

Are Freshwater Sources Safe for the Health of Humans and Domestic Animals in Terms of Deadly Trematodiasis?

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Abstract

There are many types of lentic and lotic freshwater sources on earth, such as puddles, ponds, rivers, springs, dams, lakes, etc. and many of them are found near human settlements. But most of the people are not known and aware of these freshwater sources how safe and dangerous they can be. In fact, these water sources are potentially responsible for spreading various deadly trematodiasis (trematode parasitic diseases) to both humans and domestic animals. The most common zoonotic or vector-borne dreaded trematodiasis found in humans and domestic animals are fascioliasis, schistosomiasis, paragonimiasis, echinostomiasis, amphistomiasis, etc. These parasitic diseases are endemic in almost every country. But these diseases can occur in any geographical area only when different species of snails (Mollusca: Gastropoda) and crabs or crayfish (Crustaceans) are found in the freshwater bodies there. In fact, these aquatic invertebrates are the intermediate hosts of diverse pathogenic digenetic trematode parasites including *Fasciola hepatica*, *Schistosoma mansoni*, *Paragonimus westermani*, *Ceylonocotyle scoliocoelium*, etc. and complete their life cycle. These are also known as vectors or carriers and are responsible for the transmission or spread of various trematodiasis in different geographical areas. Therefore, these diseases are also called vector-borne diseases. Apart from causing varying levels of morbidity and mortality in humans and animals, these diseases also cause tremendous economic losses to livestock owners. However, it is not necessary that all types of freshwater sources are beneficial, but from the point of view of trematodiasis, the water sources in which different types of snail species are found can also be dangerous or unsafe for the health of humans and domestic animals. But most of the people are ignorant and unaware of how these parasitic diseases transmitted or spread to humans and domestic animals through various freshwater bodies located around them. The current review highlights how freshwater sources can be hazardous or dangerous to the health of humans and domestic animals in the context of diverse trematodiasis and also focused on their prevention and control.

Keywords: Digenetic trematode parasite; Domestic animals; Humans; Freshwater sources; Intermediate hosts; Ruminants; Snails; Trematode larvae; Trematodiasis.

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Introduction

Many types of lentic (stationary) and lotic (floating) freshwater sources, such as puddles, ponds, rivers, springs, canals, dams, lakes, etc., are found on planet Earth and many of them are located in the vicinity of human and domestic animal populations. These small or large surface freshwater sources can also be shallow or deep and seasonal or perennial. The water of these sources is usually drunk by humans and domestic animals. In rural areas, most people and domesticated animals like cattle (*Bos taurus*), water buffaloes (*Bubalus bubalis*), sheep (*Ovis aries*), goats (*Capra hircus*), camels (*Camelus dromedarius*), etc. also bath and swim in the freshwater bodies. Herbivorous domestic animals also eat the various vegetation or plants growing in these freshwater sources while humans also eat or consume aquatic vegetables, fruits, fish, crabs, crayfish, etc. as food. During this time, generally, humans and domestic animals become infected with the highly infectious or infective trematode larvae, cercariae and metacercariae, of pathogenic digenetic trematode parasites (flukes). Infection with these larvae usually results in various trematodiasis. Generally, people are not aware of this type of infection nor are they aware of the infection of these parasites in their domesticated animals. The most common pathogenic digenetic trematode parasites, such as liver flukes (*Fasciola hepatica*, *F. gigantica*, etc.), rumen/intestinal flukes (*Orthocoelium scolicoelium*, *Gastrothylax cruminiifer*, *Megalodiscus temperatus*, *Cotylophorum cotylophorum*, *Ceylonocotyle scolicoelium*, *Paramphistomum cervi*, *P. microbothrium*, etc.), lung fluke (*Paragonimus westermani*), blood fluke (*Schistosoma mansoni*), urinary fluke (*S. haematobium*), etc. (Figure 1) are found in humans and domestic animals [1,6]. Generally, digenetic trematode parasites are found to be strongly host-specific, but some may have more than one definitive host or a wide range of hosts [1,7,8]. They mostly infect the important vital organs like liver, alimentary canal, heart, eyes, lungs, etc. of both human and animal hosts. They cause a lot of harm or histological and physio-chemical changes or damages to them. Humans and animals also die due to their excessive or heavy infection. The most common trematodiasis that are found in humans and animals are fascioliasis, amphistomiasis, paramphistomiasis, schistosomiasis, paragonimiasis, echinostomiasis, etc. These trematodiasis can also be regionally-specific or widespread [1,6]. But some of them are commonly found in both humans and domestic animals. However, the endemicity of any trematodiasis depends on the availability of their intermediate hosts, snails and crab or crayfish [1,6].

