

## FASCIOLIOSIS: A MAJOR GLOBAL FOODBORNE ZOOONOSIS

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### INTRODUCTION

Agriculture sector plays a major role in the economy of Pakistan. It contributes approximately 11.4% to gross domestic product. This sector hires about 45% of labor force of the country and contributes to other segments of the growth economy (Khan et al. 2018). The livestock sector holds a unique place in the National Growth Agenda and is a net source of international revenue (Saleem et al. 2018). Throughout the history, smallholders have used livestock to satisfy their everyday needs for milk, food protection, and cash earnings.

Additionally, livestock is seen as a means of jobs at the rural level (Sargison 2020). It contributes significantly to poverty alleviation and continues to improve the socioeconomic status of our rural commonalities. In 2013-14, livestock contributed roughly 11.9% to the national gross domestic product, adding 55.4% to agricultural value-added (Khan et al. 2020).

Parasitism is the major constraint to livestock production throughout the world (Das et al. 2018). The importance of worm diseases is magnified in underdeveloped countries, such as Pakistan, where 65.2% of the inhabitants live in rural areas and are economically dependent on livestock. Parasitism presents a significant challenge to the livestock economy of farmers (Abbas et al. 2014). Due to the broad spectrum of ultimate hosts, fasciolosis, also known as liver fluke disease, is very important among helminth pathogens (Chemale et al. 2010). Fasciolosis is a parasitic infection of the liver that affects both wild and domestic ruminants. It is caused by parasites of the genus *Fasciola*, which is found globally (Dawes and Hughes 1964). Economic losses occur due to cow deaths, feticide, stunted growth, decreased production of milk and meat, rejection of damaged liver and skinny cadaver, and animal treatment cost (Mehmood et al. 2017). Fasciolosis is responsible for a significant economic loss, triggered by *F. hepatica* in ruminants. The parasite has rapidly spread across Asia, Africa, and the Pacific. Though the disease is more prominent in young livestock, it may also affect older animals, impairing their fitness, growth rate, and production. Besides its common veterinary importance, fasciolosis caused by *Fasciola hepatica* and *Fasciola gigantica* has been a resurgent, affecting many human populations by spreading through zoonosis (Mas-Coma 2005).

The prevalence of Fasciolosis infestation is 49.01% in buffaloes. Between January and September, Fasciolosis was more widespread, and from October to December, it was least prevalent. Fecal tests showed a 65% prevalence of *F. hepatica*. In contrast, fecal egg counts showed that *F. gigantica* was more common in adult cattle than in calves (Khalil-ur-Rehman et al. 2009). The epidemiology and seasonal trend of flukes infection is determined by the availability of intermediate hosts and eating habits of final hosts. Life cycle of *F. hepatica* is complicated and consists of multiple stages that occur in the environment or the intermediate host (Mucheka et al. 2015). Metacercariae, the infectious stage, is encased and eaten by grazing herbivores. Temperature and rainfall are important factors affecting life cycle of *F. hepatica* and occurrence of infection (Karim et al. 2015). It has been identified in numerous studies that *F. hepatica* is endemic to cattle, buffaloes, dogs, goats and humans in Pakistan (Qureshi et al. 2005; Zafar et al. 2019).

Fasciolosis is a disease that can infect about 300M cattle 250M sheep globally (Mooney et al. 2009). The two liver flukes that are often reported to cause Fasciolosis in ruminants are *F. hepatica* and *F. gigantica* (Walker et al. 2008). Cattle that are infected usually have difficulties in gaining weight, and dairy cattle may have lower milk production and are more likely to develop metabolic diseases (Bekele and Getachew 2010). Fasciolosis costs the UK and Ireland more than £18 million annually. According to Mulcahy and Dalton (2001), the disease costs Sweden €52 million a year, or €299 per infected animal. Schweitzer determined that liver condemnations due to Fasciolosis cost Kenyan cattle slaughterers 0.26 million USD per year (Schweizer et al. 2007).

