong, Guangxi, Sichuan, and Heilongjiang [18]. In Vietnam, the disease is most prevalent in northern regions, particularly the Red River delta (e.g., Nam Dinh and Ninh Binh provinces), with prevalence ranging from 0.2% to 37.5%, while Opisthorchis viverrini predominates in southern and central regions [19-21]. South Korea has shown a declining trend due to control programs, although endemic foci persist in river basins such as the Nakdong River [22]. In Russia, approximately 3,000 cases have been reported, mainly in the Amur River basin [14, 15]. Japan, once endemic, has largely controlled the disease since the 1960s through improved sanitation and public health measures. Transmission occurs through ingestion of raw or undercooked freshwater fish containing infective metacercariae, and infection risk is strongly associated with dietary habits as well as demographic and socioeconomic factors, including age, gender, education, and hygiene practices [23-26] (Table).

Year	Milestone	Description	References
1877	First identification	*Clonorchis sinensis* was first identified in humans by Kenso Ishisaka in Japan	[10]
Late 19th century	Nomenclature	The parasite was initially named *Distoma sinense* by Cobbold	[10, 11]
1912	Second intermediate host	Cyprinid fish identified as the second intermediate host (Harujiro Kobayashi)	[11]
1915	Endemicity recognized	Clonorchiasis reported as endemic in Korea and Taiwan	[11]
1918	First intermediate host	Freshwater snails (*Parafossarulus* spp.) identified as the first intermediate host (Masatomo Muto)	[11]
Early 20th century	Life cycle elucidation	Three-host life cycle (snails, fish, mammals) fully clarified	[12, 13]
1960s	Control in Japan	Significant reduction in disease due to improved sanitation and public health measures	[14]
2000s–present	Global epidemiology	Estimated 15–35 million infected and 200–600 million at risk worldwide	[4, 16, 17]
Recent decades	Geographic distribution	High prevalence in China, Vietnam (Red River delta), Korea, and Russian Far East	[14, 15, 18-22]
Recent years	Epidemiological trends	Declining prevalence in South Korea, but persistent endemic foci remain	[22]
Current	Transmission factors	Infection associated with consumption of raw/undercooked fish and influenced by socioeconomic and behavioral factors	[23-26]

Morphology

The adult liver flukes of the three species have a similar morphology, characterized by a flattened and lance-like shape [27]. Numerous rows of spines are placed in a uniform pattern, nearly encircling the body surface. The tail tegument lacks the central electron-lucent bodies and many rod-shaped dense granules found in the body's tegumental syncytium. The oral cone has modified spines and four rows of claw-like teeth. Both morphologically and probably functionally, these teeth are different from the other body spines. Laterally, there are 30 to 37 papillae with substantially longer cilia. Four pairs of papillae are seen on the tail. Based on their location and structure, these papillae appear to play a tango-or rheoreceptive role. The oral sucker is surrounded by another kind of sheathing papillae. The cuticular tegument forms a characteristic sac-like structure at the base of the tail by expanding laterally [28].

The sizes of *Clonorchis sinensis* at various stages of life are given in Table 2.

Table 2. *Human liver fluke (Clonorchis sinensis) sizes at various stages of life*

Life Stages	Size	References
Adult	10–25 mm × 3–5 mm	[29]
Egg	27–35 μm × 11–20 μm	[29]
Cercaria	Body: 154 μm × 75 μm; tail: 392 μm × 26 μm	[27]
Metacercaria	201 μm × 167 μm	[27]

Life Cycle of Clonorchis sinensis

Clonorchis sinensis is a zoonotic liver fluke with a complex life cycle involving three hosts—freshwater snails, cyprinid fish, and humans or other fish-eating mammals (Table 3, Figure 1). The parasite alternates between sexual and asexual reproduction, producing thousands of eggs per day in the definitive host [15, 16, 30]. Infection in humans is associated with hepatobiliary diseases, including cholangitis, cholelithiasis, liver fibrosis, and cholangiocarcinoma [16, 31, 32].

