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Research Article

Snail Transmitted Parasitic Infections

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Abstract

Snail-borne parasitic infections are diseases where snails act as vectors and intermediate hosts, facilitating the transmission of parasites. Key examples include Schistosoma species, causing schistosomiasis; *Angiostrongylus cantonensis*, responsible for angiostrongyliasis; and *Paragonimus* species, which cause *Paragonimiasis*. These infections are predominantly endemic in tropical regions such as Asia, China, Korea, Japan, Latin America, and Africa. Schistosomiasis, the most widespread of these infections, affects about 78 countries across Africa, Asia, and Latin America, particularly in underdeveloped communities with inadequate public health systems. Transmission occurs when humans or animals come into contact with infected snails or consume raw or undercooked snails, leading to various health issues. Symptoms range from mild, such as abdominal pain, diarrhea, and blood in the stool, to severe complications like liver damage, kidney damage, and bladder cancer. Diagnosis of snail-borne parasitic infections traditionally involves microscopy to detect parasite eggs in stool or urine samples. Modern diagnostic techniques include enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR). Preventive measures include mass drug administration (MDA) in schools and communities to reduce prevalence, along with improving water, sanitation, hygiene, and conducting health awareness campaigns.

Keywords: Polymerase Chain Reaction (PCR); Mass Drug Administration (MDA); Schistosoma

Introduction

Snail-transmitted parasitic infections are significant public health concerns globally, especially in tropical and subtropical regions [1]. These infections occur when snails act as vectors and intermediate hosts for various parasites, facilitating the transmission of diseases to humans [1]. These infections are especially prevalent in regions like Africa, Asia (including China, Korea, and Japan), and parts of Latin America. An estimated 200 million people are affected by these infections across approximately 90 countries [1]. Some notable snail transmitted parasites include, *Schistosomia spp* which causes *Schistosomiasis, Angiostrongylus cantonensis the causative organism of Angiosrongyliasis, Fasciola spp* which causes *Fascoliasis, Paragonimus spp* causing *Paragonimiasis, Opisthorchis spp the transmitting vector of Opisthorchiaisis* and *Clonorchis spp* that causes *Clonorchiaisis.* The most widespread snail-transmitted parasitic infection, Schistosomiasis, is caused by various species of the genus *Schistosoma*, such as *S. haematobium*, *S. mansoni*, and *S. japonicum*. The disease primarily affects people who come into contact with contaminated freshwater, where larval stages (cercariae) penetrate the skin. It is prevalent in over 70 countries, mainly in Africa, Asia, and Latin America, with the highest burden found in sub-Saharan Africa with over 30 million cases reported, especially

in Nigeria, where the burden is the highest. The persistence of these infections is closely linked to inadequate access to safe water, sanitation, and health services in endemic areas [1,2]. Most snail-transmitted parasites have specific snail species that serve as their intermediate hosts, often with limited geographic distributions. For example are *Schistosoma japonicum* transmitted by the snail species *Oncomelania hupensis* and *Schistosoma mekongi* transmitted by *Neotricula aperta* as its intermediate host. These snails have limited distributions [1,2].

Types of snail transmitted parasitic infections

Schistosoma spp. *(Schistosomiasis)*

They are also known as *bilharzia*, is a group of parasitic flatworms (trematodes), also known as blood flukes, that cause the disease schistosomiasis. This disease is a significant public health problem, particularly in tropical and subtropical regions. The primary species infecting humans include *Schistosoma haematobium*, *Schistosoma japonicum*, and *Schistosoma mansoni*, among others. These parasites have a complex life cycle involving freshwater snails as intermediate hosts [3]. The lifecycle begins when human skin comes into contact with freshwater that contains the infectious larval stage, known as cercariae. These larvae are released by infected freshwater snails, which serve as the intermediate hosts. The cercariae penetrate the skin, lose their tails, and transform into schistosomula, which then migrate through the bloodstream to the liver where they mature into adult worms [3]. Adult schistosomes reside in the blood vessels of the host, specifically around the intestines or bladder, depending on the species. They mate and produce eggs, which can cause damage as they migrate through tissues. Some eggs are excreted from the body via urine or feces, continuing the transmission cycle, while others may become trapped in body tissues, leading to inflammation and organ damage [3]. The eggs that reach freshwater hatch into miracidia, which then infect specific species of freshwater snails. Inside the snail, the miracidia develop into sporocysts, which multiply and produce cercariae. The cercariae are then released back into the water, where they are capable of infecting humans, thus completing the cycle [3,4]. Schistosomiasis transmission occurs through activities involving contact with contaminated water, such as swimming, bathing, or farming. Symptoms can vary significantly, ranging from mild issues such as skin rashes and fever to severe conditions like liver fibrosis, bladder cancer, or damage to other organs due to chronic infection [4].