Fascioliasis causes substantial economic losses to pastoral agricultural communities and commercial animal farmers, estimated at US\$ 2 billion per year, through the death of infected cattle, liver condemnation, and productivity losses associated with reduced feed conversion quality (Sanchez-Vazquez and Lewis 2013). Fascioliasis is widespread in tropical areas, affecting up to 90% of cattle, and is considered the most significant helminths parasitic disease (Sanchez-Vazquez and Lewis 2013). Notably, humans may also contract *Fasciola spp.* and the infection is referred to as human Fasciolosis. It is estimated that 2.4M people are sick with this disease in

more than 60 countries, and more than 180 million people are at risk worldwide (Rapsch et al. 2006). (Khalilur-Rehman et al. 2009) recorded a Fasciolosis infestation prevalence of 49.01% in buffaloes. Additionally, they found that the highest infestation occurred between January and September, while the lowest prevalence was between October and December. In contrast, Bhutto et al. (2012) found trematodes infestation in 4% of buffalo calves. *Fasciola hepatica* and, less often, *Fasciola gigantica* caused Fascioliasis. The large trematode's life cycle is illustrated in Figure 1.

Infected animals, such as humans, pigs, and buffaloes, harbor adult flukes in their bile ducts, passing young *Fasciola* eggs in their feces. The next phase of the life cycle occurs in fresh water (Rapsch et al. 2006). After a few weeks, the eggs hatch into miracidium, which then infects a snail host. In the Snail, growth can be completed in 5 to 7 weeks under ideal conditions, and cercariae are then shed in the water. Cercariae lose their tails as they encyst to form metacercariae (infectious larvae) on water plants. Metacercariae, unlike cercariae, can live under damp conditions for extended periods because they have a hard-outer cyst wall (Zafar et al. 2019).

### Evolution of *Fasciola* species in pre-domestication times

The unique features of Fasciolidae, with a total of just nine, largely geographically limited species scattered across three subfamilies, five monospecific genera, and only one multispecific genus indicate that this is an ancient tribe, with several members expected to have perished during its evolution (Mas-Coma et al. 2009). This evolution has resulted in the Fasciolids spreading across the Old World, with only one species, *F. magna*, having a Nearctic origin. In either case, the lack of Fasciolids in the Neotropical Region (all signs indicate that the presence of only *F. hepatica* in South America is a result of a recent human introduction) confirms the origin of Fasciolidae following the breakup of Gondwanaland into Africa and South America, approximately 90–100 million years ago (Dowd et al. 1994). The results of a recent phylogenetic analysis support the logical evolution of Fasciolidae members, including adult intestinal parasites with non-ramified caeca transmitted by planorbid snails, beginning in Africa and spreading to Asia and the rest of the Holarctic Region (Figure 2), with progressive adaptation to the liver microhabitat and transmission by lymnaeid snails (Lotfy et al. 2008). The origin of *F. hepatica* in Eurasia is widely known, owing to apparent preference of this Fasciolid for the lymnaeid *Galba truncatula*, which exhibits ecological characteristics associated with mild and cold climates (Mas-Coma et al. 2009). In terms of host origin, comparative evidence on infection, life span, egg shedding, and immunity suggest that sheep is more suited for *F. hepatica* than other host species. *F. hepatica* can live up to 11 years in sheep; adult flukes can produce a large number of eggs. However, there is no indication that sheep or goats develop immunity to *F. hepatica*. The disease is self-limiting in cattle. With the majority of flukes being

removed within 9–12 months, egg development is brief, with high egg production lasting for just a few weeks, and resistance is gained during primary infection (Bekele and Getachew 2010; Mas-Coma 2005). These data indicate that *F. hepatica* originated in Eurasian ovicaprines, most likely in *Ovis* animals.

For *F. gigantica*, cattle tends to be more suited than sheep in terms of host origin, as it is more contagious and lasts longer in the former species. Resistance to *F. gigantica* has been found in sheep and *F. gigantica* has also been observed in goats (Anderson et al. 1999). Although the majority of *F. gigantica* adults survive less than a year in cattle, others may persist for at least 3–4 years (Schweizer et al. 2007), and faecal egg counts are up to 80% lower in buffaloes than in cattle with the exact infection dosage (Mehmood et al. 2017). These findings indicate that *F. gigantica* originated in African ruminant communities distinct from ovicaprines and somewhat resembling bovines (Ahmad et al. 2021).