Table 3. *Life cycle of Clonorchis sinensis: Hosts, developmental stages, and key characteristics*

Host	Species	Role	Habitat
1st intermediate host (Snails)	Parafossarulus manchuricus, P. anomalospiralis, Alocinma longicornis, Bithynia fushiana, B. misella, Melanoides tuberculata, others	Miracidia infect snails → develop intosporocysts, rediae, and cercariae	Prefer slow-moving or stagnant freshwater with abundant organic material [11, 17, 33-36]
2nd intermediate host (Fish)	Cyprinids: Pseudorasbora parva, Ctenopharyngodon idellus, Carassius auratus, Cyprinus carpio, Hypophthalmichthys nobilis, Saurogobio dabryi	Cercariae penetrate fish skin → encyst as metacercariae in muscle or subcutaneous tissue	Over 40 species in Korea; 102 species in China; 7 species in Russian Amur River [17, 30, 36-38]
Definitive host (Humans / Other mammal s)	Humans, cats, dogs, pigs, rats, weasels, foxes	Ingestion of metacercariae → excyst in duodenum → migrate via ampulla of Vater to intrahepatic bile ducts → mature into adult worms (20–30-year lifespan)	Causes clonorchiasis; sexual reproduction produces >4,000 eggs/day; associated with hepatobiliary pathology and cholangiocarcinoma [14, 16, 30-32, 35, 39, 40]

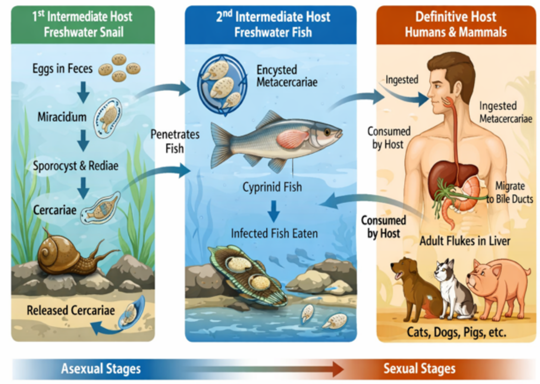

Figure 1. Life Cycle of Clonorchis sinesis (Source: OpenAI)

Clinical Manifestations and Pathogenesis

Clonorchiasis primarily affects the hepatobiliary system, and the severity of clinical manifestations is closely associated with worm burden, duration of infection, and frequency of reinfection [17, 30, 35, 41]. In early infection, patients may experience mild and nonspecific symptoms such as fever, fatigue, anorexia, epigastric discomfort, abdominal pain, and diarrhea, often accompanied by transient jaundice due to acute hepatitis or cholangitis caused by the metabolic products of juvenile *Clonorchis sinensis* [35, 41]. Many light infections remain asymptomatic. Chronic infection leads to progressive hepatobiliary damage, with symptoms including persistent abdominal pain, hepatomegaly, jaundice, and bile duct obstruction [17, 35].

Pathological changes include bile duct dilatation, periductal fibrosis, gallbladder wall thickening, sludge formation, and gallbladder enlargement [8, 42]. The host–parasite relationship may remain relatively stable in mild cases; however, prolonged or heavy infections result in significant morbidity. Severe and long-standing clonorchiasis is associated with complications such as cholangitis, cholelithiasis, cholecystitis, and cholangiectasis, ultimately leading to hepatic fibrosis and an increased risk of cholangiocarcinoma, one of the most serious outcomes [17, 31, 43, 44].

These complications arise mainly due to mechanical irritation, obstruction, and chronic inflammation of the biliary epithelium [45]. Dietary practices, particularly the consumption of raw or undercooked freshwater fish, play a central role in transmission and persistence of the disease in endemic regions, posing a major challenge for control and elimination efforts [26].

Complications of Clonorchis sinesnsis Infestation

Diagnosis and Treatment

Early infection stages usually do not have obvious clinical signs, resulting in delayed diagnoses. Adult *Clonorchis sinensis* worms can remain in the bile ducts for 20 to 25 years [17]. Moreover, clonorchiasis is often misdiagnosed due to its ambiguous clinical features, which include lethargy, vomiting, stomach pain, anaemia, and enlarged liver and spleen [14]. Imaging methods include tissue harmonic imaging (THI), computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound have significant auxiliary diagnostic benefits and are used to evaluate the advancement of illness. However, these methods are not very sensitive, are vague, and may be difficult for employees with little experience to use. Furthermore, employing these techniques can be expensive[17].

