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Review on Trematodiasis and Its Current Status in Ethiopia

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ABSTRACT

Trematodes cause chronic debilitating diseases in livestock and are a major concern for global veterinary and result in significant economic losses. Snail borne parasitic diseases, such as fascioliasis, paragonimiasis, and schistosomiasis, endanger human health and cause major economic problems in many tropical and subtropical countries. In this review, we summarize the primary roles of snails in parasite existence patterns, clinical indications, and disease dissemination, as well as snail control strategies. Snails play four roles in the parasites' life cycle: As a middle of the road contaminated by the main stage hatchlings, as the main halfway host tainted by miracidia, as the primary moderate host that ingests the parasite eggs, and as the main transitional host entered by miracidia with or without the subsequent middle of the road has been an oceanic creature. Snail borne parasitic infections affect many organs, including the lungs, liver, biliary tract, digestive tract, mind, and kidneys, causing overactive immune responses, diseases, organ disappointment, barrenness, and even death. The most notable occurrences of these infections are in non-industrialized nations in Africa, Asia, and Latin America, while a few endemic parasites have evolved into global pestilences due to the global spread of snails. To prevent infection, physical, synthetic, and natural techniques have been used to control the host snail populations.

Keywords: Fasciolosis; Paramphistomosis; Trematodiasis; Trematode

INTRODUCTION

Ethiopia has a hugely diverse terrain, a diverse variety of climatic topographies, and a plethora of agro-ecological zones that are appropriate for hosting a massive animal population. It had the greatest livestock in Africa in 2020, with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels, and 49 million poultry. Despite having a substantial livestock population, Ethiopia is unable to fully use these resources due to a multitude of reasons, including periodic droughts, infrastructural challenges, animal disease outbreaks, inadequate nutrition, poor husbandry practices, a shortage of trained manpower, and a lack of government policies for disease prevention and control.

In all parts of the world, parasitic infections have a significant influence on cattle production and welfare. Infections with two types of internal parasites, liver flukes, and gastrointestinal nematodes, are often considered the most harmful to cattle. Parasitic infections produced by helminthes, protozoa, and arthropods, in particular, can cause greater economic losses than bacteria and viruses, but the impact on animal owners is unclear.

Among the parasite diseases, trematode infections, primarily fasciolosis, are among the most economically significant

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helminth diseases affecting domestic ruminant production globally. The category *Digenea* contains all parasitic trematode species in cattle. Adult trematodes are frequently referred to as "flukes", and the families that comprise prominent veterinary parasites include Fasciolidae, Dicrocoeliidae, Paramphistomatidae, and Schistosomatidae. The most significant flukes documented from various regions of the world are *Fasciola* (liver fluke), *Paramphistomes* (rumen/stomach fluke), and *Schistosoma* (blood fluke).

Fasciolosis is one of the most prevalent parasitic diseases of domestic animals, affecting mostly cattle, sheep, goats, and, on rare occasions, humans. *Fasciola hepatica* (*F. hepatica*) and *Fasciola gigantica* (*F. gigantica*) are the two species most often implicated as etiological agents of *fasciolosis*. Only *F. hepatica* is a threat in Europe, the Americas, and Oceania, but the populations of both species overlap in many parts of Africa and Asia. It is one of the most serious parasite diseases affecting Ethiopian cattle output.

Fasciolosis is more common in young animals and is frequently chronic. Adult flukes in the bile ducts induce inflammation, bile duct blockage, liver tissue damage, and anemia. In this sense, both immature and adult flukes have a significant impact on the growth rate and feed conversion of young animals. There may be a decrease in milk output as well as a decrease in conception and pregnancy rates in cows.

Animal productivity, weight gain, and meat and milk output are all reduced by fasciolosis. Furthermore, chronic fasciolosis produces mild icterus, metabolic problems, and secondary infections due to weakened immunity, as well as liver condemnation during postmortem examination in slaughterhouses, whereas acute fasciolosis may result in fatalities.

Paramphistomosis is a pathogenic disease that affects domesticated ruminants and causes significant economic losses in the dairy and meat sectors. It is considered a neglected tropical disease, with the highest prevalence throughout tropical and subtropical regions, particularly in Africa, Asia, Europe, and Australia. It has a wide geographical distribution, particularly in Thailand, Ethiopia, and Nigeria. Different species of Rumen fluke, *Paramphistomum* predominate in different parts of the world. *Calicophoron calicophorum* is the most abundant species in Australia. *Paramphistomum cervi* is the most frequent species in countries as far apart as Pakistan and Mexico. *Calicophoron daubneyi* is the most common rumen fluke in the Mediterranean and temperate areas of Algeria and Europe, and it has recently been identified as the most common rumen fluke in the British Isles.

They are largely nonpathogenic, but clinical outbreaks have been reported to occur. Rumen flukes have a conical form that measures 5 mm–12 mm by 2 mm–4 mm; we observed that the adults prefer the rumen and reticulum of ruminants, whereas immature parasites prefer the small intestines and abomasum.

Schistosoma bovis, *S. mattheei*, and *S. leiperi* can all cause schistosomiasis in cattle in Africa. In large ruminants, schistosomiasis is typically thought to be of minor relevance, and even when a high frequency of the parasite is found in slaughtered cattle, clinical indications of the disease are only observed rarely. Infection, on the other hand, might cause serious clinical symptoms [1-6].

