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Review on Paramphistomosis

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Abstract: Paramphistomum is considered to be one of the most important emerging rumen fluke affecting livestock worldwide and the scenario is worst in tropical and sub-tropical regions. Different species of rumen fluke or paramphistomum dominate in different countries. For example, *Calicophoron calicophorum* is the most common species in Australia whilst *Paramphistomum cervi* is described as the most common species in countries as far apart as Pakistan and Mexico. In the Mediterranean and temperate regions of Algeria and Europe, *Calicophoron daubneyi* predominates and it has recently also been recognized as the main rumen fluke in the British Isles. Sharp increases in the prevalence of rumen fluke infections have been recorded across Western European countries. The species *Calicophoron daubneyi* has been identified as the primary rumen fluke parasite infecting cattle, sheep and goats in Europe. In our country Ethiopia also paramphistomum has been reported from different parts of the country. The rumen fluke life cycle requires two hosts; featuring snail intermediate host and the mammalian host usually, ruminants are the definitive host. The infection of the definitive host is initiated by the ingestion of encysted metacercariae attached to vegetation or floating in the water. Diagnosis of rumen fluke is based on the clinical sign usually involving young animals in the herd history of grazing land around the snail habitat. Fecal sample examination is of little value since the disease occurring during the prepatent period. The confirmation can be obtained by a post mortem examination and recovery of the small fluke from the duodenum. Heavy parasite burdens commonly compromise livestock production through reduced feed conversion efficiency, loss of weight and decreased milk yield, incurring economic losses with elevated morbidity and mortality.

Key words: Rumen Fluke · Emerging Problems · Diagnosis · Controls

INTRODUCTION

Paramphistomosis is a pathogenic disease of domesticated ruminants, causing a great economic loss in the dairy industry and meat production. It is considered as a neglected tropical disease with the highest prevalence throughout tropical and subtropical regions, particularly in Africa, Asia, Europe and Australia [1] with wide geographical distribution, specifically in a region of Australia [2], Thailand [3], Ethiopia [4] and Nigeria [5]. Different species of Rumen fluke Paramphistomum dominated in different countries of the world. *Calicophoron calicophorum* is the most common species in Australia Whilst *Paramphistomum cervi* is described most common species in the country far apart as Pakistan and Mexico [6]. In Mediterranean and temperature regions of Algeria and European, *Calicophoron daubneyi* predominant [7] and it has recently also been recognized as the main rumen fluke in British Isles [8, 9].

The life cycle of rumen flukes shows similarity with the other main Trematodes parasite in cattle in temperate regions, the liver *Fasciola hepatica* [10]. Ruminants are definitive hosts [11]. Freshwater snail as the intermediate host of the genus *Bulinus, Planorbis stagnicola* [12]. *G. tarantula* also a likely candidate. *Truncatula* has been shown to act as an intermediate host and, more recently this has also been confirmed in many areas [10].

Snail is also the main intermediate host *F. hepatica* suggesting that liver fluke and rumen flukes may coexist in regions with suitable snail habitat. The infection of the definitive host is initiated by the ingestion of encysted metacercariae attached to vegetation or floating in the water. Following the ingestion of metacercariae by the

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final host, the juvenile rumen fluke can be found in the small intestine where they attached to the mucosa and grow before they migrate to the rumen [13].

The subsequent pathology is predominantly associated with the immature fluke as it develops in the small intestine (duodenum). In contrast, adult fluke is primarily located in the rumen [14] where they are largely considered to be commensal although severe mucosal damage can be provoked by heavy infection [15]. A light infestation doesn't cause serious damage to the animals, but a massive number of immature paramphistomum can migrate through the intestinal tract causing acute parasitic gastroenteritis with high morbidity and mortality rates, particularly in young animals. Paramphistomum in the duodenum and ileum are plug feeder and cause hemorrhage which leads to bleeding and diarrhea and bleeding for a prolonged time may cause to anemia which farther weaken the host [14]. Mature paramphistomum is also responsible for ruminants' irregular rumination lower nutrition conversion, loss of body condition, decrease milk yield incurring economic loss with elevated morbidity and mortality and comprise the welfare [6].