Microscopic Testing

A *Clonorchis sinensis* infection can be confirmed by stool eggs. Stool testing is inexpensive and requires no sophisticated technology, but it demands experienced, labour-intensive, and troublesome workers [16, 17]. Hong et al. found that whereas FECT was more vulnerable in detecting cases of very mild illnesses, the KK approach was more trustworthy in detecting clonorchiasis [46]. Further investigation showed that the direct smear and KK method were appropriate for the thorough demographic screening of clonorchiasis [47]. However, it is simple to confuse the eggs of *Clonorchis sinensis* with those of other flukes, including Heterophyidae, Opisthorchiidae, and Lecithodendriidae [17, 46].

Serological Testing

Serological methods can be used to detect clonorchiasis. Blood samples may be able to identify a specific *Clonorchis sinensis* antibody or antigen. Serum samples may include a particular antibody or antigen of *Clonorchis sinensis*. Due to sensitivity limitations and the tiny amount of antigen present, the recognition of a particular antibody is more frequently used than the detection of an antigen. However, Nie et al. demonstrated that there is a strong correlation between ELISA optical density and egg counts (EPG) and that an immunomagnetic bead enzyme-linked immunosorbent assay (ELISA) system based on IgY (egg yolk immunoglobulin) (IgY-IMB-ELISA) appears to be a sensitive and specific assay for the detection of circulating antigen in human clonorchiasis [48].

Molecular Testing

DNA-based diagnostic methods can also be used. Among the PCR techniques that have been employed are FRET-PCR, multiplex PCR, PCR-RFLP, conventional PCR, and real-time PCR [16, 49]. The use of real-time PCR (targeting the parasite specific transcribed spacer 2 sequence) to detect *Clonorchis sinensis*-specific DNA in fecal samples has recently been assessed in an effort to provide a novel, sensitive method of diagnosing the sickness. Stool samples and DNA controls from a variety of intestinal microorganisms were used in the PCR-based test. Additionally, it had an internal control to identify any amplification inhibition brought on by the faeces in the sample [50]. Omics, which encompasses transcriptomics, proteomics, and genomes, can aid in our molecular understanding of *C. sinensis* migration, parasitism, and pathogenicity. This will be enormously beneficial for the creation of novel and efficient clonorchiasis management and prevention approaches [51]. Molecular techniques have been established for the identification and differentiation of snail larval stages in addition to their use in the diagnostics of human feces [52, 53], and metacercariae in fish [54].

Pharmacological Testing

Praziquantel

When clonorchiasis is detected early and the species is appropriately determined, praziquantel (PZQ) is an effective therapy [55]. PZQ is an effective treatment for clonorchiasis when it is diagnosed early and the species is correctly identified [55]. Furthermore, using PZQ may cause mild and transient adverse effects such as migraines, lightheadedness, feeling sick, throwing up, fatigue, diarrhoea, and hypersensitivity [15, 56, 57]. Therefore, more drugs to treat clonorchiasis should be developed. Tribendimidine is broad spectrum anthelminthic drug. It has demonstrated remarkable effectiveness in treating *Clonorchis sinensis* in vitro as well as in rats and rodents [58, 59].

Albendazole

A broad-spectrum medication that works well contrary to nematodes and cestodes, albendazole also works well compared to liver flukes [60].

Table 4. *Diagnostic methods for Clonorchis sinensis: principles, advantages, and limitations*