### Life cycle

Liver flukes infect a wide range of mammalian hosts and have a complicated life cycle (Valero et al. 2009). Humans are the accidental host of the genus *Fasciola* (LaPook et al. 2000). Metacercariae is the contagious type of this parasite, which burrows through the small intestinal wall and settles for a short time in the peritoneal cavity. Numerous liver fluke species are drawn to the biliary tree, whether intrahepatic or extrahepatic (Nyindo and Lukumbagire 2015). The hepatic stage, which in *F. hepatica* is predicted to last for approximately 6–7 weeks (Jones et al. 2008), is characterized by mechanical penetration of the parenchyma from the liver capsule, with eventual entrance into the bile duct; this is the biliary stage. After sexual reproduction, parasites mature and lay eggs (Nyindo and Lukumbagire 2015). In humans, metacercariae attain maturity within 3–4 months. Each adult worm produces an unusual number of eggs per day, depending on its definitive host. Sheep, pigs and black rats, according to reports, can extrude up to 25,000, 12,000 and 2,150 eggs, respectively (Youssef and Uga 2014). An individual liver fluke has been reported to extrude approximately 40,000 eggs per day (Mucheke et al. 2015). These immature eggs are carried to the small intestine by bile medium, where they are mixed with feces. They are excreted in the pasture and undergo embryonic growth in definitive ruminant hosts under optimum humidity and temperature. Since aquatic bodies play a critical role in the development of liver fluke larvae, hatching is determined by environmental factors such as light, temperature, and humidity (Tavil et al. 2014). Via constructive chemotactic and phototactic motions, the emerging free-swimming ciliated miracidia are designed to locate an essential Limnaeid snail intermediate host in less than 24 hours (Mucheke et al. 2015). They mature into sporocysts by mechanically penetrating the body wall and tissues of their snail hosts with their sharp stylets and proteolytic enzymes (Tavil et al. 2014). Mother rediae are produced by the further metamorphosis of the sporocysts,

which grow into daughter rediae. In the snail host, these rediae metamorphose into cercariae, which can passively infect suitable vertebrate hosts and humans, who drink infested water (Nyindo and Lukumbagire 2015). Relative humidity of more than 65%, rainfall more than 100 mm annually, and an atmospheric temperature of 25–30°C have been identified as favorable conditions for cercariae growth and shedding (Gu et al. 2012).

### Epidemiology of fascioliasis

Fasciolosis is widespread (Figure 1) in a variety of Asian countries, including the Middle East (Saudi Arabia, Russia, Pakistan, Thailand, Iraq, Iran, China, Iraq, Turkey, Vietnam, Japan, Korea, Iran, Philippines, Cambodia, Bangladesh, and Nepal) (Mehmood et al. 2017). Prevalence of Fasciolosis has been identified in thirteen countries and forty-one trials, ranging from 0.71–69.2% in cattle to 0.0–47.0% in goats (Table 1 and Figure 1). Table 1 shows the prevalence of Fasciolosis in Asian countries from 2000 to 2015. Iran and Pakistan have the most significant number of records among Asian countries. The bulk of experiments containing a greater number of animals reported a lower prevalence in comparison to those involving a short period and a smaller number of animals. Although the prevalence of Fasciolosis in Bangladesh has been reported to range between 14.28 and 21.54% in goats (Mehmood et al. 2017; Sanchez-Vazquez and Lewis 2013), and no data in other output species are known, the higher prevalence of parasite in this country can be due to the moist conditions and high rainfall, which are ideal for survival and reproduction of snails (Ahmed et al. 2007). According to a regional information method for assessing Fasciolosis, the prevalence of parasites in cattle from Cambodia has been estimated to be up to 20% (Dorny et al. 2011). Fasciolosis may affect 28% of cattle in Cambodia, areas with high and average risk concentrated in southern and central Cambodia (Dorny et al. 2011). According to a study conducted on sheep in China, the overall prevalence of liver fluke was estimated to be 28.5%, indicating that management strategies should be applied (Wang et al. 2006). In India, various figures have been recorded for sheep (2.78–8.98%), goats (2.35–15%), cattle (10.79%), and buffaloes (13.9%) (Mehmood et al. 2017). The high prevalence of these parasites may be attributed to suitable weather conditions for snails, the abundance of low-lying, well-irrigated marshy land and pastures near water sources, which are ideal for breeding of intermediate hosts. In Iran, prevalence of Fasciolosis has been reported in goats (0.20–4.4%), cattle (0.71–81.5%) and sheep (0.35–31.25%). There is a major seasonal difference in the prevalence of *Fasciola spp* (Bhutto et al. 2012). Fluke egg hatching and snail replication involve high rainfall and cool temperatures, occurring in spring and autumn. Fasciolosis has been reported in Iraq with a rate of 0.36% in sheep, 0.14% in goats, 1.27% in cattle, and 2.08% in buffaloes (Kadir et al. 2012), although it has been reported at a rate of up to 2.00% in Japan. It infects 1.10% in the Korean goat population, although it was the largest in