Recent epidemiological studies carried out in Europe have reported that *Calicophoron daubneyi* is the only paramphistomum found in slaughtered cattle with prevalence between 6.2%, 18.8% [7]. In tropical regions, this pharamphistomosis has been regarded as a very pathogenic disease [16], in Europe's it is considered a harmless entity and the prevalence of paramphistomum has increased in this area since 2008 [9]. The most serious clinical consequence has been associated with several hemorrhage enteritis, produced by the immature paramphistomum before migration to the fore stomachs [17], that occasionally has been reported as the cause of severe outbreak with relevant mortality [18]. There are various methods to detect the presence of rumen fluke. Passive surveillance in the veterinary diagnostic laboratory is based on routine examination of feces for rumen fluke egg and largely follows the same sedimentation procedure for the detection of liver fluke [19].

Adult rumen fluke live attached to the surface of the rumen and reticulum and have a light to bright red color when fresh are pear-shaped and about 1cm in length. The prepatent period may be around 70 up to 80 days and the total life cycle is thought to take at least 34 months to complete [20]. Recently a sharp increase in the prevalence of rumen fluke infection has been reported. The controlling management of rumen fluke is based on mainly control of the rumen population, fencing of the watery area [21]. However, scarce information is available in diagnosis, Pathogenic importance and controls of this rumen fluke [15]. Therefore, the objective of this paper is to reviews various literature on the emerging problem of rumen fluke with the emphasis on diagnosis and control.

Literatur Review: Parasitic diseases the global problems and considered a copacetic obstacle in the health and product performance of animals [22]. Small ruminants are impressed by multifactorial gastrointestinal parasites such as nematodes, Trematodes and cestodes [13]. In this regard, there are many sources of the infection caused by an immature sample of the Rumen fluke families, leading to earnest economic losses and mortality in ruminants [23]. These trematodes infect several wild and domestic ruminants [24].

Scientific Classification of *Paramphistomum*:

Kingdom: *Animalia*, Phylum: Platyhelminthes, Class: Trematoda, order: Plagiorchiida, Family: *Paramphistomatidae,* Genus: *paramphistomum* [25].

Phylum Platyhelminthes

Phylum Platyhelminthes contain class Trematodas and class Cestodas. Class Trematoda contains two main subclasses such as Monogenic which contain direct life cycle mainly external parasites of Fish and Digenea that require an intermediate host that is found exclusively in invertebrates and they have considerable veterinary importance [26].

Family Paramphistomatidae:

There are many Families in the class Trematoda and those which include parasite of major veterinary importance they are; - Fasciolidae, Dicrocoeliidae, Paramphistomatidae and Schistomatidae [27].

Genus *Paramphistomum*:

Paramphistomum is a genus of parasite flatworm belonging to the digenetic Trematodes [27]. The generic name (Greek: Para meaning "similar" [to Amphistoma] Amphi meaning "on both sides" and stoma for "mouth") is given due to the presence of an anterior oral sucker and posterior larger ventral sucker in adult worm [28]. The body is minute measuring less than a centimeter covered with highly folded tegument, which in turn is provided with sensory papillae. Paramphistomum is all hermaphrodite, having both male and female reproductive systems in the posterior regions of the bodies [29]. The generic name was introduced by F. Fischoeder in 1901 for the replacement of the existing genus Amphistoma [26].

Species of Rumen Fluke:

There are numerous species of paramphistomes (*Paramphistomum*, *Calicophoron*, *Cotylophoron*) in ruminants worldwide. *Paramphistomum spp* Are Platyhelminth (flatworm) parasites that cause heavy economic losses [30] to the livestock industry to the tune of several thousand crores of rupees annually [31]. Due to striking resemblance with each other and with other amphistomes, many described species are known to be synonymous. Some important species are *Paramphistomum cervi*, *Paramphistomum cotylophorum, Paramphistomum cracile, Paramphistomum gotoi, Paramphistomum grande, Paramphistomum hiberniae*, *Paramphistomum ichikawai*, *Paramphistomum epiclitum, Paramphistomum explanatum*, *Paramphistomum leydeni*, *Paramphistomum liorchis, Paramphistomum microbothrioides, Paramphistomum phillerouxi* [27].

Host Range: Paramphistomum infects cattle, sheep, goats and other livestock as well as many wild ruminants. Ruminants are definitive hosts [11]. Freshwater snail acts as the intermediate host of the genus *Bulinus, Planorbis, Stagnicola* [12].