A thorough understanding of parasite epidemiology and interactions with hosts in a given environment and management system is required for a reasonable and long-term helminth control campaign. To reduce the economic losses caused by trematode infections, which are known as neglected tropical diseases and chronic debilitating diseases, various studies in various parts of the country have been presented thus far. As a result, the following objectives were set for the current review:

- To review major snail borne trematode infections, existence patterns, clinical indications, disease dissemination, and snail control strategies.

LITERATURE REVIEW

Definition and Taxonomy

Trematoda is divided into two subclasses: *Monogenia*, which has a direct life cycle, and *Digenia*, which needs an intermediary host. The Fasciolidae, Dicrocoeliidae, Paramphistomatidae, and Schistosomatidae families are among the Trematoda families that comprise parasites of great veterinary interest and the Troglotrematidae and Opisthorchiidae are less important families. Snail Borne Trematodes (SBTs) (*Trematoda*: *Digenea*) have infected humans and animals since prehistoric times and exert deleterious effects. They may also induce life-threatening cancer leading to death. SBT diseases, namely, fasciolosis, paramphistomosis, and schistosomiasis, greatly hamper profitable livestock production in many countries of the world, especially in the humid tropics and subtropics.

Adult trematodes (flukes) are easily identified by their flat, leaf like structure and the presence of suckers. There are two forms of trematodes of veterinary interest: Those that live as ectoparasites on fish (*Monogenean* trematodes) and those that live as endoparasites in vertebrates (endoparasites) (*Digenean* trematodes). *Monogenean* trematodes feature a single oral sucker as well as several suckers attached to a noticeable posterior attachment organ (haptor). They have direct lifecycles and, since there is no intermediary host, diseases in aquaculture systems can spread quickly by direct transfer.

Digenea is one of the most diverse platyhelminthes groups, parasitizing a broad variety of invertebrate and vertebrate hosts, including humans. These worms can be detected in a variety of organs in the vertebrate final host, including the intestines, lungs, liver, and vascular system. Infections with these parasites cause significant losses in the cattle industry as well as a decline in human quality of life.

The suckers of *Digenean* trematodes are only ventral and oral. The mouth connects to a muscular pharynx, which propels

food into two seemingly endless caecas. These are branched to enhance the surface area in some genera, such as *Fasciola*. They must regurgitate waste products through the mouth since there is no anus. The eggshell is produced by the ovary, two testes, and vitelline glands. *Fasciola* causes output loss in ruminants with access to wet pastures by accumulating in the liver. *Dicrocoelium* is less harmful and occurs in drier environments, whereas fascioloides are harmless to wild ruminants but fatal to sheep. Adult amphistomes are normally harmless, but their immature stages can have serious and occasionally fatal impacts in warmer, wetter environments. *Schistosomes* are dangerous diseases that are typically found in tropical areas. Some are found only in humans, while others are found only in animals, and a few may be passed from animals to humans or vice versa.

Etiology

***Fasciola*:** The two most significant species are *F. hepatica* and *F. gigantic*. *F. gigantica* is only found in the tropics and measures (27 mm to 75 mm) × (3 mm to 12 mm), but *F. hepatica* is found in temperate areas (high altitude regions in East Africa) and measures (20 mm to 30 mm) × (10 mm).

***Paramphistomes*:** Some of the most notable species include *Paramphistomum cervi*, *Paramphistomum cotylophorum*, *Paramphistomum cracile*, *Paramphistomum gotoi*, *Paramphistomum grande*, *Paramphistomum ichikawai*, *Paramphistomum leydeni*, *Paramphistomum liorchis*, and *Paramphistomum microbothrioides*.

Schistosoma: *Schistosoma* species such as *Schistosoma bovis, S. indicus, S. nasalis*, *S. suis*, and *S. mattheei* can affect domestic animals in tropical areas. *Schistosoma japonicum* has also been found in humans, cats, and other animals in Africa.

Morphology

***Fasciola*:** Adult flukes are flattened and leaf like in shape, measuring 30 by 13 mm. These liver flukes are wider in the front part and have an anterior cone shaped protrusion followed by a pair of large laterally oriented shoulders. The tegument is well armed with backwardly pointed spines, which, together with the suckers, serve as an efficient mechanism for keeping the parasite in the bile duct. Eggs of *Fasciola* consist of a fertilized ovum with vitelline cells surrounded by a proteinous shell. *F. hepatica* eggs are operculated and measure 130 micrometers–150 micrometers in length and 63 micrometers–90 micrometers in breadth with a characteristic of yellow color. They were not readily differentiated from *F. gigantica* eggs.

Paramphistomes

Macroscopic: Adult *Paramphistomes* are small flukes approximately 1 cm long, conical in form, and pink or reddish, mostly parasitic in ruminant fore stomachs (rumen reticulum).

Microscopic: Unlike many other fluke species, their bodies are pear shaped, with the head at the narrowest end. The cross-section is almost cylindrical. They have two suckers, one oral and one ventral, the latter being bigger and closer to the rear end. They, like other flukes, show no outward evidence of segmentation. The pharynx, a muscular tube that permits sucking, is where the mouth ends. The digestive system is blind (*i.e.*, without anus: The only opening is the mouth) and branching, rather than linear, as in other animals, terminating in many blind ducts (called coeca). Rumen flukes, like other flukes, are hermaphrodites, meaning they have both male and female reproductive organs. The male and female reproductive systems are both present in the posterior portion of the body, as in hermaphrodites. The testes are lobed and placed anterior to the ovary. The eggs are clear shelled, barrel shaped, and contain an operculum at one end.

