HAEMONCHOSIS IN SHEEP: A REVIEW

Eyachew Ayana

Bahirdar Animal Health Investigation And Diagnostic Laboratory, P.O.Box 70, Bahirdar, Ethiopia
eyuelayana83@gmail.com

Abstract: Small ruminants are an integral part of the livestock sector of the economy and the mainstay of livelihood of the majority population especially in developing countries like Ethiopia. However, the economic benefits remain marginal chiefly due to prevailing disease. Among the parasites of sheep and goats that restraint the survival and productivity of small ruminants is *H. contortus* being of overwhelming significance and is one of the most pathogenic helminths belonging to gastrointestinal strongylids affects sheep. High economic impact is seen in sheep and goats in tropical and warmer temperate countries especially where there is good summer rainfall. It is blood sucking parasite of the ovines and caprines. Various intrinsic and extrinsic factors determine the survival of *Haemonchus contortus* and the development of the disease in the animal. In general, control of gastrointestinal nematode infestation in sheep relies heavily on anthelmintic treatments. However, the indiscriminate use of these drugs has led to the widespread emergence of drug resistant strains of parasites that has necessitated the development and use of various parasite control methods such as grazing management, biological agents and vaccines and the selection of resistant breeds of animals with or without moderate use of anthelmintics. The ultimate goal of such control programs is to enhance productivity, while minimizing risks regarding drug resistance and consumer and environmental concerns. This review attempts to highlight the different methods employed in the control of haemonchosis in sheep and the practical limitations associated with both control programs and the internal and external factors associated with the parasite and its microenvironment.
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1. INTRODUCTION

Ethiopia has 25.49 million sheep and 24.06 million goats (1). These livestock are almost entirely managed by the resource-poor, small-holder farmers and pastoralists. However, they make a critical contribution to food self sufficiency for rural households by providing milk, meat, skin, manure and traction, as well as generating direct cash income. In addition, livestock are a source of risk mitigation against crop failures. Small ruminants (sheep and goats) are particularly important resources for their owners, because they require smaller investments, have shorter production cycles, faster growth rates and greater environmental adaptability than cattle. Therefore, they form an important economic and ecological niche in all agricultural systems throughout the country (2).

Although, small ruminants represent a great resource for the nation, the productivity per animal is low. Small ruminant disease particularly the gastrointestinal helminthes are among the major causes of reduced productivity in Ethiopia (3). Gastrointestinal parasitism is arguably the most serious constraint affecting sheep production worldwide. Economic losses are caused by decreased production, costs of prophylaxis and treatment and death of the infected animals. The blood-feeding nematode, *H. contortus,* is among the most important gastrointestinal (GI) parasites of sheep and it is recognized globally as a major constraint to both small and large-scale small ruminant production systems in developing countries, leading to significant economic losses (4).

Haemonchus contortus, better known as barber pole worm or red worm, is a pathogenic nematode that uses sheep as a host and causes haemonchosis, an infection characterized by anemia and digestive disturbances. *H. contortus* is active mainly in warm, humid climates in the summer months. Adult worms colonize the abomasal mucosa of the sheep and feed on their blood. The eggs they produce are excreted in the feces, hatch and are ingested by the sheep through the consumption of grasses especially those that are short and/or covered in dew (5). *H. contortus,* as the highest egg producer of all sheep worms, is one of the more devastating internal parasites (6). Haemonchosis, if untreated, can lead to protein deficiency, anemia, bottle jaw or the swelling of the lower jaw (7). It is the most prevalent and pathogenic parasite and also economically important of small ruminants (8).

Haemonchus contortus is a species most commonly found in sheep and goats but *Haemonchus placei* is the usual species in cattle and there may be cross infection occur when small ruminants and cattle graze together but its severity is usually less (9). The infection causes anaemia and occasional death of the animals and is a major animal welfare problem. The main problem for the farmer is production losses due to decrease in weight and growth of the host animal that in turn leads to economic losses. *H. contortus* is frequently found in tropical and subtropical regions, where the conditions for the survival of this parasite are optimal. However, the parasite has also become a growing problem in temperate regions (10).