Snail species inhabit most freshwater sources

It is well established that in different lentic and lotic freshwater sources, such as puddles, ponds, rivers, springs, dams, lakes, etc. have their own type of ecosystem in which different species of snails are inhabited [7]. The most common and widely distributed snail species found in various freshwater bodies in different geographical regions generally belong to the families Lymnaeidae, Planorbidae, Thiariidae (Melanidae) and Viviparidae of the Class- Gastropoda of the Phylum- Mollusca. The most common snail species found in various freshwater sources in Asian countries are *Lymnaea acuminata* f. *patula*, *L. acuminata* f. *chlamsy*, *L. acuminata* f. *typica*, *L. acuminata* f. *rufescens*, *L. luteola* f. *australis*, *L. luteola* f. *typica*, *L. luteola* f. *impura*, *Gyraulus convexiusculus*, *Planorbis (Indoplanorbis) exustus*, *Faunus ater*, *Melania (Plotia) scabra*, *Thiara (Tarebia) lineata*, *Melanoide striatella tuberculata*, *Vivipara bengalensis* race *gigantica*, *V. bengalensis* race *mandiensis*, etc. (Figure 2) [9-12]. Many

of these snails are habitat-specific. Therefore, they have been considered as bio-indicators for various freshwater habitats and trematodiasis [13,14]. These aquatic snails are also carriers or vectors of various trematodiasis in humans and cattle and are responsible for the transmission of these trematode parasitic diseases. Therefore, these diseases are also called as snail-borne trematodiasis. It is well known that almost all freshwater snail species are intermediate hosts of digenetic trematodes (flukes) parasites and complete their life cycle. In fact, in these snails, various larval stages of these pathogenic trematodes parasites develop called sporocyst, redia, and cercaria. Importantly, thousands of cercarial larvae can develop from a single sporocyst by following the mechanism of asexual reproduction. This is one of the parasitic adaptations in trematode parasites by which they can survive and thereby save their species. Interestingly, these intra-molluscan larvae develop only in the vital organs of the snail hosts, the hepatopancreas (liver) and gonads (ovotestis).

Zoonotic trematodiasis

In humans and herbivorous domestic animals, various zoonotic or vector-borne trematodiasis are caused by infection with diverse species of pathogenic digenetic trematode parasites. The life cycle of these parasites is complicated and is completed in two different species of hosts, primary or definitive (humans and mammalian animals) and secondary or intermediate (aquatic snails) hosts. However, in certain species of digenetic trematode parasite, such as *P. westermani*, the life cycle is completed in three different hosts instead of two, man/animals, snails, and crabs/crayfish. Their asexually developing larvae, sporocysts, redia, and cercariae are also found to be pathogenic to the snail hosts in which they develop and multiply. These trematode larvae cause varying degrees of pathogenesis in the vital organs of snails, hepatopancreas and gonads depending on degree of parasitemia [15,22]. Transmission of trematode parasites, generally, occurs through consumption of water and food contaminated with larval stages found in their life cycle, cercariae and metacercariae. Therefore, trematodiasis developed due to consumption of water and food contaminated with larval stages is known as water- and food-borne trematodiasis, respectively. In general, in a host organism, the eggs of trematode parasites are spread through feces or stool, but there are also species of trematode parasites, such as *Schistosoma* sp. (blood fluke) and *P. westermani* (lung fluke) whose eggs are also spread through urine and sputum, respectively.