***Schistosoma**:* Eggs, miracidia, sporocysts, cercariae, and adult worms are the five stages of the development of blood flukes. The eggs are spherical to oval in shape, operculate (hinged at one end), and contain an embryonic larva that is growing (miracidia). Differences in egg shape can be applied to differentiate *Schistosoma* species based on spine position.

When some types of eggs are expelled in the faeces (*S. mansoni and S. japonicum*) and urine (*S. hematobium*), they are endowed with spines. *Hetrobiliharzia americana* eggs are very spherical, with only a tiny bulge on one side rather than a spine as observed in *S. hematobium* and *S. mansoni*. The eggs contain typical morphological characteristics. They are larger, thin (spindle) in shape, and feature a lateral terminal spine (pointed at both ends).

Miracidia are elliptical, free swimming larval stages (200 mm long) coated with cilia. Sporocysts are pleomorphic sac like structures that contain growing cercariae. Mature cercariae are elongate, free-swimming larval stages (400 mm–600 mm long) with a tapering head (with visible penetration glands) and a forked tail. Flukes are elongated tubular worms (10 mm–20 mm long) with primitive oral and ventral suckers. Males are shorter and stouter than females, and they have a longitudinal cleft (Gynecophoral canal or schist) in which the long, thin female rests folded (schisto-soma=split body) [7-11].

Life Cycles

***Fasciola*:** Immature eggs are excreted in the biliary ducts and faeces. Eggs become embryonated in water; eggs release miracidia (a free swimming ciliated larval stage in which a parasitic fluke passes from the egg to its first host, typically a snail), which infect a suitable snail intermediate host, such as the genera *Galba*, *Fossaria*, and *Pseudosuccinea*. Parasites go through numerous phases of development in the snail (sporocysts, rediae, and cercariae (a free swimming larval stage in which a parasitic fluke passes from an intermediate host)). The cercariae are discharged from the snail and encyst as metacercariae (a tailless encysted late larva of a digenetic trematode that is usually the form that is infective for the definitive host) on aquatic plants or other surfaces. Mammals become infected by consuming plants harboring metacercariae. Humans can become infected by consuming metacercariae-containing freshwater plants, particularly watercress. After ingestion, the metacercariae excyst in the

duodenum and travel through the intestinal wall, the peritoneal cavity, and the liver parenchyma into the biliary ducts, where they mature into adults (**Figure 1**).

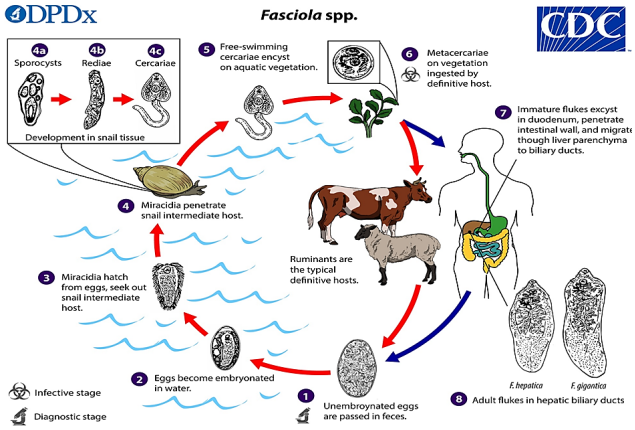

Figure 1: The life cycle of *F. hepatica*; the sheep liver fluke.

Immature eggs are discharged in the biliary ducts and pass into the stool/feces (1). Eggs become embryonated in freshwater over ~2 weeks (2); Embryonated eggs release miracidia (3), Which invade a suitable snail intermediate host (4). In the snail, the parasites undergo several developmental stages (sporocysts (4a), rediae (4b), and cercariae (4c)). The cercariae are released from the snail (5) and encyst as metacercariae on aquatic vegetation or other substrates. Humans and other mammals become infected by ingesting metacercariae contaminated vegetation (e.g., watercress) (6). After ingestion, the metacercariae excyst in the duodenum (7) and penetrate through the intestinal wall into the peritoneal cavity. The immature flukes then migrate through the liver parenchyma into the biliary ducts, where they mature into adult flukes and produce eggs (8). In humans, maturation from metacercariae into adult flukes usually takes approximately 3–4 months; the development of *F. gigantica* may take longer than of *F. hepatica* [12-15].

Paramphistomes

The rumen fluke life cycle necessitates two hosts: Snails as intermediate hosts and mammals, mainly ruminants, as definitive hosts. Ingestion of encysted metacercariae clinging to plants or floating in water initiates infection of the final host. Their life cycle is indirect, needing both definitive hosts such as ruminants and intermediate hosts such as snails. The sexually mature monoecious self-fertilizes (hermaphrodite) in the mammalian rumen and excretes the egg. In water, eggs develop into ciliated miracidia. Miracidia then enter the bodies of intermediate hosts, which are snails from the genera *Bulinus*, *Planorbis*, and *Stagnicola*.

Adult flukes in the stomach lay eggs, which are excreted outside with the faeces. Miracidia emerge from the eggs approximately two weeks later. They swim about in the water until they discover a suitable snail. They enter the snail and grow into sporocysts and rediae, which can replicate asexually and create daughter rediae. Each medium contains approximately 15-30 cercariae. Mature cercariae have two eyespots and a long thin tail, which they use to discover aquatic plants or other appropriate substrates to which they adhere and encyst to become metacercariae.