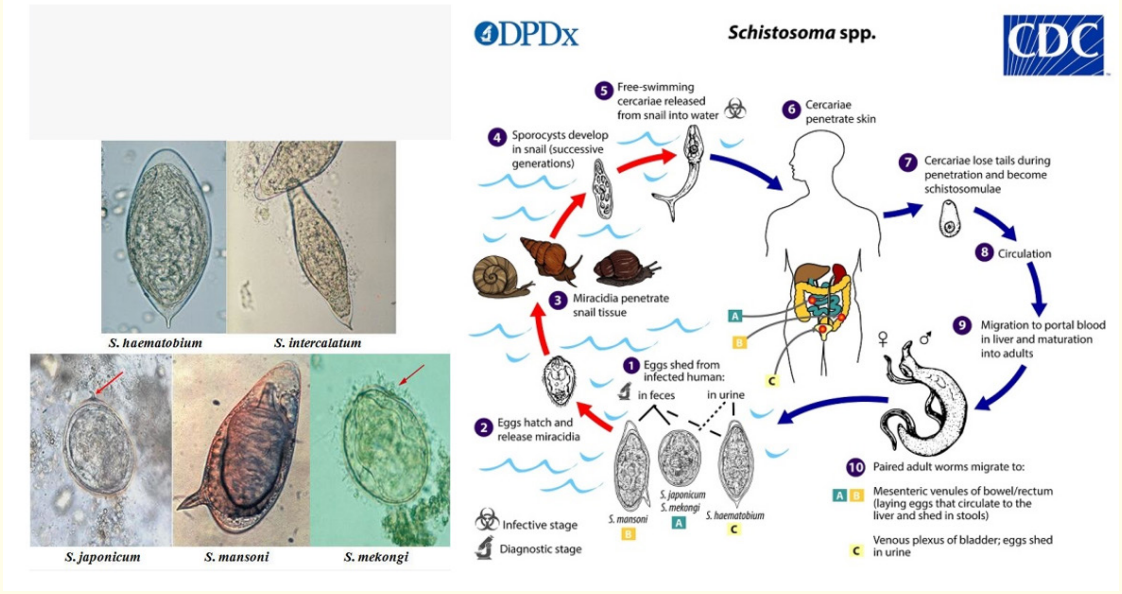

Figure 1: Life cycle of *schistosoma* spp [4].

Angiostrongylus cantonensis (Rat Lungworm)

Angiostrongylus cantonensis, commonly referred to as the rat lungworm, is a parasitic nematode primarily affecting rodents, with humans and other animals serving as incidental hosts [1]. The lifecycle of *A. cantonensis* involves rats as the definitive hosts, where adult worms reside in the pulmonary arteries [1,5]. Female worms release larvae that are expelled through rat feces, which are then ingested by intermediate hosts such as snails and slugs. Inside these mollusks, the larvae develop into the infective third stage (L3) larvae [5]. Humans become accidental hosts by consuming raw or undercooked snails, slugs, or other contaminated sources such as unwashed vegetables and water. Upon ingestion, the L3 larvae penetrate the intestinal wall and travel through the bloodstream to the central nervous system, leading to eosinophilic meningitis. Symptoms in humans include severe headaches, neck stiffness, and neurological issues. While the parasite cannot complete its lifecycle in humans, understanding these transmission pathways is crucial for prevention and control. Preventative measures include avoiding the consumption of raw or undercooked mollusks, ensuring proper hygiene, and educating at-risk populations in endemic areas [6].