buffalo and goat populations in Nepal compared to all other Asian countries (Mehmood et al. 2017). Numerous tests have been performed in Pakistan, and the average prevalence of Fasciolosis in sheep is 6.50–29.99%, in goats it is 0.66–28.75%, in cattle it is 19.30–20.42%, and in buffaloes it is 14.71–30.50% (Mas-Coma et al. 2009). The causes for the rise in Fasciolosis infection rates may be the farmers' socioeconomic status or the creation of tolerance due to the inappropriate use of anti-parasitic drugs at insufficient doses for a prolonged period. In Saudi Arabia, Fasciolosis affects 13.50% of sheep and 52.90% of cattle (Sanad and Al-Megrin 2005). The higher incidence in cattle may be attributed to local farmers' lack of awareness about control measures. Numerous experiments conducted in Turkey indicate that Fasciolosis is present in up to 16.20% of sheep, 0.80% of goats, and 69.20% of cattle. Owing to less swampy regions and global warming, Turkey has a lower incidence of Fasciolosis than the nearby countries (Mehmood et al. 2017).

### The transmission pattern of Fascioliasis

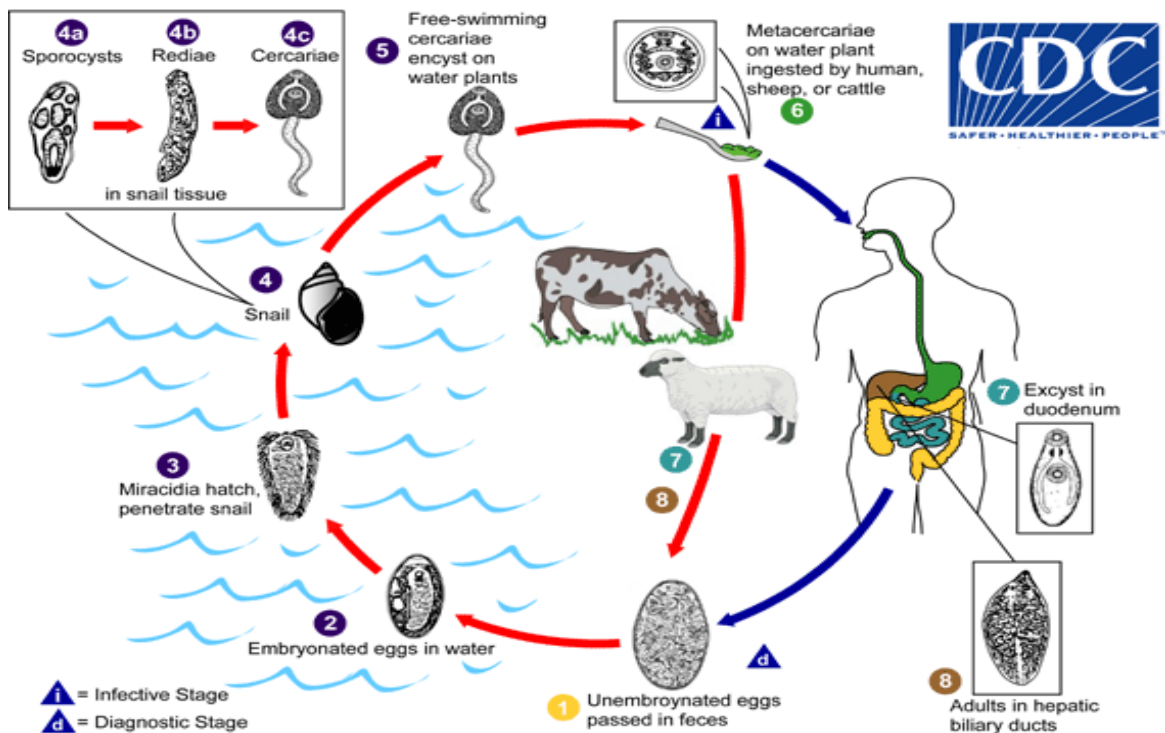
It is worth noting that there is remarkable variability of human Fascioliasis in epidemiological scenarios and dissemination rates worldwide (Ahmad et al. 2021). It may be inferred that well-known circumstances and trends do not always sufficiently account for disease attributes in a given region (Mehmood et al. 2017). Thus, when tackling an unstudied endemic area, the scenarios and dynamics of human infection outlined above must always be regarded as starting points. Only after an accurate evaluation of the epidemiology and transmission characteristics of the new region has been undertaken, suitable protection mechanisms for the zone in question can be planned (Nyindo and Lukumbagire 2015). It is critical to emphasize on the relationship between the lymnaeid vector species and the propagation pattern in question. Lymnaeids exhibit marked ecological and behavioral variation among species. Factors such as water selection temperature thresholds, habitat type, population dynamics, seasonality, and liver fluke infection susceptibility are critical for Fascioliasis (Mas-Coma 2005). All of these facts suggest that lymnaeids can serve as excellent disease markers, help differentiate between the various human Fascioliasis scenarios and trends, and thus as determinants for developing effective control strategies (Kadir et al. 2012).