In fact, without aquatic snails, the life cycle of trematodes is not possible or completed, that is, if there are no aquatic snails in an area, there will be no trematode parasites or trematodiasis. These snails are also potential for the transmission of various water-and food-borne trematodiasis from one geographical region to another. That is why to control trematodiasis in any geographical area or country; the first step is to control the snail population [7]. Interestingly, the intra-molluscan larval stages of trematode parasites develop in the snails also control the population of snails naturally by the mechanism of parasitic castration [17,21,23].

In general, almost all vertebrates including human beings and domestic animals are the primary or definitive hosts of almost all pathogenic digenetic trematode parasites. Thousands of fertilized eggs of these parasites are eliminated or released or excreted through the feces, saliva/sputum, urine, etc. of infected individuals (the primary hosts), depending on the species of trematode parasites. Ultimately, these eggs are carried by rainwater to various freshwater bodies where the eggs hatch

into miracidium larvae, the first larval stage of trematode parasites. These free-swimming infective larvae eventually infect the intermediate host, the snail where they undergo asexual reproduction or multiplication and develop various parthenogenic developmental stages, such as sporocyst, redia, and cercaria. In these intra-mollusc trematode larvae, cercarial larvae are free-swimming larvae and usually emerge from the snail host during the day hours. Cercariae of different species of trematode parasites have different anatomy and morphology. Based on their anatomy and morphology, these are also classified or named as monostome, xiphidio, furcocercous, amphistome, echinostome, gymnocephalous, transversotrematid cercariae, etc. [23,41]. The type of trematodiasis that is endemic in any area can be predicted or expected based on the types of cercariae as well as snail species [7].

Most of the cercarial larvae are highly active, good swimmers, phototrophic, and negative geotaxis [42,44]. They have also strong host-specificity [42,44]. These larvae have well-developed organ systems, such as digestive system, excretory system, nervous system, etc. [45,52]. Whenever, while swimming, they come in contact with any objects or substratum (mostly leaves and twigs of aquatic plants, crabs, crayfish, fish, etc.), they stick to them where they undergo encystment or form a cyst around themselves. These encysted cercariae are called metacercariae larvae. Actually, these larvae are juvenile flukes or trematodes. These larvae are highly infective or infectious and can survive for a short time in unfavorable environments due to the presence of cysts around them. Whenever, these larvae enter the body of definitive hosts, humans and animals, through eating of aquatic foods contaminated with these larvae then they become excysted in the digestive system. Ultimately, the larvae reach their target organs in the body where they develop into adults and then start sexual reproduction and simultaneously also cause varying degrees of pathogenicity. Trematodiasis develops by eating raw or inadequately cooked aquatic foods, such as vegetables, fruits, crabs, crayfish, fish, liver of animals, etc. contaminated with metacercariae, then it is also called as food-borne trematodiasis (fascioliasis, amphistomiasis, paragonimiasis, etc). In some digenetic trematode parasites such as *Schistosoma* sp., their cercarial larvae are also infective and directly enter human and animal bodies through their skin and cause the fatal disease, schistosomiasis [1,4,5]. This type of trematodiasis developed by infection of cercarial larvae is called water-borne trematodiasis. A schematic representation of the life cycles of most of the common digenetic trematode parasites is shown in Figures 3-5. In these life cycles of trematode parasites, the intermediate host snail is common, but the life cycle of the trematode *P. westermani* (lung fluke) involves two intermediate hosts, the snail and the crab or crayfish (Figure 4).

The prevalence and endemicity of any kind of vector-borne or water- and food-borne trematodiasis in any geographical area depends on the infected snail population. Depending on the species of snail, it can also be predicted which type of trematodiasis will be endemic in area. Since each snail species completes the life cycle of a particular species of digenetic trematode parasite. In fact, those freshwater sources in which snail species are found are potential sources of transmission of various trematode parasitic diseases or trematodiasis to humans and animals. Therefore, such freshwater sources are not safe for the health of humans and animals. But most of the people are unaware of this. Though, these trematodiasis can easily be diagnosed by stool examination of definitive or primary hosts [53,56].