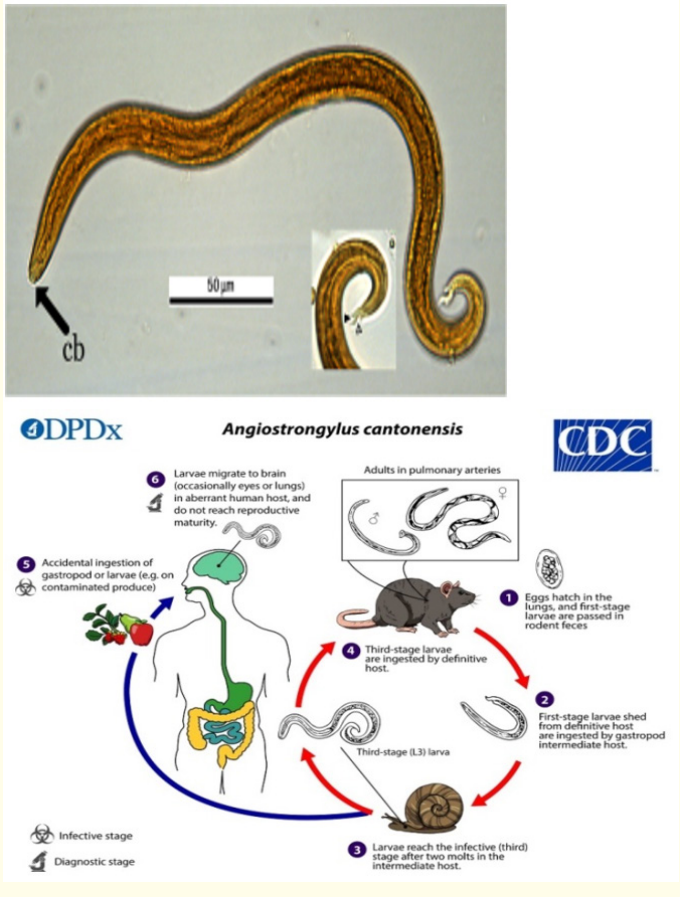

Figure 2: Life cycle of *Angiostrongylus cantonensis* [6].

Fasciola spp. (Fascioliasis)

Fascioliasis is a parasitic infection caused by liver flukes of the genus Fasciola, primarily Fasciola hepatica and *Fasciola gigantica* [1,7]. The lifecycle begins with the release of eggs from adult flukes residing in the bile ducts of a definitive host (e.g., cattle, sheep, or occasionally humans). These eggs are passed out of the host in the feces [1,7]. Once the eggs are in water, they hatch to release the miracidium, a free-swimming larval stage. The miracidium is covered in cilia and actively seeks out a suitable intermediate host, typically a freshwater snail. Inside the snail, the miracidium transforms into

a sporocyst, which then develops into one or more rediae. The rediae further produce cercariae, another larval stage. The cercariae are released from the snail into the water. They are free-swimming and have a tail to aid in locomotion. Cercariae encyst on aquatic plants or other substrates to become metacercariae [7]. These encysted larvae are resistant to environmental conditions and can survive until ingested by a definitive host. When a definitive host (e.g., a grazing animal or human) ingests contaminated water or plants containing metacercariae, the cysts are activated in the digestive tract [3,7]. The metacercariae are released in the intestines, penetrate the intestinal wall, and migrate through the peritoneal cavity to the liver. They then enter the bile ducts, where they mature into adult flukes [1]. Adult flukes reside in the bile ducts of the liver, where they reproduce. Eggs are released into the bile ducts and eventually pass out of the host through the feces, completing the lifecycle. The acute phase of fascioliasis involves symptoms such as fever, abdominal pain, hepatomegaly, and gastrointestinal disturbances as the larvae migrate through the liver [3,7]. In the chronic phase, the adult flukes reside in the bile ducts, causing inflammation, fibrosis, and obstruction, which can lead to severe liver damage and biliary complications [7,8].