The infective larvae are consumed by mammalian hosts. Their cysts are removed once they enter the duodenum and jejunum. They enter the intestinal wall by aggressively damaging the mucosa and then travel to the rumen, where they mature into adult flukes and begin to lay eggs. It takes 2 to 4 months after ingestion by the last host for metacercariae to finish development and begin lying eggs (prepatent phase).

Schistosoma

Schistosoma have a lifecycle similar to that of a trematode invertebrate. *Schistosomes* feed on blood and generate eggs with a distinctive terminal or lateral spine in the host's mesenteric and hepatic veins (except for *S. nasale*, which lives in the nasal veins).

Infected individuals release parasite eggs into the environment, which hatch when they come into contact with freshwater, releasing the free-swimming miracidium. Miracidia enter freshwater snails through the snail's feet and infect them. After infection, the miracidium changes into a main (mother) sporocyst around the site of penetration. Germ cells within the original sporocyst will then divide to form secondary (daughter) sporocysts, which will relocate to the snail's hepatopancreas. Once in the hepatopancreas, germ cells within the secondary sporocyst divide once again, generating hundreds of new parasites known as cercariae, which are larvae capable of infecting mammals.

Cercariae emerge from the snail host daily in a circadian rhythm that is affected by ambient temperature and light. Young cercariae are extremely dynamic, alternating between rapid upward motions and sinking to retain their place in the water. Cercarial activity is heightened by water turbulence, shadows, and chemicals present in human skin (**Figure 2**).

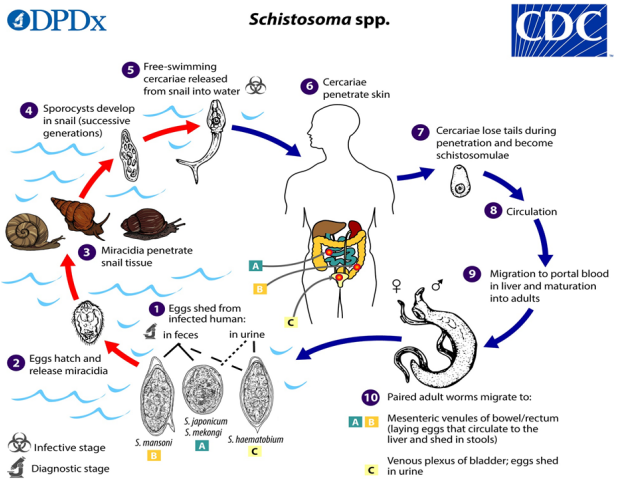

Figure 2: Life cycle of Schistosomes.

Schistosoma eggs are eliminated with feces or urine, depending on the species (1) Under appropriate conditions, the eggs hatch and release miracidia (2), Which swim and penetrate specific snail intermediate hosts (3). The stages in

the snail include two generations of sporocysts (4) and the production of cercariae (5). Upon release from the snail, the infective cercariae swim, penetrate the skin of the human host (6), and shed their forked tails, becoming schistosomulae (7). The schistosomulae migrate *via* the venous circulation to the lungs, then to the heart, and then develop in the liver, exiting the liver *via* the portal vein system when mature (8,9). Male and female adult worms copulate and reside in the mesenteric venules, the location of which varies by species (with some exceptions) (10). For instance, *S. japonicum* is more frequently found in the superior mesenteric veins draining the small intestine (10A), and *S. mansoni* occurs more often in the inferior mesenteric veins draining the large intestine (10B). However, both species can occupy either location and are capable of moving between sites. *S. intercalatum* and *S. guineensis* also inhabit the inferior mesenteric plexus but are lower in the bowel than *S. mansoni*. *S. haematobium* most often inhabits the vesicular and pelvic venous plexus of the bladder (10C), but it can also be found in the rectal venules. The females (size ranges from 7 mm–28 mm, depending on species) deposit eggs in the small venules of the portal and perivesical systems. The eggs are moved progressively toward the lumen of the intestine (*S. mansoni, S. japonicum, S. mekongi, S. intercalatum/guineensis*) and bladder and ureters (*S. haematobium*), and are eliminated with feces or urine, respectively [16-20].

Epidemiology

***Fasciola*: Geographical distribution:** Fasciolosis affects both humans and animals globally. Human fasciolosis, unlike animal fasciolosis, is found in underdeveloped countries, except in Western Europe. Fasciolosis arises only in regions where intermediate hosts may thrive.

Intermediate host ecology*: Lymnae truncatula* is the most widely distributed and essential species for the dissemination of *F. hepatica*. The snails are amphibious, and they emerge from the surrounding mud regularly, despite spending hours in shallow water. They can survive summer drought and winter cold for several months by aestivating and hibernating deep in the mud. Acidic pH environment, as well as a slowly flowing water medium, are ideal settings for waste removal. They primarily feed on algae, and the ideal temperature range for development is 15°C to 22°C; below 5°C, development ceases. This snail is usually found on poorly drained ground, drainage ditches, and area of seepage from springs or damaged drains, muddy gateways, vehicle wheel ruts, damp and muddy areas around drinking troughs, and animal hoof tracks on clay soil.

Factors influencing the agent: The key parameters influencing the time and intensity of metacercariae accumulation on herbage are given below. Temperature and moisture (rainfall) in particular influence the geographical and temporal abundance of snail hosts as well as the rate of development of fluke eggs and larvae. The availability of appropriate snails and their habits, temperature, moisture, and pH are the four primary elements essential for the outbreak of fasciolosis and influence the generation of metacercariae.