The Lifecycle of Rumen Flukes: The rumen fluke life cycle requires two hosts featuring snail intermediate and mammalians usually ruminants definitive host. The infection of the definitive host is initiated by the ingestion of encysted metacercariae attached to vegetation or floating in water [11]. Their life cycle is indirect, requiring definitive hosts such as a ruminant and an intermediate host such as a snail. The sexually mature monoecious self-fertilized in the mammalian rumen and release the egg along with the feces. Egg hatch in water into ciliated miracidia. The miracidia then enter the body of an intermediate host which is snails belonging to genera *Bulinus, Planorbis* and *stagnicola* [21].

Adult flukes in the stomach lay eggs that are shed outside with the feces. About 2 weeks later miracidia hatch out of the eggs. They swim in the water until they find a suitable snail. They penetrate the snail and continue development to sporocysts and rediae, which can multiply asexually and produce daughter rediae. Each media contains about 15-30 cercariae. Mature cercariae are possessed by two eyespots and a long slender tail, by which they find aquatic plants or other suitable substrata to which they get attached and encyst to become metacercariae [32].

The mammalian hosts ingest the infective larvae. Once inside the duodenum and jejunum, their cysts are removed [33]. They penetrate the intestinal wall by actively destroying the mucosa and then migrate to the rumen, where they complete development to adult flukes and start producing eggs. After ingestion by the final host, it takes 2 to 4 months for metacercariae to complete development and start laying eggs (pre-patent period) [34].

Site of Infection: Adult rumen flukes are located in the rumen of ruminants and immature flukes in the small intestine mainly in the duodenum [14]. Following the ingestion of metacercariae by the final host, the juvenile rumen fluke can be found in the small intestine where they attach to the mucosa and grow before they migrate to the rumen [13]. Experiment infections of goats with *Paramphistomum cervi* and cattle, with *Calicophoron microbothrium,* have revealed that immature worms migrating in the small intestine cause more severe damage than the adult worms established in the rumen and reticulum [11].

The immature stages develop within the snail host until cercariae are shed and the resultant infectious metacercariae cysts are ingested by the definitive host. The immature *Paramphistomes* penetrate the duodenal mucosa and migrate to the rumen where adult parasites attach to the ruminal surface with their large posterior suckers (acetabula), feeding on ruminal contents. Light infestations and the presence of adult parasites do not appear to cause serious damage or production losses in infected animals, but the migration of large numbers of immature *Paramphistomes* through the intestinal mucosa has been shown to cause clinical signs, such as diarrhea, weight loss, stunting and even death [35].

Epidemiology: *Paramphistomum* is distributed all around the world, but the highest prevalence has been reported in tropical and subtropical regions, particularly in Africa, Asia, Australia, Eastern Europe and Russia [15]. The epidemiology of *paramphistomosis* determined by several factors governed by parasite-host-environment interactions. The major epidemiological variable influencing the worm burdens of animals is the infection rate from pastures. It is also influenced by the climatic requirement for egg hatching, development and survival of the larvae in pasture [30].

In Ethiopia, paramphistomosis has been reported from different parts of the country with approximately

45.83% in western Gojam, 28.6% in Debrezeit and 6.7% in Hawassa and there is a scarcity of well-documented information on the occurrence of paramphistomum in ruminants in grazing around Lake Ashenge [12]. In general, paramphistomosis is one of the major obstacles for livestock development in Ethiopia by causing remarkable production losses in different parts of the country. This is because the area of origin of the animals is suitable for the survival of the snail intermediate host and the parasite [36].

Sharp increases in the prevalence of rumen fluke infections have been recorded across Western European countries. The species *Calicophoron daubneyi* has been identified as the primary rumen fluke parasite infecting cattle, sheep and goats in Europe. Prevalence levels as high as 29-36% in Spain 20% in France and 59% in Wales in cattle and up to 77% in Ireland and 42% in Wales in sheep, have now been reported (Table 1). The factors driving these increased levels are not fully understood, but the introduction of *C. daubneyi* to Western Europe during the movement of livestock, the presence of a suitable snail intermediate host [32] and climate change (milder winters and higher rainfall) favoring the completion of the parasite lifecycle [37] are all thought to contribute. The detail of prevalence across Western Europe is summarized in the following table.