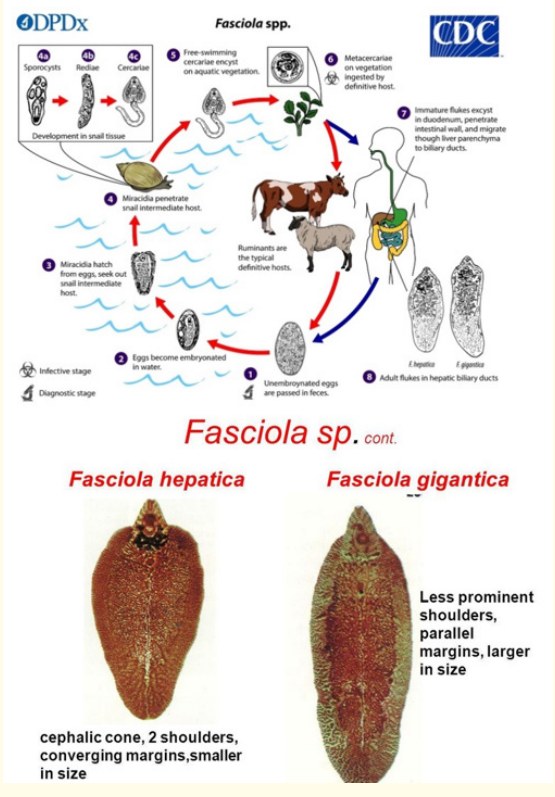

Figure 3: Life cycle of *Fasciola* spp [8].

Paragonimus spp. (*Paragonimiasis*)

Paragonimiasis is an infection caused by lung flukes of the genus *Paragonimus*, with *Paragonimus westermani* being the most common species involved, although other species can also cause infection [1,9]. These parasitic trematodes primarily affect the lungs but can also impact other organs, including the brain and skin [1,9]. The lifecycle of *Paragonimus* involves several stages and different hosts. Adult flukes residing in the lungs or other organs of a definitive host (such as humans) release eggs. These eggs are coughed up, swallowed, and eventually pass out of the host in feces. Once the eggs are in water, they hatch into miracidia, free-swimming larvae. These miracidia must find and penetrate a suitable freshwater snail, which serves as the first intermediate host [9]. Inside the snail, the miracidia develop into sporocysts, which then transform into rediae. The rediae produce cercariae, another larval stage. Cercariae are released from the snail into the water. They are free-swimming and seek out a second intermediate host, typically a crustacean such as a crab or crayfish [9]. In the crustacean host,

cercariae encyst to become metacercariae. These encysted larvae are resistant to environmental conditions and can survive until ingested by a definitive host [9]. Humans become infected by consuming raw or undercooked crustaceans containing metacercariae [9]. Once ingested, the metacercariae are released in the digestive tract and migrate through the abdominal cavity to the lungs or other organs, where they mature into adult flukes Adult flukes in the lungs or other organs reproduce and lay eggs. The eggs are expelled from the host in sputum or feces, depending on the location of the infection, thus completing the lifecycle [9-11]. Symptoms of *Paragonimiasis* can range from chronic cough and hemoptysis (coughing up blood) to severe neurological and systemic manifestations in cases of ectopic infections [9-11].

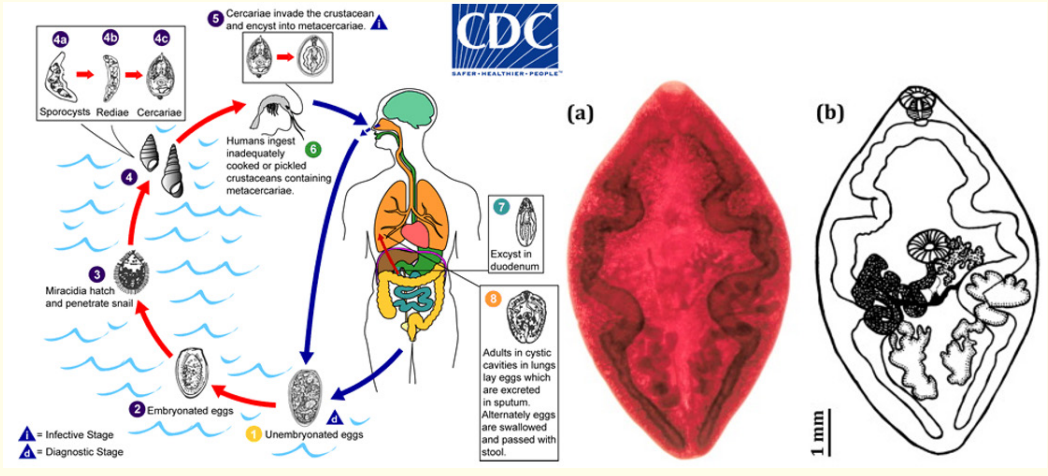

Figure 4: Life cycle of *pargonimus* spp [10].