A very high-altitude trend is linked with only *F. hepatica* transmission in Andean countries through imported *Galba truncatula*; within this group, two sub-patterns can be differentiated based on seasonal and psychological characteristics (Mas-Coma 2005). The altiplanic pattern is characterized by year-round transmission (e.g. in the Northern Bolivian Altiplano and the Puno Altiplano). The valley pattern is seasonal and varies in severity due to altitude as in the Peruvian valleys of Mantaro and Cajamarca (Mehmood et al. 2017). A Caribbean insular trend, with smaller yet more regular outbreaks in human hypo-endemic regions and lymnaeid species except

**Table 1:** Global prevalence range (%) of Fasciolosis in ruminants reported in different continents from 2000 to 2020 (Mehmood et al. 2017; Opió et al. 2021).

Sr. No.	Countries	Continent	Studies	Prevalence in different species			
				Goats	Sheep	Cattle	Buffaloes
1	Egypt, Kenya, Chad, Ethiopia, Nigeria, Sudan, Tunisia, Africa Uganda, Zimbabwe, Tanzania, Zambia		31	0.28-68.4	0.19-73.7	1.2-91.0	9.73-33.7
2	Colombia, Argentina, Peru, Brazil, Mexico	America	10	24.5-100	8.87-100	3.0-66.7	11.4-24.4
3	India, Bangladesh, China, Iraq, Cambodia, Pakistan, Asia Nepal, Iran, Japan, Korea, Vietnam, Saudi Arabia, Turkey		41	0.0-47.0	0.35-31.4	0.71-69.2	2.08-68.0
4	Australia, Papua New Guinea	Australia/Oceania region	03	(18.2)	5.5-52.2	26.5-81.0	--
5	England, Italy, Belgium, Denmark, Spain, Germany, Ireland, Switzerland, Poland, Sweden, Wales	Europe	23	0.0-0.8	3-83.3	0.12-86.0	--

(-): just single study no range is available.

**Figure 1:** The life cycle of large liver fluke (*F. hepatica*) (Hurtrez-Boussès et al. 2001).

primary vector species, is involved in transmission, as in the Pinar del Rio Province in Cuba. A trend characteristic of Afro-Mediterranean lowlands involves alternating *F. hepatica* and *F. gigantica*, many *Galba fossaria* and *Radix lymnaeids*, as well as secondary transmitting *Pseudosuccinea* (Ahmad et al. 2021). A trend was seen in surrounding areas of Caspian Sea, including human hypodemic zones, in which significant epidemics occasionally reach 10,000 people, including *F. hepatica* and *F. gigantica*, as well as many *Galba fossaria*, *Radix*, and stagnicoline lymnaeids (Iran) (Lotfy et al. 2008).