Diagnostic Method	Principle / Sample	Advantages	Limitations	References
Imaging techniques (THI, CT, MRI, Ultrasound)	Visualization of hepatobiliary abnormalities (bile duct dilation,	Non-invasive; useful for assessing disease progression and complications	Low sensitivity for early infection; non-specific findings; operator-dependent; expensive; requires technical expertise	[17]
Microscopy (Stool examination: direct smear, Kato-Katz (KK), Formalin-ether concentration technique (FECT))	Detection of parasite eggs in stool samples	Inexpensive; widely used; no advanced equipment required; suitable for field surveys	Low sensitivity in light infections; labor-intensive; requires trained personnel; eggs may be confused with other trematodes	[16, 17, 46, 47]
Serological testing (ELISA, IgY-IMB-ELISA)	Detection of specific antibodies or circulating antigens in blood	Higher sensitivity than microscopy; useful in early or light infections; can correlate with infection intensity (EPG)	Cannot always distinguish past vs. current infection (antibody detection); limited antigen levels; possible cross-reactivity	[48]
Molecular methods (PCR, real-time PCR, multiplex PCR, PCR-RFLP, FRET-PCR)	Detection of parasite DNA in stool or biological samples	Highly sensitive and specific; capable of early detection; useful for species differentiation	Expensive; requires specialized equipment and expertise; not suitable for routine field use	[16, 49, 50]
Omics-based approaches (genomics, proteomics, transcriptomics)	Molecular profiling of parasite biology and host–parasite interaction	Provides deep insight into pathogenesis; potential for novel diagnostics and targets	Not yet routine diagnostic tools; costly; mainly research-based	[51]
Detection in intermediate hosts (snails and fish)	Identification of larval stages (cercariae/metacercariae) using molecular tools	Useful for epidemiological surveillance and transmission studies	Not applicable for direct human diagnosis; requires laboratory facilities	[52-54]

Prevention and Control Strategy

Clonorchiasis control relies on an integrated approach, including environmental management, health education, and chemotherapy [61]. Health education involves raising public awareness through school programs, television, informational posters, and community campaigns, promoting safe dietary practices such as avoiding raw or undercooked freshwater fish [61-63]. Mass or selective chemotherapy with PZQ has been widely used in endemic regions. In moderately endemic areas, one or two selective treatments combined with health education are sufficient, whereas highly endemic areas require repeated mass or selective treatment every six to twelve months, achieving high egg reduction and low reinfection rates [56]. In a Korean endemic village, biannual PZQ therapy effectively reduced infection prevalence.

Emerging strategies include alternative anthelmintics such as tribendimidine, which show higher efficacy and fewer side effects than PZQ, and fish vaccines combined with safe aquaculture practices, offering a potential solution to reduce transmission and ensure freshwater fish safety [13]. Recommendations from various agencies for the prevention of clonorchiasis are exhibited in Table 5.

Table 5. *Key prevention recommendations from different agencies*

Agency	Recommendations	References
CDC	Avoid fermented or uncooked freshwater fish; cook thoroughly (internal temperature >63 °C) or freeze (≤ −20 °C for 7 days; ≤ −35 °C for 15 hours)	[7]
WHO	Implement food safety measures and public health strategies in veterinary practice; improve efficacy and safety of anthelmintics to manage morbidity	[64]
NHFPC	Improve access to hygienic sanitation and anthelmintics; raise awareness of health and parasite prevention; increase proportion of trained medical staff in local communities	[65]

Conclusion

Clonorchiasis remains a significant public health challenge in East Asia, driven by cultural dietary practices and persistent transmission through freshwater fish. Infection with Clonorchis Sinensis can cause progressive hepatobiliary damage, including bile duct inflammation, fibrosis, gallstones, and a strong risk of cholangiocarcinoma. While praziquantel remains an effective treatment, high reinfection rates in endemic regions highlight the need for integrated control strategies combining chemotherapy, health education, improved sanitation, and safe aquaculture practices. Emerging interventions, including alternative anthelmintics such as tribendimidine and fish vaccination, offer promise in reducing transmission. Strengthening surveillance, community awareness, and food safety measures is essential to minimize disease burden and prevent long-term complications in endemic populations.

Author Contributions

Asra Nawab handled writing – original draft, visualization, methodology, investigation, formal analysis, data curation, and conceptualization. Dr. Ghulam Murtaza managed writing – review & editing, visualization, validation, supervision, resources, project administration, funding acquisition, and conceptualization. Iqra Moomina, Bareera Fatima, Shazia Parveen, and Nimra Akhtar collectively contributed to writing – review & editing, investigation, data curation, formal analysis, visualization, methodology, and validation as specified in their respective roles.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

Acknowledgment

The University of Gujrat, Pakistan, supports this work.