Clonorchis sinensis (Clonorchiasis)

Clonorchis sinensis, commonly known as the Chinese liver fluke, is a parasitic worm responsible for clonorchiasis [12]. The lifecycle of *Clonorchis sinensis* involves both freshwater snails and fish as intermediate hosts, with humans becoming infected through the consumption of raw or undercooked freshwater fish containing the infective metacercariae [1,12]. The lifecycle begins with the release of eggs from adult flukes residing in the liver, gallbladder, or bile ducts of the definitive host (humans). These eggs are expelled with bile into the small intestine and are eventually passed out of the host in feces [12]. When the eggs are released into freshwater, they hatch into miracidia, free-swimming larvae that seek out and penetrate a suitable freshwater snail, which serves as the first intermediate host [12]. Inside the snail, miracidia develop into sporocysts, which then transform into rediae. These rediae further produce cercariae [12]. Cercariae are released from the snail into the water. They are free-swimming and actively seek out a second intermediate host, typically a freshwater fish [12]. In the fish, cercariae encyst to become metacercariae. These encysted larvae are resilient and can survive until the fish is consumed by a definitive host [12]. Humans become infected by eating raw or undercooked fish containing metacercariae [1,12]. Once ingested, the metacercariae are released in the digestive tract and migrate to the liver, gallbladder, and bile ducts, where they mature into adult flukes [12]. Adult flukes in the liver or bile ducts reproduce and lay eggs. The eggs are excreted with bile into the intestine and then pass out of the host in feces, continuing the lifecycle [12]. humans becoming infected by consuming raw or undercooked fish harboring the larvae [1,12]. This foodborne trematode primarily infects the liver, gallbladder, and bile ducts of humans. Clonorchiasis can lead to serious health issues, including jaundice, biliary inflammation, bile duct obstruction, and in severe cases, liver cirrhosis and cholangiocarcinoma [12].

Epidemiology of snail transmitted parasitic infection

Fascioliasiasis

Fascioliasis is a significant zoonotic disease with a global distribution, affecting both human health and livestock productivity [7]. The disease is prevalent in regions with extensive livestock farming and irrigation practices, especially in temperate and tropical

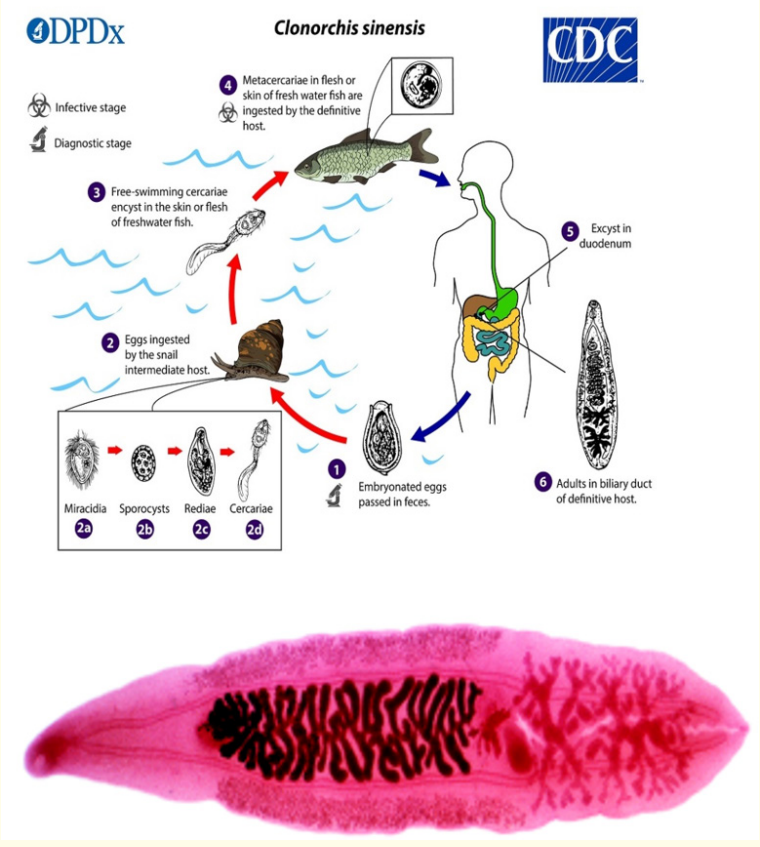

Figure 5: Life cycle of *clonorchis sinensis* [12].