Diagnosis is made on the basis of clinical signs, grazing history, season, demonstrating eggs of fecal examination is confirmative but specific identification is difficult and required specialized laboratories and observation of adult parasite during post mortem examination (11).

Consequently, there is an urgent and ever-present need to control infections caused by *H. contortus* in small ruminants in the tropics. Control is generally achieved by the use of synthetic anthelmintics in combination with grazing management. Ideally, this may entail an integrated approach, including biological control, reduced frequency of anthelmintic treatments, parasite vaccines, livestock breeds that are resistant to parasites and the use of plants with anti-parasitic properties as well as the use of traditional herbal remedies or ethnoveterinary medicine (12).

Therefore, the general objective of this seminar paper is:

- To review haemonchosis in sheep

2. LITERATURE REVIEW

Gastrointestinal nematodes of the order *Stronglida* are the most common causes of clinical helminthosis. These parasites infest the wall or the lumen of abomasum, small intestine and large intestine. The most common gastrointestinal nematodes of small ruminants belong to the following genera: *Haemonchus, Trichostrongylus, Ostertagia, Oesophagostomum, Cooperia, Nematodirus, Marshalagia, Strongyloides and Trichuris.* Mixed infection of several genera is common in most of the natural infections (13).

2.1. *Haemonchus contortus*

Haemonchus contortus is a voracious blood sucking abomasal nematode and is responsible for extensive losses in sheep, goat and cattle especially in the tropics. Haemonchosis is for the most part a primary parasitosis, predisposing causes for infestation including overcrowding, lush pasture and hot humid climatic conditions. However, the development of clinical illness is favored by a fall in plane of nutrition particularly in young animals (14).

Haemonchus contortus known as barber pole worm or red worm is a pathogenic nematode that uses sheep as a host and causes haemonchosis, an infection characterized by anemia and digestive disturbances. *Haemonchus contortus* is active mainly in warm, humid climates in the summer months. Adult worms colonize the abomasal mucosa of the sheep and feed on their blood. The eggs they produce are excreted in the feces, hatch and are ingested by the sheep through the consumption of grasses especially those that are short and/or covered in dew (5). *Haemonchus contortus,* as the highest egg producer of all sheep worms, is one of the more devastating internal parasites (9).

Lambs and kids are the most affected members of the flock and older sheep and goats under stress also may have total anaemia (15). The haematocrit reading become less than 15% and progressive weight loss. But diarrhea is not a common feature of haemonchosis; the lesions are those associated with anemia. The abomasa become edematous and in the chronic phase the pH increase causing gastric dysfunction (8).

At peak infection, naturally acquired populations of *H. contortus* can remove one fifth of the circulating erythrocyte volume per day from lambs and may average one tenth of the circulating erythrocyte volume per day over the course of nonfatal infections lasting two months. Thus the anaemia of haemonchosis is generally considered to be moderately macrocytic normochromic in nature (16).

Observation of a phenomenon called self-cure is found to be the characteristic feature of haemonchosis in endemic areas in which the major part of the adult worm burden is expelled resulting in sharp drop in egg per gram to near zero after the advent of a period of heavy rain (8).

2.1.1. Morphology

The members of the genus *Haemonchus* are large worms. They are known as the large stomach worms of ruminants because they are the largest worms of the abomasum (17). An adult *H. contortus* measures about 15 to 30 mm long, the male being shorter than the female. The morphological characteristics of *H. contortus* (Figure 1) are a mouth capsule with a single dorsal lancet and two prominent cervical papillae in the oesophageal area. The male parasite is characterised by its copulatory bursa formed of two large lateral lobes and a small asymmetrically positioned dorsal lobe. Together with the two chitinous spicules, which are inserted in the female genital opening during copulation, this part of the worm is important for identification. The females have a reddish digestive tube filled with ingested blood, spirally surrounded by two white genital cords (ovaries) giving the appearance of a barber pole. They have a sharply pointed slender tail and a vulva with or without anterior vulval flap (18). The adult worm is yellowish and usually red in color when engouraged with blood (19).