Prevention and control of trematodiasis

Diverse water-borne or snail-borne digenetic trematode parasitic diseases or trematodiasis, such as fascioliasis, amphistomiasis, schistosomiasis, paragonimiasis, echinostomiasis, etc. not only cause people and animals to fall sick and die but also cause huge economic losses in the country where these diseases are endemic. People who do animal husbandry business, when their animals suffer from these diseases, a lot of money is spent in their treatment and the death of the animals causes further financial loss. Therefore, prevention and control of trematodiasis is more important and necessary. But most of the people or villagers are still unaware of these water or snail-borne various dreaded trematode parasitic diseases. General awareness in both urban and rural populations is highly suggestive for the prevention and control of these parasitic diseases in humans as well as in their domesticated animals. Antiparasitic treatment, control of snail populations, improved sanitation and access to safe water, and communication about improved food safety and hygiene are important for the control of trematode parasitic infections. Interestingly, apart from water- and food-borne trematodiasis, people in many countries including India are also unaware of hydrofluorosis, a hyperendemic water-borne disease caused by chronic fluoride intoxication, which is prevalent not only in humans but also in their various species of domesticated animals (cattle, buffaloes, sheep, goats, camels, etc.) [57,73].

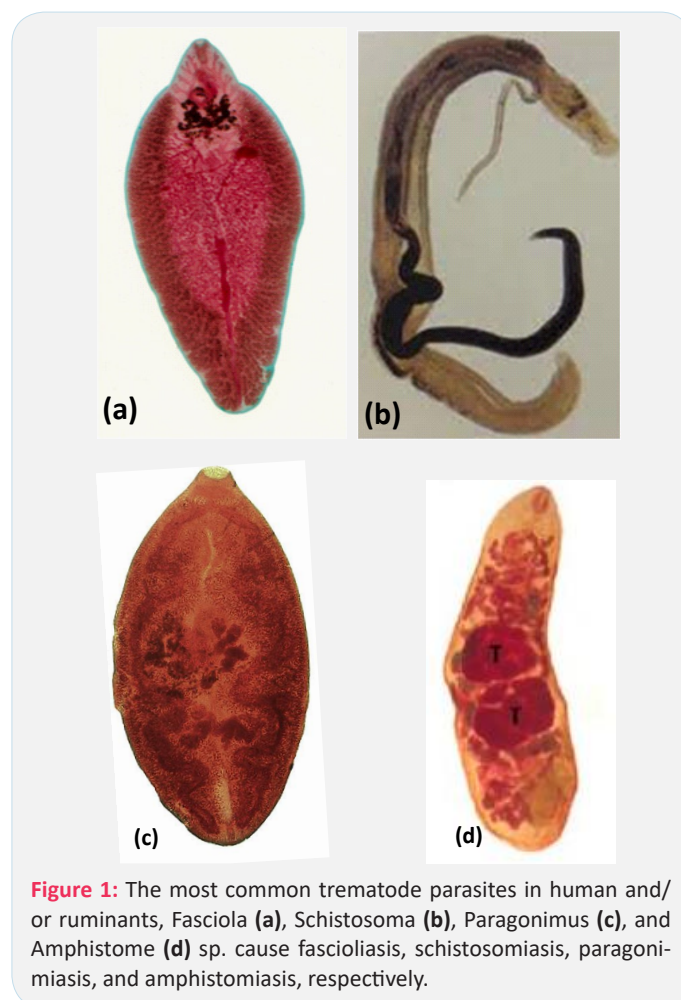


Figure 1: The most common trematode parasites in human and/or ruminants, *Fasciola* (a), *Schistosoma* (b), *Paragonimus* (c), and *Amphistome* (d) sp. cause fascioliasis, schistosomiasis, paragonimiasis, and amphistomiasis, respectively.