climates. Various studies from India estimated the prevalence rate of 60% from Assam, 22.4% from Uttar Pradesh and 63% from Maharashtra [13]. In other study 45.8% residents of a sector of a village in Bihar was found to be infected with F. buski [8]. The actual prevalence could be more as only symptomatic individuals were included in the study [13]. A study on fascioliasis in northern Bauchi state reported different prevalence values for different localities. The highest infection rates reported were Jama' are (48.5%) followed by Zaki (46.9%) [14]. A study from another Asian country, Bangladesh, reported that Satkania in the Chittagong district is the most vulnerable place for infections (50%) caused by trematode parasite *Fasciola hepatica* [15]. For Africa, 31 studies reported data for 2000–2015; the incidence was the highest in cattle (1.2–91%) and the lowest in sheep (0.19–73.7%). In Iran, which is a neighboring country of Pakistan, the mean prevalence reported for the period 2000–2016 was 4.2% in cattle, 2.4% in goats, 2% in sheep, and 21% in buffaloes [15].

Schistosomiasis is the second most common NTDs after hookworm in Sub-Saharan Africa. Children and young adults bear most of the burden resulting from this disease in Africa. Five parasites species have been reported to infect humans, they include, *Schistosoma hematobium, Schistosoma japonicum, Schistosma mansoni, Schistosoma mekongi* [16]. over 240 million people worldwide are affected by schistosomiasis, with more than 700 million people living in at-risk areas across 78 countries Sub-Saharan Africa carries the largest burden of schistosomiasis, accounting for approximately 90% of the global cases. The disease is endemic in many countries within this region due to the abundance of freshwater sources that facilitate the lifecycle of the parasite's intermediate host, freshwater snails [3,4]. Nigeria is one of the most heavily affected countries in Sub-Saharan Africa, with an estimated 29 million cases of schistosomiasis, making it the country with the highest burden globally. Both *S. haematobium* and *S. mansoni* are endemic across Nigeria, particularly affecting rural communities with inadequate

water supply and sanitation facilities. In some states, the prevalence among school-aged children can exceed 50%, reflecting the urgent need for enhanced control measures, including regular mass drug administration and improvements in water, sanitation, and hygiene (WASH) infrastructure [1,3,4]. A study carried out in Nigeria reported that 2.3% of over 1000 cases of appendicitis had schistosome eggs discovered in histological sections, with 56% of the cases attributable to *S. mansoni*, 26.0% to *S. haematobium*, and 19.0% to coinfection by both species In another study, 4.2% of appendicitis cases were classified as schistosomiasis of the appendix. Schistosomiasis due to *S. mansoni* is on top of the list of the causes of pulmonary hypertension worldwide, especially in areas where schistoasomiasis is endemic [3,4].

The report of a pilot study in 2010, in the Eastern Cape Province of South Africa, with school-age students revealed an alarming prevalence of 73.3% [3]. A nation-wide survey of the prevalence of schistosomal infections and soil helminths in school children from Mozambique reported a prevalence of 47.0% *S. haematobium* infection and 1.0% *S. mansoni* infection [3,4].

A survey of school children aged 5-19 years in Mbita and some Islands close to Lake Victoria in Kenya revealed that the communities were highly endemic for *S. mansoni* infection with prevalence as high as 60.5% [1,3,4] Another survey covering the inhabitants of Lake Rweru in Rwanda indicated that 21.1% of the population screened had intestinal schistosomiasis [3].

Clonorchiasis and *opisthorchiasis*

Pathogens that cause *clonorchiasis* and *opisthorchiasis* include the liver flukes *C. sinensis*, *O. viverrini* and *O. felineus*, members of the *Opisthorchiidae* family. The disease is prevalent in East Asian countries where consuming raw fish is common [12]. Thirty-five million people are estimated to be infected with *C. sinensis* worldwide, approximately 15 million of whom are Chinese [1,12]. Approximately 10 million people are infected with *O. viverrini*, with 4 in 5 infections having occurred in Thailand and the remainder having occurred in Laos [1,11]. It is believed that 1.2 million people are infected with *O. felineus*, which is endemic to the area encompassing the former Soviet Union [1,12]. Infection with *Opisthorchis viverrini* and its associated cholangiocarcinoma (CCA) is an underestimated problem in the Mekong region of Southeast Asia, despite the widespread use of praziquantel and health education measures for parasite control [17]. The liver flukes endemic to Asia and eastern Europe include *Opisthorchis viverrini*, *Clonorchis sinensis* and *O. felineus*: worldwide infections number ~17 million: 7 million with *C. sinensis*, 9 million with *O. viverrini* and 1.2 million *O. felineus* [18] O. *viverrini* is prevalent in Thailand, Lao PDR and Cambodia, while *C. sinensis* is widespread in Korea, China, Taiwan, Vietnam and formerly Japan. *O. felineus* is found in the Russian Federation and eastern [18].