### Diagnosis and treatment

In endemic areas, if the clinical picture is highly indicative, it is often unremarkable. As a result, coprological procedures, such as looking for larvae, or examining adult worms vomited or passed out in feces are used for diagnosis (Le et al. 2008). In the GenBank database, two sequences corresponding to *Fasciola buski*'s

18S rRNA gene are available. Recently, Vietnamese child raise sequence of a fluke was used to verify the diagnosis. When the alleles were compared, only two nucleotide substitutions were detected (Nguyen et al. 2009). A number of drugs have been evaluated for the treatment of the disease in different ways. Tetrachloroethylene was discovered as an effective antibiotic (Karim et al. 2015) and became the preferred drug. Thiabendazole, levamisole and mebendazole are ineffective (Kelly et al. 1977). In the later studies, praziquantel was found to be effective, even in severe cases, resulting in prescribing a single 15 mg/kg dosage as the preferred therapy (Coles 1986), even though this drug was unable to save the life (Maqbool et al. 2002). In experiments on pigs, relative efficacy of triclabendazole, rafoxanide and oxcyclozanide for the treatment of Fascioliasis was investigated. It is worth mentioning that triclabendazole has a high degree of efficacy (97.12%), followed by oxcyclozanide (93.27%) and rafoxanide (83.17%), all of which are completely safe (Chhabra and Singla 2009).





Figure 2: Geographical spread routes followed by *F. gigantica* in the post-domestication period (Mas-Coma et al. 2009).

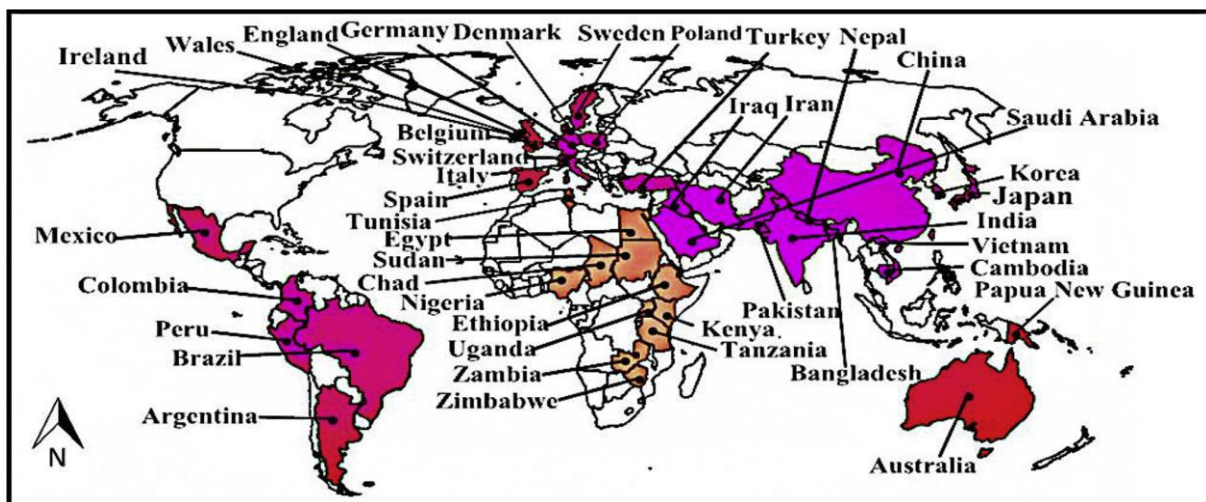


Figure 3: Global prevalence of Fasciolosis in ruminants reported (2000-2015) in different countries (Mehmood et al. 2017).