Table 1: Reported Prevalence of Rumen Fluke across Western Europe

Area	Host	Method	Prevalence (%)	References
France	Goat	FEC	58.1	Paraud *et al.* [38]
France	Cattle	PM	20	Szmidt-Adjidé *et al.* [39]
Belgium	Cattle	PM, FEC	28, 22	Jones *et al.* [32]
Ireland	Sheep, Cattle	PM	14, 52	Toolan *et al.* [40]
Spain	Cattle	FEC	36	Gordon *et al.* [41]
Spain	Cattle	PM	6.2	Ferreras *et al.* [7]
Wales	Cattle, sheep	FEC	42, 59	Jones *et al.* [32]
Ireland	Cattle	FEC	57-100	Zintle *et al.* [9]
Ireland	Sheep	FEC	77	Martinez [18]
England	Cattle	PM	25	Bellet [42]

* FEC = fecal sampling method *PM = post-mortem method

Identification of Rumen Fluke's

Gross Identification: Adult paramphistomes are small flukes about 1 cm long, conical in shape and pink or a reddish color mainly parasitic in the fore stomachs (Rumen, reticulum) of ruminants [40].

Microscopic Identification: Some studies Rumen flukes were preliminarily identified under a microscope using low power magnification by preparing slides for detailed morphological studies and identification [11]. The fluke can be placed on a Petri dish and observed trough stereo microscopy to appreciate the morphology. Final identification of paramphistomum spp. could be done based on the morphology of fluke, its shape, anterior sucker, posterior sucker, terminal genitalium and tegumental papillae following the standard guidelines [19].

Unlike many fluke species, their body is not flattened but pear-shaped, with the head at the narrowest end. The cross-section is almost cylindrical. They have two suckers, an oral and a ventral one, the latter much larger and close to the posterior end. Like other flukes, they have no external signs of segmentation. The mouth ends in the pharynx, a muscular tube that allows sucking. The digestive system is blind (i.e. without anus: the only opening is the mouth) and not linear, as in most animals, but branched, ending in several blind ducts (called coeca). Like most flukes, rumen flukes are simultaneous hermaphrodites, i.e. they have both male and female reproductive organs [43]. As hermaphrodite, both male and female reproductive systems are present towards the posterior region of the body. Testes are slightly lobed and are located anterior to the ovary. Eggs are clear shell and measure about 140 x 80 µ; barrel-shaped with operculum at one end [27].

The identification of the fluke may also be explained by species. For instance, adult *P. cervi* is conical in shape, the anterior end tapering and the posterior being broad and pink in color. The color is due to its hemoglobin. They are 5-13 mm long, 2-5 mm wide, with the ventral side somewhat concave while the dorsal side is convex. It has two suckers, an anterior oral sucker and a posterior larger ventral sucker, hence the generic name (Greek: *para* meaning "besides", *Amphi* meaning "on both sides" and *stoma* for "mouth"). The tegumental surface is highly corrugated with transverse folds alternating with grooves and is spineless, which is uncharacteristic of trematodes. The genital pore is situated at the anterior third of the body. There are two types of bulbous shaped sensory papillae on the surface, each measuring 10-15 µ in diameter at the base with nipple-like tips; one has short cilia on top. Clusters of papillae on the ventral surface and around the anterior suckers are larger in size and number; while there are few on the dorsal surface [45].

Pathogenesis of Rumen Flukes: The pathogenesis effect of rumen fluke is associated with the intestinal phase of infection. The young fluke is plug feeders and this results in severe erosion of the duodenal mucosa. In heavy infection, these cause enteritis characterized by edema, hemorrhage and ulceration [5]. In tropical regions this

paramphistomosis has been regarded as a very pathogenic disease, it causes enteritis and anemia in livestock mammals and result in substantial production and economic losses [16].

Pathological symptoms are produced by immature flukes. When the young flukes start to gather in the intestine, there is watery and fetid diarrhea which is often associated with high mortality (even up to 80-90%). In ruminants, at a given time as many as 30, 000 flukes may accumulate, fervently attacking the duodenal mucosa to induce acute enteritis. Adult flukes are relatively harmless and liver tissue is generally damaged extensively indicated by swelling, hemorrhage, discoloration, necrosis, bile duct hyperplasia and fibrosis [46]. In heavy infection of previously uninfected young animals, the immature helminths attach to the duodenal mucosa using their power full ventral sucker and deeply embedded in the mucosa causing severe enteritis, duodenitis, hypoproteinemia, edema, hemorrhage and possibly necrosis. The pathological lesion leads animals to exhibit anorexia, polydipsia, severe diarrhea and death due to immature paramphistomum is very high and maybe as high as 80% to 90% in domestic ruminants [47].