Angiostrongyliasis

Angiostrongyliasis is caused by the emerging pathogen, *A. cantonensis*, which was first reported in Canton, China [1]. By 2008, more than 2800 cases had been documented in nearly 300 countries and regions, of which the major outbreaks were reported in endemic areas, particularly in China [1]. *A. cantonensis* has a global distribution, with cases reported in Southeast Asia, the Pacific Islands, the Americas, and parts of Africa [1,5,6]. Increased global travel and trade have contributed to its spread, making it an emerging public health concern [5]. Now Angiostrongyliasis has spread from endemic areas in the Pacific Basin and Southeast Asia to countries in the Americas, including Brazil, the Caribbean Islands and the USA, and has been found in many areas worldwide [1,5]. An extensive outbreak of 160 cases that occurred in 2006 in Beijing, China, attracted a great deal of public attention [1].

Paragonimiasis

Paragonimiasis, which is caused by members of the genus *Paragonimus*, is an inflammatory lung disease [1]. The disease is prevalent in parts of Asia, Africa, and the Americas where traditional diets include raw or poorly cooked freshwater crustaceans Approximately 20 million people are infected with *Paragonimus* species, 293 million are at risk of infection [1,12]. The disease is primarily endemic to China, Korea, and Japan, as well as several other Asian countries. *P. westermani* is the most common and widespread species of this genus and is widely distributed in Asia [12]. This parasite can infect human lungs, brain, spinal cord, and other organs, causing pulmonary, neurological, and abdominal diseases [12].

Risk factors and symptoms of snail transmitted parasites

The distribution of snail transmitted parasitic infection is widespread and commonly observed in rural areas where occupational and recreational activities are linked to water contact due to the presence of the snail vectors [19]. Tourists who engage in freshwater activities have been observed to be at risk of the infection [20]. Communiteies which use surface water as water sources rely

on rivers and dams to sustain the daily household needs for water such as bathing, washing, and gardening, which expose its population, particularly school-going children, to water infested with snail intermediate hosts [21]. Frequent contact with infested water during bathing, swimming, fishing, and washing of cloth is associated with the high prevalence of schistosomiasis [22]. The suitability of the climate conditions for snail intermediate hosts and poor environmental sanitation contributed to the high endemicity of snail transmitted parasitic infection [22].

Snail transmitted parasitic infection presents symptoms such as fever, headache, abdominal pain, myalgia, malaise, fatigue and eosinophilia. Chronic *schistosomiasis*, which is common in endemic regions, manifests as non-specific intermittent rectal bleeding, abdominal pain and diarrhoea, heavily affecting people's ability to study and work and can even lead to death [23]. Liver enlargement is common in advanced cases and is frequently associated with an accumulation of fluid in the peritoneal cavity and hypertension of the abdominal blood vessels [24]. Kidney damage and fibrosis of the bladder and ureter are sometimes diagnosed in advanced cases. Bladder cancer is another possible complication in the later stages [24]. It can also present with genital lesions, vaginal bleeding, pain during sexual intercourse and nodules in the vulva, pathology of the seminal vesicles, prostate and other organs and ultimately infertility or even Death [24].

Laboratory diagnosis of snail transmitted parasites

Currently, the available diagnostic methods for snail transmitted parasitic infections are those that rely on stool and urine microscopy for parasite detection. These include Kato-Katz (KK) and urine microscopy, serum antibodies, antigen detection, and the detection of DNA of the parasite [25]. Diagnosis is established by demonstration of typical eggs in stool. However, as egg morphologies are similar for F. hepatica and F. busk [13]. The diagnostic standard for active *schistosomiasis* is detection of viable ova in urine (*S. haematobium*) or faeces (*S. japonicum, S. mansoni*).Nevertheless, the presence of a schistosomes infection cannot be ruled out definitively owing to the low sensitivity of standard urine and faecal tests. Despite the drawbacks, the WHO recommends microscopic examination of polycarbonate filters for ova in the urine, urine dipstick assays for heme, or the Kato-Katz faecal examination for schistosome mapping and field-based control of schistosomiasis [11,25].