### A neglected disease

Fascioliasis caused by certain species of macroscopic and leaf-like digenetic liver flukes of the genus *Fasciola* is a medically necessary, primitive foodborne neglected zoonotic disease (Hugh-Jones et al. 1995). In 1379, a French scientist, Jehan De Brie identified the first known parasite, *F. hepatica* (ME et al. 1995). A pathologist and resident physician in Calcutta, Professor James McConnell, in 1874, discovered a Chinese human liver fluke called *Clonorchis Sinensis* after an autopsy on the body of a twenty-year-old carpenter (Nyindo and Lukambagire 2015). At the moment, alleged hybrids between *F. hepatica* and *F. gigantica* are being studied to determine their actual taxonomic status (Jones et al. 2008).

This is because an estimated 2.4M people in more than 70 countries worldwide suffer from Fascioliasis. These trematodes infest every continent, and 180M people are at risk (ME et al. 1995). Moreover, it is estimated that *F. hepatica* infects over 250M sheep and 300M cattle

worldwide, along with *F. gigantica*, causing an estimated US \$ 3B in economic damage per year (Hugh-Jones et al. 1995). Recently, the global incidence of human Fascioliasis has increased significantly (Mehmood et al. 2017), with a close link to a high infection rate in definitive ruminant hosts. The transmission of parasite is carried out by a diverse population of universal aquatic snails in Limnaeidae. For example, *Hinkleyia caperata*, *Austropeplea tomentosa*, *Galba truncatula*, *Radix rubiginosa*, *Stagnicola corvus*, and *Pseudosuccinea columella* have been recorded as endemic to Australia, North America, Europe, Africa, Asia, and South America, respectively (Vázquez et al. 2018). Fascioliasis caused by *F. gigantica* is endemic in tropical and subtropical lowlands. As a result, more disease cases are being recorded in a more significant portion of Sub-Saharan Africa (SSA), where suitable snail intermediate hosts occur naturally (Kelly et al. 2019).

Due to the high prevalence of Fasciolid infection in humans, this disease has been underestimated. Between

the 1950s and 1990s, the disease gained attention in France due to the hundreds of thousands of patients hospitalized during that period (Corvo et al. 2013). Fascioliasis was one of the most untreated illnesses on a global scale. Although the situation has dramatically changed since the 1990s, the often-used term 'sheep and cow disease' continues. This presents challenges in convincing political and health authorities of vital existence of human infection in many countries and the importance of introducing prevention measures, expert research and health literature (Jones et al. 2008). Thus, Fascioliasis receives no coverage in textbooks covering various diseases, such as tropical or human parasitic diseases. Researchers make fewer attempts to update knowledge on secondary infections than on primary ones. At times, research papers published in high-impact technical journals include inaccuracies, misunderstandings, or mistakes (Le et al. 2008).

### Immediate concern about Fascioliasis

Global understanding of zoonoses and a one-health solution are by far the most systematic approaches for the control of Fascioliasis (Phiri et al. 2005). Sustaining actions, including trade and travel restrictions, are expected to prevent infected animals transmission between countries. Additionally, enhanced food and water hygiene systems are critical parts of the monitoring scheme (Hammami et al. 2007). Stakeholder engagement and political support for these policies are essential for their successful implementation. Complete triclabendazole resistance cases (Islam and Ripa 2015) should be thoroughly reviewed to find out alternate treatment or solutions.

Additionally, vaccine development should be a focus of future studies. Multiple trematodes or intestinal parasite infections complicate the early diagnosis of Fascioliasis (Ahmed et al. 2007). Delayed and missing diagnosis, principally among the young ones, magnifies adverse effects of the disease (Karim et al. 2015). While Fascioliasis has been recognized as a disease of human importance, it is mainly considered as an animal disease, most notably of cattle and sheep. Lack of knowledge is a significant impediment to effectively managing human Fascioliasis (Bekele and Getachew 2010). Unfortunately, Fascioliasis in humans is not a recognized and reportable disorder in a large proportion of the world's least developed countries, which are plagued by hunger and infectious diseases. Sensitization and awareness are critical first steps in any proposed intervention strategy. Fortunately, there is no death identified due to human Fascioliasis infection to date. As a result, the disease is predictably assigned a low emergency health priority, making it one of the most underestimated tropical diseases (Mehmood et al. 2017).