The ruminal lesion has also been associated with heavy infection by the adult worm of *paramphistomum ichikawai* [15] and *C. microbothrium* which may have affected digestion and absorption resulting in diarrhea, anorexia, anemia and weakness [16]. *P. cervi*are plug feeders and cause serious disease by burying themselves into the submucosa of the duodenum and feeding on the epithelial cells of the burners gland resulting in anorexia, perfuse fetid diarrhea drop in plasma protein's concentration and anemia which weakens the host [5].

The Clinical Sign of Rumen Flukes: Rumen fluke which is mostly parasitizing livestock ruminants, as well as some wild mammals are responsible for the serious disease called paramphistomosis also known as amphistomosis especially in cattle and sheep. Its symptoms include profuse diarrhea, anemia, lethargy and often result in death if untreated. The major clinical sign of stomach fluke infection is enteritis (inflammation of the small intestine) and strong diarrhea (watery scour) with blood traces and as a consequence dehydration, dullness, weight loss, etc. Anemia and bottle jaw can also develop [44].

Immature rumen fluke is a plug feeder [48] and causes serious disease by burying themselves into the submucosa of the duodenum and feeding on the epithelial cells of the Brunner's gland resulting in anorexia perfuse fetid diarrhea, drop in plasma protein concentration and anemia, which weakens the host. Mature paramphistomum is also responsible for irregular rumination, rumenitis, lower nutritional conversion and loss of body condition, anorexia, polydipsia and severe diarrhea [44].

Diagnosis of Rumen Fluke: Paramphistomosis is considered to be one of the most important emerging diseases affecting livestock worldwide [20]. Currently, sharp increases in the prevalence of rumen fluke infections have been recorded throughout Western Europe [49]. Diagnosis of rumen fluke is based on the clinical sign usually involving young animals in the herd and history of grazing land around the snail habitat. Fecal sample examination is of little value since the disease occurring during the prepatent period. The confirmation can be obtained by a post mortem examination and recovery of the small fluke from the duodenum [50]. Symptoms are usually visible on the behavior of the host. Infected sheep and cattle become severely anorexic or digest food inefficiently and become unthrifty. Continuous diarrhea is an obvious indication of heavy infection in the digestive system, thus a primary diagnosis. The fluid feces are examined to identify immature flukes [44].

Fecal Sampling and Examination: Fecal samples (Approximately 10 gram) from bovine and ovine can be collected directly from the rectum of the animal. The sample then put in a plastic container with detailed water history about age, group, sex and the district of individual animals [50]. Ten percent formalin could be added and the sedimentation technique is applied for detecting trematode eggs in the feces [51].

Most trematode eggs are relatively large and heavy compared to nematode eggs. This technique concentrates them in sediment three grams of feces weighed or measured using a sensitive balance and transferred into container 1. Then 42 ml of tap water poured into Container 1. It could be mixed thoroughly with a stirring device. The Faecal suspension filtered through the area strainer into container 2. The filtered material poured into a test tube and centrifuged at 1500 rpm for 5 minutes. After centrifugation, the supernatant removed and a few drops of 5% methylene blue added. Then the sediment transferred to a micro slide, covered with a coverslip and examined fewer than 10x objective microscope [52].

Ante Mortem Examination: Antemortem inspection can be carried out on the animals before slaughter to assess their general health status. To identify the effect of snail

Table 2: Trematodicide drug evaluated against paramphistomosis of cattle and sheep

Drug	Dose (g/kg)	Species	Efficacy against mature flukes (%)	Efficacy against immature fluke (%)
Albendazole	20	Sheep	0	13-99
Closantel	7.5	Cattle	0	0
Fenbendazole	4.4	Sheep	0	99, 5
Hexaclorophene	20	Cattle	100	91, 1
Niclosamide	160	Sheep	0	99, 8
Niclosamide	100	Cattle	0	0
Oxiclozanide/Levamisole	10	Cattle	100	99, 9
Triclabendazole	100	Sheep	0	44, 9

Adapted from Rolfe and Boray [2]

burden, most of scientific studies focus on the origin and management of the animal. Some *Paramphistomatic* animals may be anemic up on the examination before slaughter [52].