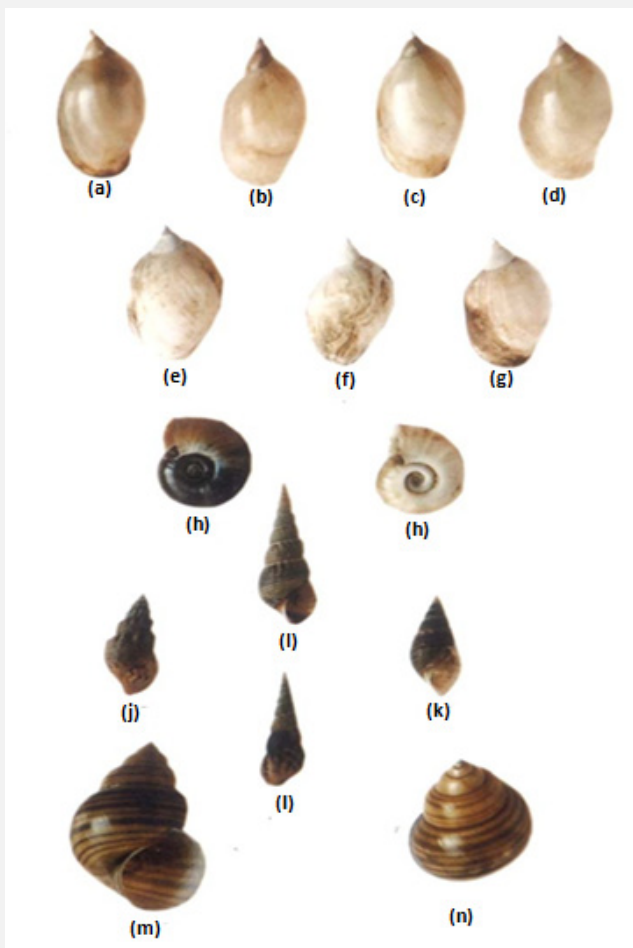


Figure 2: The most common species of freshwater snail hosts, *Lymnaea acuminata* f. *patula* (a), *L. acuminata* f. *chlamys* (b), *L. acuminata* f. *typica* (c), *L. acuminata* f. *rufescens* (d), *L. luteola* f. *australis* (e), *L. luteola* f. *typical* (f), *L. luteola* f. *impure* (g), *Planorbis (Indoplanorbis) exustus* (h), *Faunus ater* (i), *Melania (Plotia) scabra* (j), *Thiara (Tarebia) lineate* (k), *Melanoides striatella tuberculata* (l), *Vivipara bengalensis race gigantica* (m), and *V. bengalensis race mandiensis* (n).

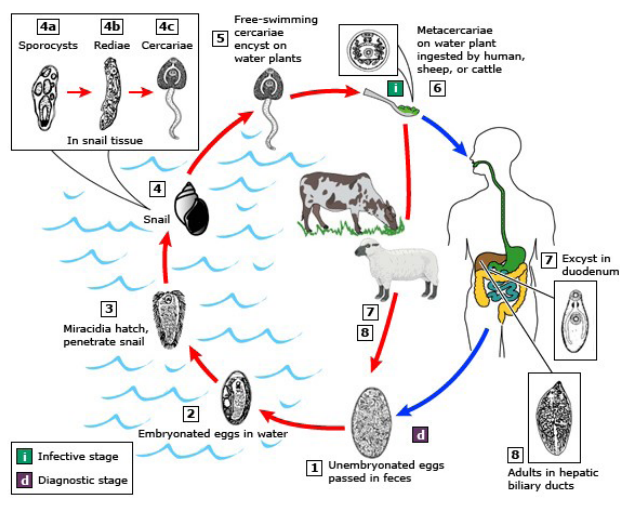


Figure 3: The life cycle of most of the digenetic trematode parasites (flukes) is completed in two different hosts, primary or definitive (man and animals) and secondary or intermediate (snails) hosts. The fertilized eggs of the parasite are excreted or passed out through the fecal matter of the primary host. Humans and other mammals become infected by eating metacercariae contaminated food.