The eggs are of strongyle type with a diameter between 70 and 85 μm (20).

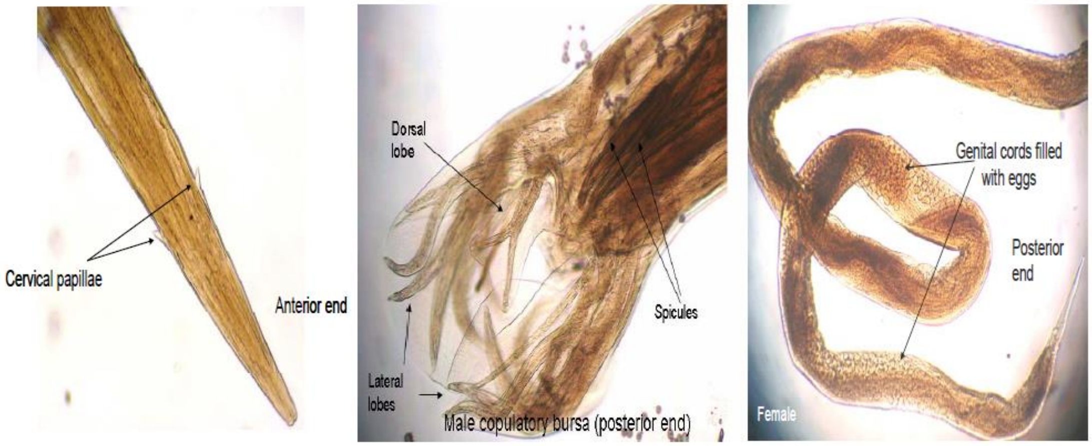

Figure 1: Morphology of male and female *H. contortus* (21).

2.1.2. Life cycle

The life cycle of *H. contortus* is typical to its superfamily *Trichostrongylidae* which have a direct life cycle (17). An understanding of the life cycle of *Haemonchus* is important for effective control programs. Adult *Haemonchus* worms live in the abomasum and lay eggs that are passed in the faeces (Figure 2). Each adult female parasite has a tremendous egg laying potential (5000 -10000 eggs per day). The eggs that are excreted together with faeces hatch and pass through three larval stages, the third stage (L3) being infective to the host. The period required for hatching of the egg and development of the larvae ranges from 5 days to several months depending on the weather conditions. Ingestion of the L3 together with grass while grazing leads to infection of the host. L3 then penetrates the mucus membrane of the abomasum and molt to L4 within the next few days. L4 remain in the mucus membrane for 10-14 days after which they emerge and molt into adult stage and females start egg production within 14-21 days post infection (22).