Post Mortem Examination: The findings on some scholars showed that there is muscular atrophy, subcutaneous edema and accumulations of fluid in the body cavities and the fat deposits are gelatinous. In the upper part of the duodenum, the mucosa is thickened and covered with bloodstained mucus and there are patches of hemorrhage under the serosa. Large numbers of small, flesh-colored flukes (3-4 mm long and 1-2 mm wide) are present in this area but decrease in number toward the ileum. There may be none in the abomasum and fore stomachs. There may be a few in the peritoneal cavity and on histologic examination, the young flukes are present not only on the mucosal surface but are also embedded in the mucosa and deeper layers [52, 53].

Treatment : Drugs shown to be effective for treatment are resorantel, oxyclozanide, clorsulon, ivermectin, niclosamide, bithional and levamisole [21]. An in-vitro demonstration shows that plumbagin exhibits high efficacy on adult flukes [54]. In Table 2 below, the effectiveness of some drugs on paramphistomids summarized mainly emphasizing on those more available in tropical regions [2].

Control and Prevention: Paramphistomum is considered to be one of the most important emerging Rumen fluke affecting livestock worldwide and the scenario is worst in tropical and subtropical regions. For better and appropriate control strategies, it is important to identify the epidemiological aspects of the disease and the associated risk factors that are unique to a particular area and farming system [11]. The occurrences of the fluke diseases are closely associated with environmental factors and ecology and the infection of snail intermediate host in a particular area. In a certain geographical region, the microclimate determines the type and severity of parasitic infections in pasture grazing animals [51]. Thus management of infection is mainly based on control of the snail population [21].

Emerging Problems of Rumen Fluke: The paramphistomum is an emerging parasite that can affect a wide variety of livestock species across a broad geographical range including subtropical and tropical regions and decreased production loss [40]. Heavy parasite burdens commonly compromise livestock production through reduced feed conversion efficiency, loss of weight and decreased milk yield, incurring economic losses with elevated morbidity and mortality and compromised welfare [55].

In many countries, stomach fluke infection is still underestimated. However, paramphistomes can limit livestock productivity and account for high economic losses in cattle and immature flukes cause disease. Paramphistomosis is one of the trematode infections in domestic ruminants that have received little or no attention in Ethiopia because of misbelieving that it does not cause disease in animals. However, this infection causes substantial economic losses to the livestock industry and is widely spread and reported in ruminants of different parts of Ethiopia especially in areas having waterlogged and marshy grazing fields [12]. Mature *Paramphistomum* is also responsible for ruminitis, irregular rumination, unthriftiness, lower nutritional conversion and loss of body condition decrease in milk production and reduction of fertilities [56].

CONCLUSION AND RECOMMENDATIONS

The paramphistomum is an emerging parasite that can affect a wide variety of livestock species across a broad geographical range including subtropical and tropical regions and decreased production loss. *Paramphistomum spp.* are Platyhelminth (flatworm) parasites responsible for the disease called

Paramphistomosis. In many countries, these fluke infection is still underestimated. However, paramphistomes can limit livestock productivity and account for high economic losses in cattle and immature flukes cause disease. Ruminants are the definitive host and freshwater snails are the intermediate hosts of the genus Bulinus, Planorbis and Stagnicola. The pathogenesis effect of rumen fluke is associated with the intestinal phase of infection. The young fluke is plug feeders and this causes severe erosion of the duodenal mucosa. In heavy infection, these cause enteritis characterized by edema, hemorrhage and ulceration. The epidemiology of *Paramphistomum* is determined by several factors governed by parasite-host-environment interactions. The major epidemiological variable influencing the worm burdens of animals is the infection rate from pastures. Diagnosis of rumen fluke is based on the clinical sign usually involving young animals in the herd and history of grazing land around the snail habitat. Fecal sample examination is of little value since the disease occurring during the prepatent period. Based on these outlines the strict supervision on the diagnosis and controls of rumen flukes 'implementation is recommended.

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