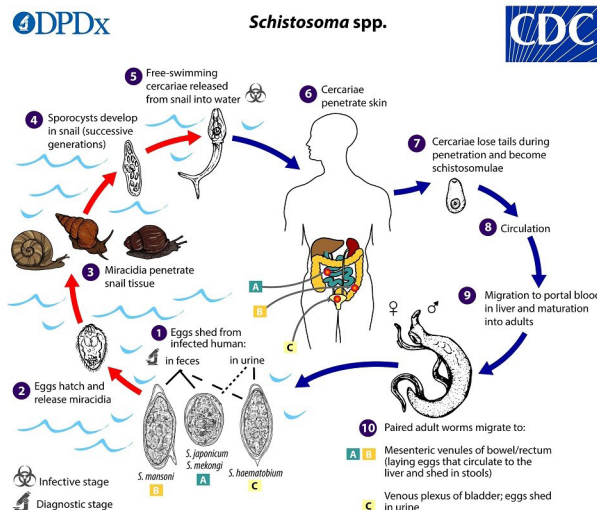


Figure 4: The life cycle of *Schistosoma* species is completed in two hosts, definitive (man and mammals) and intermediate (aquatic snails) hosts. The fertilized eggs of the parasite are eliminated with both feces and urine, depending on species, from definitive host. Infective furcocercous cercariae are transmitted to humans and animals through direct skin penetration.

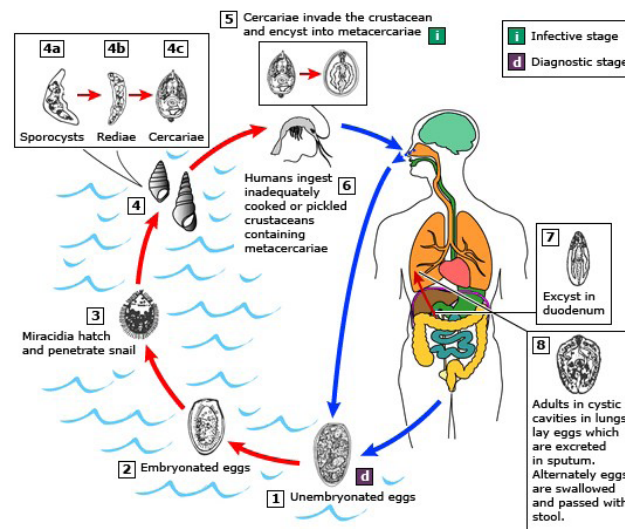


Figure 5: The life cycle of digenetic trematode parasite, *P. westermani* (lung fluke) is completed in three hosts, primary (man and mammalian animals), secondary (aquatic snails), and tertiary (crabs or crayfish) hosts. The fertilized eggs of parasite excreted or passed out through both fecal matter and sputum of the primary host. Humans become infected by ingestion of inadequately cooked or raw foods or pickled crustaceans (freshwater crabs and crayfish) containing or contaminated with infectious metacercariae.

Conclusion

Most lentic and lotic natural freshwater sources, such as puddles, ponds, rivers, canal, springs, dams, lakes, etc., contain populations of different species of snails. In fact, these snails are intermediate hosts of diverse species of pathogenic digenetic trematode parasites and complete their life cycle. Various fatal trematodiasis, such as fascioliasis, amphistomiasis, schistosomiasis, paragonimiasis, echinostomiasis, etc. occur in vertebrates, including humans and animals, through infection with the infective larvae of digenetic trematode parasites developing in snails. Therefore, freshwater sources that contain various species of snails are hazardous to human and animal health as

they are more likely to cause trematodiasis in them. Any kind of trematodiasis not only causes morbidity and mortality in humans and animals, but also causes enormous economic losses in several ways. Therefore, prevention and control of these water-borne parasitic diseases is highly suggestive. General awareness, improved food safety, hygiene and sanitation, and health education at school level are effective in prevention and control of these diseases. There is a great need to run a large scale campaign to control these diseases in the countries where these diseases are found in abundance or hyperendemic. This will also help directly or indirectly in maintaining the economic condition of these countries.

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