The availability of appropriate snails and their habits: *Lymnae truncatula* favors moist mud over free water, and its regular habitats include ditches or stream sides, as well as the borders of small ponds. Temporary habitats may be created by hoof tracks, wheel ruts, or rain ponds after heavy rains or flooding. While a slightly acidic pH environment is ideal for *Lymnae truncatula*, overly acidic pH values are harmful.

Temperature: Temperature has a significant impact on the growth rate of snails as well as the stages of parasites outside the host. A mean day and night temperature of 10°C or above is required for the snail host to reproduce and *F. hepatica* to grow within the snail. When the temperature falls below 5°C, all activities have a stop. This is also the minimum temperature range for *F. hepatica* egg development and hatching. However, a large multiplication of snail and fluke larval stages is only achieved when the temperature increases to 15°C and remains above this level.

Moisture: When rainfall exceeds evaporation and field saturation is reached, optimal moisture conditions for snail breeding and the development of *F. hepatica* snails are achieved. Such circumstances are also required for fluke egg development, miracidia seeking snails, and the dissemination of cercariae excreted by the snail.

Power of hydrogen: Fields with rush clumps are frequently areas with low pH. Eggs incubated at 27°C will develop and hatch within a pH range of 4.2 to 9.0, but development is slowed when the pH surpasses 8.0.

Paramphistomes

Although *Paramphistomum* is found all over the world, it is most common in tropical and subtropical areas, notably in Africa, Asia, Australia, Eastern Europe, and Russia. Paramphistomosis epidemiology is governed by several that are governed by parasite-host-environment interactions. The infection rate in pastures is the most important epidemiological variable in determining worm load in animals. It is also regulated by the climatic requirements for pasture egg hatching, development, and survival.

Paramphistomosis has been found in several locations in Ethiopia, with approximately 45.83% in Western Gojam, 28.6% in Debrezeit, and 6.7% in Hawassa. There is a lack of well documented data on the incidence of *Paramphistomum* in ruminants grazing near lake Ashenge.

Schistosoma

It resembles *Fasciola* and *Paramphistome* in appearance. The eggs of *Schistosoma* need the presence of water for development. Eggs can hatch in conditions where the pH is acidic. Temperature affects cercariae shedding. In snails, *Schistosoma* takes a long time to develop. High rainfall is a good predisposing factor for the emergence of these parasites. Epidemiological studies on bovine schistosomiasis point to the endemicity of the disease, particularly in places

with large permanent bodies of water and marshy pastures. The optimal distribution range for *S. mansoni* in Ethiopia has been observed to be 1500 meters–2000 meters above sea level.

Host Range

Definitive Host: Domestic animals are more highly infected by snail borne trematodes than other animals, although the degree of infection varies.

***Fasciola*:** The final hosts include sheep, goats, cattle, horses, deer, humans, and other mammals whose typical predilection site is the liver. Within the biliary tract of the liver, the immature stage migrates and matures. The agent blocks the duct system as it matures. The adult female lays one egg, which is secreted into the stomach and expelled with feces.

Paramphistomes: Cattle, sheep, goats, and other animals, as well as numerous wild ruminants, are all susceptible to *Paramphistomum*. Ruminants are the most reliable hosts.

***Schistosoma**:* The definitive host includes all domesticated mammals, mostly sheep and cattle.

Intermediate Host

Fasciola: In Europe and South America, *Galba truncatula* is the most common intermediate host for *F. hepatica*. Freshwater snails from the Lymnaeidae family are intermediate hosts of *F. hepatica*. Planorbidae snails are occasionally used as intermediate hosts for *F. hepatica*. The following are significant species involved in the transmission of *F. heptica* and are responsible for the establishment of miracidium in the cercaria stages of *Fasciola* larvae (**Table 1 and Figure 3**).

Table 1: Snail intermediate hosts and their distributions.

Snail intermediate host	Country
Lymnae truncatula	Europe
Lymnae stagnalis	Europe
Lymnae viator	Peru
Lymnae columella	New Zealand
Lymnae tomentosa	Australia
Lymnae natalensis	West and Eastern Africa
Lymnae rufescens	West Africa
Lymnae glarba	Europe

Figure 3: Shell layers of *Galba truncatula*; intermediate host of *F. hepatica*.

Paramphistomes: Snails of the genera *Bulinus, Planorbis,* and *Stagnicola* serve as intermediate hosts.

***Schistosoma**: Bulinus* and *Physopsis* species are particularly significant in the transmission of schistosomiasis in cattle and sheep.

Pathogenesis

Fasciola: The parenchymal (migratory) phase and the biliary phase are the two phases in which infection develops in a definitive host. When excysted immature flukes pierce the intestinal wall, they enter the parenchymal phase. Flukes travel through the abdominal cavity after penetrating the gut, eventually reaching the liver or other organs. The liver tissues are favored by *F. hepatica*. The lungs, diaphragm, intestinal wall, kidneys, and subcutaneous tissue are all possible ectopic fluke sites. Tissues are physically damaged during fluke migration, and inflammation occurs along fluke migratory pathways. When parasites penetrate the liver's bile ducts, the second phase (the biliary phase) begins. Flukes develop, feed on blood, and lay eggs in biliary channels. Tissue injury causes biliary duct hypertrophy and lumen blockage. Adult flukes are rather innocuous, but liver tissue is generally severely injured, as seen by edema, bleeding, discoloration, necrosis, bile duct hyperplasia, and fibrosis.