Appendix A. Data Availability

Data will be made available on request

References

[1] Qian MB. Neglected tropical diseases and global burden of disease in China. Infect Dis Poverty. 2017;6(1):25. https://doi.org/10.1186/s40249-017-0237-y
[2] Kaminsky R, Maser P. Global impact of parasitic infections and the importance of parasite control. Front Parasitol. 2025;4:1546195. https://doi.org/10.3389/fpara.2025.1546195
[3] Fang YY, Chen YD, Li XM, Wu J, Zhang QM, Ruan CW. [Current prevalence of Clonorchis sinensis infection in endemic areas of China]. Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi. 2008;26(2):99-103, 109.
[4] Furst T, Keiser J, Utzinger J. Global burden of human food-borne trematodiasis: a systematic review and meta-analysis. Lancet Infect Dis. 2012;12(3):210-221. https://doi.org/10.1016/S1473-3099(11)70294-8
[5] Chen ER. Clonorchiasis in Taiwan. Southeast Asian J Trop Med Public Health. 1991;22 Suppl:184-185.
[6] Dai F, Hong SJ, Pak JH, Le TH, Choi SH, Na BK, et al. High Prevalence of Clonorchis sinensis and Other Zoonotic Trematode Metacercariae in Fish from a Local Market in Yen Bai Province, Northern Vietnam. Korean J Parasitol. 2020;58(3):333-338. https://doi.org/10.3347/kjp.2020.58.3.333
[7] Bahk YY, Shin EH, Cho SH, Ju JW, Chai JY, Kim TS. Prevention and Control Strategies for Parasitic Infections in the Korea Centers for Disease Control and Prevention. Korean J Parasitol. 2018;56(5):401-408. https://doi.org/10.3347/kjp.2018.56.5.401
[8] Qian M-B, Li H-M, Jiang Z-H, Yang Y-C, Lu M-F, Wei K, et al. Severe hepatobiliary morbidity is associated with Clonorchis sinensis infection: the evidence from a cross-sectional community study. PLoS neglected tropical diseases. 2021;15(1):e0009116. https://doi.org/10.1371/journal.pntd.0009116
[9] Kim T-S, Pak JH, Kim J-B, Bahk YY. Clonorchis sinensis, an oriental liver fluke, as a human biological agent of cholangiocarcinoma: a brief review. BMB reports. 2016;49(11):590-597. https://doi.org/10.5483/bmbrep.2016.49.11.109
[10] Qian M-B, Zhou C-H, Zhu H-H, Zhu T-J, Huang J-L, Chen Y-D, et al. From awareness to action: NIPD's engagement in the control of food-borne clonorchiasis. Advances in parasitology. 2020;110:245-267. https://doi.org/10.1016/bs.apar.2020.04.004
[11] Yoshida Y. Clonorchiasis—a historical review of contributions of Japanese parasitologists. Parasitology international. 2012;61(1):5-9. https://doi.org/10.1016/j.parint.2011.06.003
[12] Chai JY, Darwin Murrell K, Lymbery AJ. Fish-borne parasitic zoonoses: status and issues. Int J Parasitol. 2005;35(11-12):1233-1254. https://doi.org/10.1016/j.ijpara.2005.07.013
[13] Tang ZL, Huang Y, Yu XB. Current status and perspectives of Clonorchis sinensis and clonorchiasis: epidemiology, pathogenesis, omics, prevention and control. Infect Dis Poverty. 2016;5(1):71. https://doi.org/10.1186/s40249-016-0166-1
[14] Qian MB, Chen YD, Yan F. Time to tackle clonorchiasis in China. Infect Dis Poverty. 2013;2(1):4. https://doi.org/10.1186/2049-9957-2-4
[15] Qian M-B, Utzinger J, Keiser J, Zhou X-N. Clonorchiasis. The Lancet. 2016;387(10020):800-810. https://doi.org/10.1016/S0140-6736(15)60313-0
[16] Hong ST, Fang Y. Clonorchis sinensis and clonorchiasis, an update. Parasitol Int. 2012;61(1):17-24. https://doi.org/10.1016/j.parint.2011.06.007
[17] Lun ZR, Gasser RB, Lai DH, Li AX, Zhu XQ, Yu XB, et al. Clonorchiasis: a key foodborne zoonosis in China. Lancet Infect Dis. 2005;5(1):31-41. https://doi.org/10.1016/S1473-3099(04)01252-6
[18] Ma Y, Wang H. Epidemiological evolvement of Clonorchiasis sinensis in China for the past 60 years. Int J Med Parasit Dis. 2009;36(5):362-367.
[19] Doanh PN, Nawa Y. Clonorchis sinensis and Opisthorchis spp. in Vietnam: current status and prospects. Trans R Soc Trop Med Hyg. 2016;110(1):13-20.