Microscopic examination of stool or urine

Stool examination: For intestinal *schistosomiasis*, a stool sample is collected, and microscopic examination is performed to detect the presence of *Schistosoma* eggs. The specific species of *Schistosoma* can often be identified based on the morphology of the eggs [25].

Urine examination: For urinary *schistosomiasis*, a urine sample is collected, and the sediment is examined under a microscope for the presence of *Schistosoma haematobium* eggs [25].

Serological tests

immunological Diagnosis As of today, we have constantly been introduced with various methods developed to measure the host's immune response using crude or purified egg and adult worm antigens to detect antibodies. Immunological assays target immunoglobulins or antigens circulating in body fluids (plasma, serum, urine, or sputum). Intradermal test (ID), indirect hemagglutination assay (IHA), enzyme-linked immunosorbent assay (ELISA), dipstick dye immuno-assay (DDIA), circunoval precipitin test (COPT), dot immunogold filtration assay (DIGFA), indirect immunofluorescence test (IFT) [25].

Enzyme-linked immunosorbent assay (ELISA) and immunofluorescence assays (IFA) can detect antibodies against *Schistosoma* antigens in blood samples. These tests are useful for diagnosing active or recent infections, as they may remain positive for some time even after treatment [26].

Polymerase chain reaction (PCR)

Molecular techniques like PCR can be used in Detection of fragments of pathogen associated DNA in specimens, such as urine, stool, or blood. PCR can provide highly specific and sensitive results and may be used when microscopic methods are inconclusive or in research settings.

Has been demonstrated [26]. The presence of a schistosome infection cannot be ruled out definitively owing to the low sensitivity of standard urine and faecal tests." While sensitivity may vary, newer methods like PCR and antigen detection provide more reliable diagnoses.

Management of snail transmitted parasites

During the past few decades, control strategies of schistosomiasis relied on treatment of patient targeting to decrease morbidity, largely in sub-Saharan Africa and other high-prevalence areas. The use of targeted mass drug administration (MDA) has managed to reduce local prevalence among the victimized population after repeated treatment programs in school children and communities [26]. The use of preventive chemotherapy with 40 mg/kg praziquantel (PZQ) (the drug of choice for schistosomiasis), as advocated by the World Health Assembly in 2001 through resolution 54.19 [12,26]. Despite its effectiveness, praziquantel does not prevent reinfection, which necessitates repeated treatments in endemic area [26]. Other control measures include Using molluscicides to reduce snail populations in freshwater bodies, Improving water management to make habitats less suitable for snails. Improving access to clean water and sanitation facilities can significantly reduce exposure to contaminated water, thereby lowering transmission rates and Educating communities about avoiding contact with infested water and promoting safe water practices is essential for long-term control and prevention [26].

Conclusion

In conclusion, snail-transmitted parasite infections, represent a significant global health challenge, particularly in regions with inadequate access to clean water and sanitation. These infections are caused by parasitic flatworms that rely on freshwater snails as intermediate hosts in their life cycle. The risk factors for acquiring these infections are numerous, including exposure to contaminated water, poor sanitation, and occupation-related contact with infested water bodies. Effective diagnosis of snail-transmitted parasite infections is possible through various laboratory methods, such as microscopy, serological tests, PCR, and point-of-care tests. Early detection and appropriate treatment with anti-parasitic medications, most notably praziquantel, are crucial for managing and controlling the spread of the disease.

Prevention is equally important and encompasses a range of measures, from snail control programs and access to clean water and sanitation facilities to health education and behavior change initiatives. Community-wide interventions, such as mass drug administration and environmental management, play a vital role in reducing the prevalence and burden of these infections. Ultimately, a comprehensive and multidisciplinary approach that combines treatment, prevention, and education is essential for addressing snail-transmitted parasite infections. The goal is not only to reduce the incidence of these diseases but also to improve the overall well-being of affected communities and promote sustainable development in endemic regions. With continued research, surveillance, and concerted efforts at local, national, and global levels, progress can be made in the fight against these neglected tropical diseases.

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