***Paramphistomes*:** The pathogenic impact of rumen fluke is connected with the intestinal phase of infection. Because the immature fluke feeds on plugs, the duodenal mucosa is severely eroded. In severe infections, this results in enteritis, which is marked by edema, bleeding, and ulceration. This paramphistomosis is considered a very pathogenic illness in tropical climates. In livestock animals, it causes enteritis and anemia, resulting in significant output and economic losses.

Pathological signs are caused by immature flukes. When immature flukes begin to congregate in the bowel, there is watery and fetid diarrhea, which is frequently linked to high mortality (even up to 80%-90%). In ruminants, up to 30,000 flukes can accumulate at one time and assault the duodenal mucosa, causing acute enteritis. The immature helminths adhere to the duodenal mucosa *via* their strong complete ventral suckers and are firmly embedded in the mucosa, producing severe enteritis, duodenitis, hypoproteinemia, edema, bleeding, and perhaps necrosis in previously uninfected young animals. Pathological lesions caused by immature *Paramphistomum* cause anorexia, polydipsia, severe diarrhea, and mortality in domestic ruminants.

Ruminal lesions have also been linked to heavy infection with the adult worms *Paramphistomum ichikawai* and *P. microbothrium*, which may have hampered digestion and absorption, leading to diarrhea, anorexia, anemia, and weakness. *P. cerviare* are plug feeders that cause significant disease by burrowing into the duodenum's submucosa and feeding on epithelial cells of the burner gland, causing anorexia, perfused fetid diarrhea, and a reduction in plasma protein concentration, and anemia that weakens the animal.

Schistosoma: Schistosomiasis (or bilharziasis) is unique among helminth infections for two reasons the majority of the pathogenesis is attributable to the eggs (rather than larvae or adults), and much of the pathology is caused by host immune responses (delayed type hypersensitivity and granulomatous reactions). Infections are frequently classified into three stages: Migratory, acute, and chronic. The migratory phase occurs when cercariae enter and travel through the skin. This condition is usually asymptomatic, but in sensitive individuals, it can cause temporary dermatitis ("swimmer's itch") and, in rare cases, pulmonary lesions and pneumonitis.

Adult worm eggs put into the circulation can infect local tissues, releasing poisons and enzymes and inducing a TH-2 mediated immune response. Inflammation and granuloma development occur around the deposited eggs, which can lead to fibrosis and scarring of afflicted tissues if the weight of the eggs is substantial. Eggs either reach the intestine (near the mesenteric veins where adult worms dwell) or move to the liver *via* the portal venous system. Granulomatous inflammation surrounding invading eggs in the gut can result in intestinal schistosomiasis, which is marked by ulceration and scarring.

Mechanical damage and lesions may result from egg migration. Furthermore, trapped *Schistosoma* eggs cause a granulomatous response that is meant to kill the eggs. These granulomas are made up of a variety of cells, the most common of which are eosinophils, macrophages, and lymphocytes. In the chronic stages of the disease, the pathology is accompanied by collagen deposition and fibrosis, resulting in organ damage and dysfunction.

Clinical Sign

***Fasciola*:** The clinical manifestations of fasciolosis are usually closely related to the infectious dosage (the amount of ingested metacercariae). During the winter, *Fasciola* infections can lead to a decrease in milk output in dairy cows. Clinically, they are difficult to diagnose since fluke loads are generally modest and anemia is not visible. The major impacts include a decrease in milk yield and quality, notably of the solids-not-fat component. Clinical appearance in cattle and sheep, the most common definitive hosts, is classified into four kinds. Fasciolosis can manifest in one of four clinical forms.

- **Acute type I fasciolosis:** More than 5000 swallowed metacercariae constitute an infectious dosage. Animals died unexpectedly, with no prior clinical indications. Ascites, abdominal bleeding, icterus, membrane pallor, and weakness may occur.
- **Acute type II fasciolosis:** The infectious dose was 1000–5000 metacercariae swallowed. As previously said, it can cause mortality, but it also causes pallor, loss of condition, and ascites for a short period.
- **Subacute fasciolosis:** The infectious dose is 800-1000 metacercariae swallowed. Sheep and cattle are sluggish, anemic, and may perish. Weight loss is a prominent.
- **Chronic fasciolosis:** The infectious dosage is 200–800 ingested metacercariae. All varieties of fasciolosis can cause asymptomatic or slow development of the bottle jaw and ascites (ventral edema), emaciation, weight loss, anemia, hypoalbuminemia, and eosinophilia.

Paramphistomes

This fatal disease is caused by the rumen fluke, a parasite that predominantly parasitizes cattle ruminants as well as certain wild animals. Paramphistomosis, also known as amphistomosis, is a condition that mostly affects cattle and sheep. Its symptoms include copious diarrhea, anemia, and lethargy, and if left untreated, it can lead to death. The most common clinical indications of stomach fluke infection are enteritis (small intestine inflammation) and severe diarrhea (watery scour) with blood traces as a result of dehydration, dullness, weight loss, and so on. Anemia and bottle jaw are also possibilities.

The immature rumen fluke is a plug feeder, that causes serious disease by burying itself in the submucosa of the duodenum and feeding on the epithelial cells of Brunner's gland, causing anorexia, perfusing fetid diarrhea, drop in plasma protein concentration, and anemia, all of which weaken the host. Mature *Paramphistomum* is also responsible for irregular rumination, rumenitis, decreased nutritional conversion and body conditions, anorexia, polydipsia, and severe diarrhea.

Schistosoma

Clinical signs in cattle included emaciation, severe diarrhea mixed with blood or mucous dehydration, pale mucous membrane, significant weight loss, decreased production, rough hair coat, anemia, hypoalbuminemia, hyperglobulinemia, and

severe eosinophilia that developed after the onset of egg excretion. Severely afflicted animals degenerate quickly and typically die within a few months of infection, but less severely infected animals suffer from the chronic disease with growth retardation.