https://doi.org/10.1093/trstmh/trv103
[20] Hung NM, Madsen H, Fried B. Global status of fish-borne zoonotic trematodiasis in humans. Acta Parasitol. 2013;58(3):231-258. https://doi.org/10.2478/s11686-013-0155-5
[21] Sithithaworn P, Andrews RH, Nguyen VD, Wongsaroj T, Sinuon M, Odermatt P, et al. The current status of opisthorchiasis and clonorchiasis in the Mekong Basin. Parasitol Int. 2012;61(1):10-16. https://doi.org/10.1016/j.parint.2011.08.014
[22] Shin EH, Guk SM, Kim HJ, Lee SH, Chai JY. Trends in parasitic diseases in the Republic of Korea. Trends Parasitol. 2008;24(3):143-150. https://doi.org/10.1016/j.pt.2007.12.003
[23] Nontasut P, Thong TV, Waikagul J, Anantaphruti MT, Fungladda W, Imamee N, et al. Social and behavioral factors associated with Clonorchis infection in one commune located in the Red River Delta of Vietnam. Southeast Asian J Trop Med Public Health. 2003;34(2):269-273.
[24] Thi Cam TD, Yajima A, Viet KN, Montresor A. Prevalence, intensity and risk factors for clonorchiasis and possible use of questionnaires to detect individuals at risk in northern Vietnam. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2008;102(12):1263-1268. https://doi.org/10.1016/j.trstmh.2008.06.002
[25] Vinh HQ, Phimpraphai W, Tangkawattana S, Smith JF, Kaewkes S, Dung DT, et al. Risk factors for Clonorchis sinensis infection transmission in humans in northern Vietnam: A descriptive and social network analysis study. Parasitol Int. 2017;66(2):74-82. https://doi.org/10.1016/j.parint.2016.11.018
[26] Yoo WG, Sohn WM, Na BK. Current status of Clonorchis sinensis and clonorchiasis in Korea: epidemiological perspectives integrating the data from human and intermediate hosts. Parasitology. 2022;149(10):1296-1305. https://doi.org/10.1017/S0031182022000798
[27] Kaewkes S. Taxonomy and biology of liver flukes. Acta Trop. 2003;88(3):177-186. https://doi.org/10.1016/j.actatropica.2003.05.001
[28] Fujino T, Ishii Y, Choi DW. The ultrastructural characterization of the tegument of Clonorchis sinensis (Cobbold, 1875) cercaria. Z Parasitenkd. 1979;60(1):65-76. https://doi.org/10.1007/BF00928972
[29] Control CfD, Prevention. Clonorchis: resources for health professionals. 2021.
[30] Kim J-H, Choi M-H, Bae YM, Oh J-K, Lim MK, Hong S-T. Correlation between discharged worms and fecal egg counts in human clonorchiasis. PLoS neglected tropical diseases. 2011;5(10):e1339. https://doi.org/10.1371/journal.pntd.0001339
[31] Bouvard V, Baan R, Straif K, Grosse Y, Secretan B, El Ghissassi F, et al. A review of human carcinogens—Part B: biological agents. The lancet oncology. 2009;10(4):321-322. https://doi.org/10.1016/s1470-2045(09)70096-8
[32] Rim HJ. Clonorchiasis: an update. J Helminthol. 2005;79(3):269-281. https://doi.org/10.1079/joh2005300
[33] Choi DW. Clonorchis sinensis: life cycle, intermediate hosts, transmission to man and geographical distribution in Korea. Arzneimittelforschung. 1984;34(9B):1145-1151.