Additionally, a slightly higher prevalence in school-aged girls has been reported. Thus, the morbidity and Disability Modified Life Years (DALY) effects of the disease are of great significance (Moje et al. 2015). The morbidity associated with chronic disease remarkably

leads to reduced life expectancy, poor quality of life and economic performance. The adult worms can survive for more than ten years in a suitable host (Mas-Coma et al. 2009).

### Fascioliasis as an emerging zoonosis

The World Health Organization has stressed the critical nature of foodborne fluke infections and the critical nature of controlling measures (ME et al. 1995). Plant-borne trematodes were newly added to the Institute of Food Technologists' Specialist Council on Food Safety and Nutrition (Hugh-Jones et al. 1995). In November 2004, the Third Global Meeting of the Partners for Parasite Control at the WHO Headquarters in Geneva, Fascioliasis and other foodborne trematode diseases were added to the significant list of helminthiases that have a direct effect on human health (Nyindo and Lukumbagire 2015). Additionally, it appears that current climate and global patterns affect some snail-borne helminthiases that depend on the environment for their transmission. Fascioliasis is an excellent example of a parasitic disease emerging/re-emerging in various countries due to a mixture of natural and human-made changes (Nguyen et al. 2009).

### Prevention and control

Regulations can be made for handling livestock, preventing augmentation, and adopting new pig farming techniques (Schweizer et al. 2007). Individual avoidance is straightforward: prevent use of foods obtained from freshwater plants. However, application of such regulation is incredibly difficult when century-old rituals are involved (Graczyk and Fried 2007). Infections are most likely to spread within families, since food storage, and eating practices are passed on over generations (Hurtrez-Boussès et al. 2001). Additionally, due to their low cost and availability, aquatic plants are a common food source (Hugh-Jones et al. 1995). Techniques for preventing contamination include preventing the use of human feces as waste, abandon defecation, and washing pig excreta into nearby water bodies (Le et al. 2008). Desiccation and direct solar radiation destroy metacercariae. The prevention approach should be focused on sustained outreach, emphasizing the importance of extensively cooking freshwater plants, immersing fruit and plants in boiling water for a few minutes, and use of boiled water in areas without access to purified water (Jones et al. 2008).

### Future challenges

There have been significant advancements in the diagnosis, surveillance, and treatment of Fascioliasis. Nonetheless, under-developed countries, primarily low-income populations, cannot benefit from these advancements due to poverty. With pathogens, civil strife, and competition for scarce capital, it is unsurprising that these areas have too few cases of human

Fascioliasis. Control initiatives should continue with extensive education and sensitization campaigns about the effects and magnitude of Fascioliasis in animals and humans. The new "One Health Integrated Global Approach to Disease" is the most systematic and participatory response available, not only for human Fascioliasis but also for most zoonotic diseases in general. A classic indicator of the challenges it discusses is the latest movement to "Go Eco" as a sustainable alternative to the current artificial lifestyle. This has resulted in extraordinary growth in the intake of fresh, raw/green vegetables and fruits. This is contradicted by a lack of funding for water protection, fertilizer-pesticide controls, and waste management. The use of unmonitored and unprocessed fresh vegetables has aided in the spread of plants/foodborne liver flukes such as Fascioliasis and a variety of other health problems. Clinical trials to assess confirmed cases of Fasciola bithionol and triclabendazole resistance are urgently needed. Further production of chemotherapeutic agents, such as Mirazid and nitazoxanide extracted from myrrh, and other innovative interference directed at the snail, could provide much-needed alternative chemotherapy. Aggressive monitoring for disease hotspots and control techniques run at animal reservoirs allow early intervention. Simultaneously, increased water and food safety, in conjunction with vaccine production, is crucial for human Fascioliasis prevention strategies. All of this must be followed by vigorous understanding, sensitization, and political support to optimize these measures to be effective.

## Conclusion

Fascioliasis has been recognized as a significant foodborne pathogen with zoonotic and veterinary implications. The advent of drug resistance, the creation of new parasite strains through hybridization and climate change are the major threats that can alter the epidemiology of the disease in the immediate future. To this end, researchers must accelerate their efforts to develop effective vaccinations that provide optimum protection for farm animals and humans while still substantially contributing to the global eradication of the disease by minimizing its occurrence and severity. The governments of tropical and subtropical countries should make deliberate efforts to raise support for research workers.

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