Major clinical indicators linked to the intestinal and hepatic types of schistosomiasis in ruminants include hemorrhagic enteritis, anemia, and emaciation, which emerge following the commencement of egg excretion. Severely afflicted animals decline rapidly and typically die within a few months of infection.

Diagnosis

***Fasciola*:** Faecal exams and immunological tests are used to make the diagnosis. Clinical symptoms, biochemical and hematological profiles, season, weather, epidemiological scenario, and snail inspections must be considered. Several approaches, such as fluke egg count, liver enzyme detection, and post-mortem investigation, are utilized to identify the condition based on this information.

Postmortem examination: If liver fluke is suspected, the easiest way to diagnose it is to examine fresh corpses. Because untreated animals offer the most precise indication of the liver fluke and times of challenge, a post-mortem examination will also reveal any lesions caused by concomitant diseases such as black disease or parasite gastroenteritis. There is no remedy, and death comes soon. Because *Clostridium novyi* is prevalent in the environment, the black disease can be found anywhere populations of liver flukes and sheep converge. Although it is impossible to identify *Fasciola* in live animals, liver testing after slaughter or necropsy was determined to be the most direct, reliable, and cost effective way of diagnosing fasciolosis.

Fluke egg count: Finding the eggs in the feces confirmed the diagnosis of *Fasciola*. These eggs must be distinguished from the eggs of other flukes, particularly the large eggs of *Paramphistomes*. *Fasciola* eggs are oval, yellow brown, and measure 130 m to 150 m by 60 m to 90 m. Each egg will have a unique operculum.

Serological detection: ELISA and other serological methods on blood samples can be used to identify antibodies to *F. hepatica* with excellent specificity. Antibodies against fluke components are found in blood or milk samples, with ELISA and passive hem agglutination assays being the most reliable.

Detecting liver enzymes: Typically, two enzymes are tested. When parenchymal cells are injured, Glutamate Dehydrogenase (GLDH) is produced, and levels rise within the first several weeks of infection. The other Gamma-Glutamyl Transferase (GGT) shows epithelial cell injury lining the bile ducts, and elevated levels are sustained for extended periods. Subacute or chronic elevations in liver enzyme activity, such as Glutamate Dehydrogenase (GLDH), Gamma-Glutamyl Transferase (GGT), and Lactate Dehydrogenase (LDH) have been identified in subacute or chronic fasciolosis 12–15 weeks following metacercariae consumption.

Paramphistomes

The clinical indications of rumen fluke are frequently associated with young animals in the herd, as well as the history of grazing areas near the snail habitat. Because the disease arises during the prepatent period, a faecal sample investigation is of limited use. A postmortem examination and recovery of the small fluke from the rumen can be used to confirm the diagnosis. Symptoms are typically obvious in the host's behavior. Infected sheep and cattle become excessively anorexic or have poor digestion, resulting in thrift. Consistent diarrhea is a clear sign of a serious infection in the digestive tract, and hence the main diagnosis. Immature flukes are identified by examining watery feces.

DISCUSSION

Schistosoma

The primary technique of diagnosis for suspected schistosome infections is the examination of stool and/or urine for eggs. The type of sample used to diagnose schistosomiasis is determined by the parasite species that are most likely to cause the infection. Adult stages of *S. mansoni*, *S. japonicum*, *S. mekongi*, and *S. intercalatum* dwell in the mesenteric venous plexus of infected hosts, where they shed eggs in feces; adult *S. haematobium* worms live in the lower urinary tract venous plexus, where they shed eggs in urine.

When schistosomiasis is suspected, a thorough postmortem examination reveals lesions in the skin, as well as, if the mesentery is stretched, the presence of typical lesions in the skin that come into contact with ponds, lakes, streams, or ocean water containing infective cercariae from snail intermediate hosts. A thorough postmortem investigation is the best way to establish early infection. Because egg production decreases as infection increases, it is most beneficial in the early stages of infection. The majorities of eggs is spindle shaped and lack an operculum.

Treatment

Fasciola: Animals with fasciolosis have been treated with a variety of medications. Drugs differ in terms of efficacy, mechanism of action, price, chemical name, trade name, and market availability. Fasciolicides (drugs against *Fasciola* species) are divided into five chemical categories.

- **Halogenated phenols:** Hexachlorophene (bilevon), bithionol (bitin), nitroxynil (trodax).
- **Salicylanilides:** Rafoxanide (flukanide, ranizole), closantel (flukiver, supaverm).
- **Benzimidazole group**: Albendazole (vermitan, valbazen), triclabendazole (fasinex), luxabendazole (fluxacur), mebendazoles (telmin).
- **Sulphonamides:** (Ivomec) or Clorsulon
- **Phenoxyalkanes:** Diamphenetide or (Coriban).

Due to its exceptional effectiveness against both adult and juvenile flukes, triclabendazole (Fasinex) is the most

commonly used medicine. In several countries, triclabendazole is used to treat fasciolosis in animals. Nonetheless, its long term veterinary care resulted in the development of *F. hepatica* resistance. Its resistance in animals has been documented. As a result, scientists have begun developing new medicine. A novel fasciolicide was recently tested on naturally and experimentally infected cattle in Mexico and found to be effective. This new medicine is known as "compound alpha," and it has a molecular structure that is quite similar to triclabendazole.