[34] Chung PR, Soh CT. Snail-borne parasitic zoonoses in Korea. Southeast Asian J Trop Med Public Health. 1991;22 Suppl:391-395.
[35] Na BK, Pak JH, Hong SJ. Clonorchis sinensis and clonorchiasis. Acta Trop. 2020;203:105309. https://doi.org/10.1016/j.actatropica.2019.105309
[36] Tang J, Lin R, Zhu X. Animals infected with Clonorchis sinensis in China. Chin J Zoonoses. 2007;23(2):177-179.
[37] Fattakhov RG, Ushakov AV, Stepanova TF, Ianovich VA, Kopylov PV. [Epizootiological characteristics of clonorchiasis foci in the Amur River ecosystem in the Jewish autonomic region]. Med Parazitol (Mosk). 2012(4):15-18.
[38] Sohn WM. Fish-borne zoonotic trematode metacercariae in the Republic of Korea. Korean J Parasitol. 2009;47 Suppl(Suppl):S103-113. https://doi.org/10.3347/kjp.2009.47.S.S103
[39] Kim TI, Yoo WG, Kwak BK, Seok JW, Hong SJ. Tracing of the Bile-chemotactic migration of juvenile Clonorchis sinensis in rabbits by PET-CT. PLoS Negl Trop Dis. 2011;5(12):e1414. https://doi.org/10.1371/journal.pntd.0001414
[40] Rim HJ. The current pathobiology and chemotherapy of clonorchiasis. Kisaengchunghak Chapchi. 1986;24 Suppl:1-141. https://doi.org/10.3347/kjp.1986.24.suppl.1
[41] Qian MB, Chen YD, Fang YY, Xu LQ, Zhu TJ, Tan T, et al. Disability weight of Clonorchis sinensis infection: captured from community study and model simulation. PLoS Negl Trop Dis. 2011;5(12):e1377. https://doi.org/10.1371/journal.pntd.0001377
[42] Fedorova OS, Fedotova MM, Zvonareva OI, Mazeina SV, Kovshirina YV, Sokolova TS, et al. Opisthorchis felineus infection, risks, and morbidity in rural Western Siberia, Russian Federation. PLoS Negl Trop Dis. 2020;14(6):e0008421. https://doi.org/10.1371/journal.pntd.0008421
[43] Qiao T, Ma R-h, Luo X-b, Luo Z-l, Zheng P-m. Cholecystolithiasis is associated with Clonorchis sinensis infection. 2012;7(8):e42471. https://doi.org/https://doi.org/10.1371/journal.pone.0042471
[44] Sripa B, Kaewkes S, Intapan PM, Maleewong W, Brindley PJ. Food-borne trematodiases in Southeast Asia epidemiology, pathology, clinical manifestation and control. Adv Parasitol. 2010;72:305-350. https://doi.org/10.1016/S0065-308X(10)72011-X
[45] Chen M, Mott K. Progress in assessment of morbidity due to Fasciola hepatica infection: a review of recent literature. Tropical diseases bulletin. 1990;87.
[46] Hong S-T, Choi M-H, Kim C-H, Chung B-S, Ji Z. The Kato-Katz method is reliable for diagnosis of Clonorchis sinensis infection. Diagnostic microbiology and infectious disease. 2003;47(1):345-347. https://doi.org/10.1016/s0732-8893(03)00113-5
[47] Choi MH, Ge T, Yuan S, Hong ST. Correlation of egg counts of Clonorchis sinensis by three methods of fecal examination. Korean J Parasitol. 2005;43(3):115-117. https://doi.org/10.3347/kjp.2005.43.3.115
[48] Nie G, Wang T, Lu S, Liu W, Li Y, Lei J. Detection of Clonorchis sinensis circulating antigen in sera from Chinese patients by immunomagnetic bead ELISA based on IgY. PLoS One.