***Paramphistomes*:** Resorantel, oxyclozanide, clorsulon, ivermectin, niclosamide, bithional, and levamisole have all been proven to be successful treatments.

Schistosoma: Praziquantel can cure infections caused by all major *Schistosoma* species. The timing of therapy is critical because praziquantel is most effective against adult worms and requires the development of a developed antibody response to the parasite. Various medications with recognized *Schistosoma* but also hazardous effects, such as antimonial, trichlorphon, or nequvon, have been investigated against visceral *Schistosoma* infection in cattle over the years.

Control

***Fasciola*:** Different approaches to fasciolosis control have been developed.

Reduction of snail population: To assess whether snail habitats are confined or widespread, a survey of the region for snail habitats should be performed. Drainage is the most effective long term means of diminishing mud snail populations, such as *Lymnae truncatula*, since it assures that snail habitats are permanently destroyed. When snail habitats are restricted, fencing off the area or treating it with a molluskicide ($CuSO_4$) on an annual basis is a straightforward technique of management. When the intermediate snail host is aquatic, such as *Lymnae tomentosa*, adding molluskicide to the snail's aqueous habitat can provide effective control.

Anthelmintic therapy: Fluke anthelmintics are used prophylactically to reduce pasture contamination by fluke eggs during the year when they are most likely to develop, which in the tropics is between April and August. Another therapeutic option is to eliminate the fluke population during a period of high burden or nutritional or pregnancy stress for the animal. For years with normal or below average rainfall, a good management approach is recommended to attain these goals. Because most metacercariae occur in autumn and early winter, the treatment time may need to be adjusted for usage in various places. The exact dates for spring and autumn treatments will be determined by lambing and service dates.

Forecasting the occurrence: The climate has an impact on the life cycle of liver flukes and the occurrence of fasciolosis. As a result, forecasting methods based on meteorological data have been developed to predict the disease's likely timing and severity. The forecast is used to provide an early warning of disease by computing data from May to August and implementing control actions before cercariae shedding. Although this approach is primarily used to predict snail infection in summer, it may also be used to anticipate snail infection in the winter by adding values for August, September, and October. The "wet day" prediction is another strategy utilized. From June through September, widespread fasciolosis is linked to 12 wet days (above 1.0 mm of rainfall) per month, while temperatures do not fall below the seasonal average.

Immunological approach: The host produces an antibody against the antigen in the unsheathing fluid as well as the worm's enzymes. Vaccination using antigen material obtained from helminths might provide immunity. Helminth immunity is often less effective and temporary than microorganism immunity since they do not replicate in the host as bacteria, viruses, and protozoa do. Although cattle have a higher immune response to *F. hepatica* than sheep, the severe reaction in cattle causes hepatic fibrosis, hyperplasia, and bile duct calcification.

***Paramphistomes*:** The best management, like with *Fasciola*, is to provide a piped water supply to the troughs and to prevent the animals from accessing natural water. Snails may obtain access to watering troughs even then, necessitating the use of a molluscicide at the source or the hand removal of snails.

***Schistosoma**:* This is comparable to what has been described for *Fasciola* and *Paramphistome* infections. The most efficient strategy to manage cattle schistosomiasis in endemic regions is to keep the animals from coming into contact with the parasite by fencing off risky areas and providing clean water. Unfortunately, this is not always practicable in places of the world where management is nomadic. Other means of management include chemical or biological destruction of the snail intermediate host population at transmission points, or eradication of the snail intermediate host population using mechanical barriers or snail traps.

The most efficient means of preventing schistosomiasis in people is to provide sanitary facilities and piped water, as this limits human contact with contaminated water.

Public Health Importance

***Fasciola*:** Human fasciolosis has been identified as a major public health issue in recent studies. The availability of intermediary snail hosts, domestic herbivorous animals, climatic circumstances, and human dietary patterns determine human *F. hepatica* infection. Humans can be infected by drinking fresh; untreated water with metacercariae since *F. hepatica* cercariae also encysts on the water surface. In addition, an experimental investigation found that individuals might become infected after eating raw liver dishes produced from fresh liver contaminated with juvenile flukes.

Schistosoma: Schistosomiasis, often known as bilharziasis in the past, is a significant helminth disease that, together with ancylostomiasis and filariosis, is one of the most serious. *S. mansoni* and *S. japonicum* are the two most frequent intestinal species, with the latter rarely being seen in domestic cattle. *S. hematobium*, the third kind, is found in the veins of the bladder. A kind of cutaneous lama migrans, often

known as "swimmer itch," exists in humans and is presumed to be caused by cercariae of avian and animal *Schistosomes*, which have restricted motility in human skin.

CONCLUSION

Trematodiasis in cattle, which might subsequently reduce the economic output of cattle, and hence, remain a major problem that could hinder the growth of cattle production. This occurrence is closely associated to the major feed resources, which was almost natural pasture in the form of grazing land, and which was seasonally water logged, and the area lacked clean piped water to animals, consequently, increasing the chance of exposure to trematode infection. Moreover, epidemiologically, the area was favorable for the development and multiplication of intermediate hosts. Consequently, there was a need to institute adequate control programmes. Based on the above conclusions, the following recommendations were forwarded.

RECOMMENDATIONS

- The strategic application of deworming and preventing animals from grazing in water reservoir areas should be improved.
- The character of different risk factors and the type of intermediate hosts involved in the prevalence of trematode infections should be studied further.

DATA AVAILABILITY

All the datasets generated or analyzed during this study are included in this manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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