2014;9(12):e113208. https://doi.org/10.1371/journal.pone.0113208
[49] Huang SY, Zhao GH, Fu BQ, Xu MJ, Wang CR, Wu SM, et al. Genomics and molecular genetics of Clonorchis sinensis: current status and perspectives. Parasitol Int. 2012;61(1):71-76. https://doi.org/10.1016/j.parint.2011.06.008
[50] Kim EM, Verweij JJ, Jalili A, van Lieshout L, Choi MH, Bae YM, et al. Detection of Clonorchis sinensis in stool samples using real-time PCR. Ann Trop Med Parasitol. 2009;103(6):513-518. https://doi.org/10.1179/136485909X451834
[51] Wang X, Chen W, Huang Y, Sun J, Men J, Liu H, et al. The draft genome of the carcinogenic human liver fluke Clonorchis sinensis. Genome Biol. 2011;12(10):R107. https://doi.org/10.1186/gb-2011-12-10-r107
[52] Intapan PM, Thanchomnang T, Lulitanond V, Pongsaskulchoti P, Maleewong W. Detection of Opisthorchis viverrini in infected bithynid snails by real-time fluorescence resonance energy transfer PCR-based method and melting curve analysis. Parasitol Res. 2008;103(3):649-655. https://doi.org/10.1007/s00436-008-1026-0
[53] Chen Y, Wen T, Lai DH, Wen YZ, Wu ZD, Yang TB, et al. Development and evaluation of loop-mediated isothermal amplification (LAMP) for rapid detection of Clonorchis sinensis from its first intermediate hosts, freshwater snails. Parasitology. 2013;140(11):1377-1383. https://doi.org/10.1017/S0031182013000498
[54] Cai XQ, Yu HQ, Bai JS, Tang JD, Hu XC, Chen DH, et al. Development of a TaqMan based real-time PCR assay for detection of Clonorchis sinensis DNA in human stool samples and fishes. Parasitol Int. 2012;61(1):183-186. https://doi.org/10.1016/j.parint.2011.06.010
[55] Choi BI, Han JK, Hong ST, Lee KH. Clonorchiasis and cholangiocarcinoma: etiologic relationship and imaging diagnosis. Clin Microbiol Rev. 2004;17(3):540-552, table of contents. https://doi.org/10.1128/CMR.17.3.540-552.2004
[56] Choi MH, Park SK, Li Z, Ji Z, Yu G, Feng Z, et al. Effect of control strategies on prevalence, incidence and re-infection of clonorchiasis in endemic areas of China. PLoS Negl Trop Dis. 2010;4(2):e601. https://doi.org/10.1371/journal.pntd.0000601
[57] Lee JM, Lim HS, Hong ST. Hypersensitive reaction to praziquantel in a clonorchiasis patient. Korean J Parasitol. 2011;49(3):273-275. https://doi.org/10.3347/kjp.2011.49.3.273
[58] Xiao SH, Xue J, Xu LL, Zheng Q, Qiang HQ, Zhang YN. The in vitro and in vivo effect of tribendimidine and its metabolites against Clonorchis sinensis. Parasitol Res. 2009;105(6):1497-1507. https://doi.org/10.1007/s00436-009-1579-6
[59] Xue J, Xu LL, Qiang HQ, Zhang YN, Xiao SH. [Therapeutic effect of tribendimidine, artesunate and praziquantel administered to hamsters infected with Clonorchis sinensis]. Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi. 2009;27(3):215-218.
[60] Chai J-Y, Jung B-K, Hong S-J. Albendazole and mebendazole as anti-parasitic and anti-cancer agents: an update. The Korean journal of parasitology. 2021;59(3):189. https://doi.org/10.3347/kjp.2021.59.3.189
[61] Wu W, Qian X, Huang Y, Hong Q. A review of the control of clonorchiasis sinensis and Taenia solium taeniasis/cysticercosis in China. Parasitol Res. 2012;111(5):1879-1884. https://doi.org/10.1007/s00436-012-3152-y
[62] Qian MB. Clonorchiasis control: starting from awareness. Infect Dis Poverty. 2014;3:33. https://doi.org/10.1186/2049-9957-3-33
[63] Xin-Hua H, Zhi-Qi L, Yue-Yi F, Cai-Yun R, Xue-Jun Z, Di-Xuan L, et al. [Effect of comprehensive control in demonstration plot of clonorchiasis in Yangshan County, 2006-2009]. Zhongguo Xue Xi Chong Bing Fang Zhi Za Zhi. 2011;23(5):569-570, 574.
[64] Keiser J, Utzinger J. Food-borne trematodiases. Clin Microbiol Rev. 2009;22(3):466-483. https://doi.org/10.1128/CMR.00012-09
[65] Zhang J, Xia J, Zhu H, Lin W, Wu D-N, Wan L, et al. Final evaluation of the prevention and control plan of key parasitic diseases in Hubei Province, 2016-2019. 2023. https://doi.org/10.13604/j.cnki.46-1064/r.2023.05.05

Disclaimer / Publisher's Note