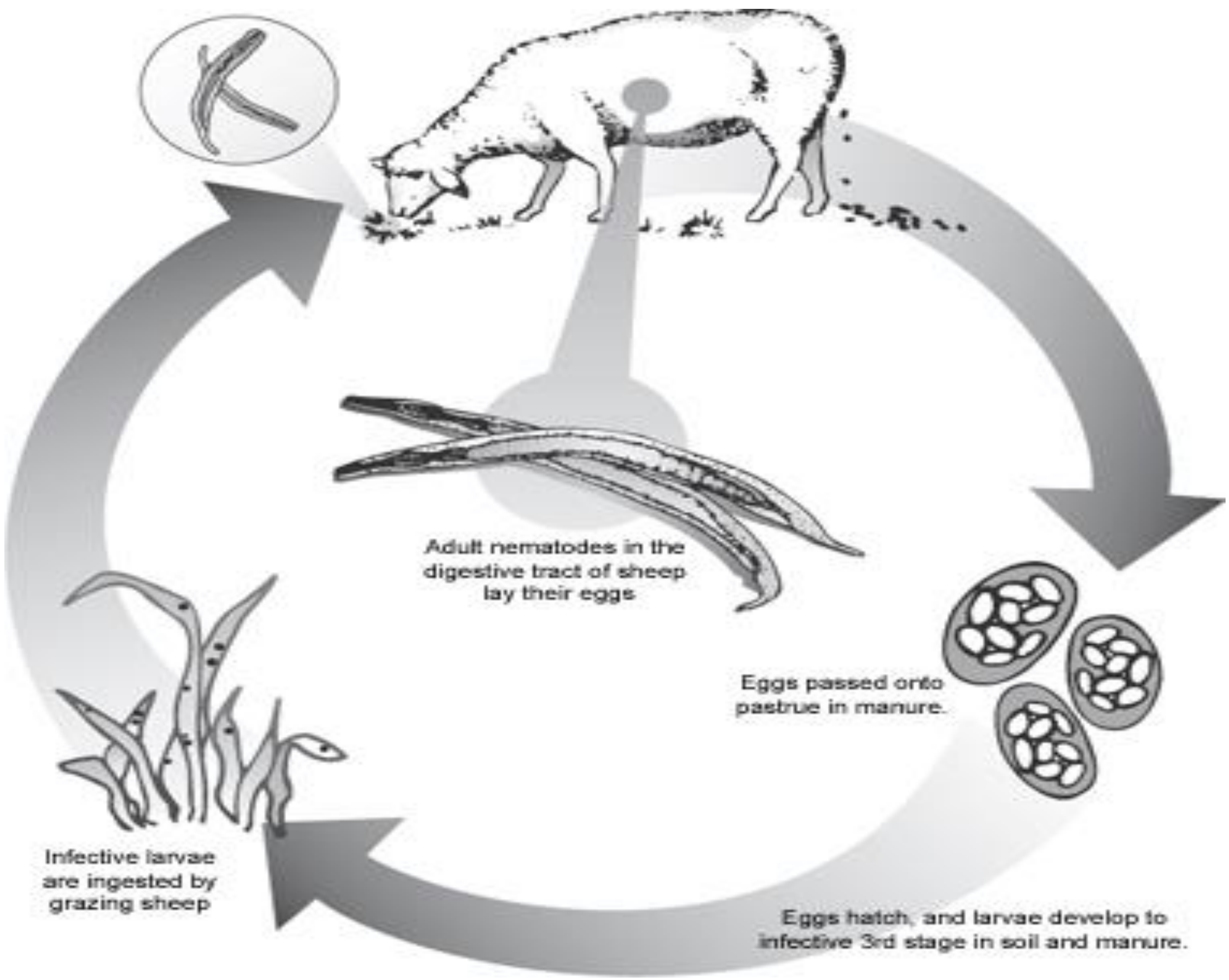

Figure 2: Life cycle of nematode parasite *H. contortus* (22).

2.1.3. Epidemiology

Haemonchus contortus has a worldwide distribution with concentrations in the tropics and subtropics where there are high temperatures and a lot of rainfall. The parasite can also be found in more temperate areas, such as the United States. In the southeast United state, *H. contortus* predominates over other gastrointestinal nematodes, such as *Teladorsagia* and *Trichostrongylus* species and can be found in large numbers because of the warm and humid environment. The optimum environmental temperatures for *H. contortus* are 31°C-34°C (23), but it can be found in temperatures as low as 10°C and as high as 36°C (24). High humidity (more than 85%) is important for the parasite because a lot of moisture in the air helps to protect it from desiccation at high temperatures (23). *Haemonchus contortus* does not endure the cold very well (24) and eggs do not hatch below 9°C (23).

2.1.4. Pathogenesis

Haemonchosis is characterized by hemorrhagic anemia attributable to blood loss via the blood-sucking activities of worms in the abomasum. The mechanism of blood sucking involves the worm attaching to the mucosa and extruding its oral lancet to slit capillaries in the abomasal mucosa. Fourth stage larvae (L4) as well as adults ingest blood flowing from these slit capillaries (25). They also secrete anticoagulant into the bleeding lesion ensuring the continual bleeding after the worm has moved away, thus causing hemorrhagic anemia. Each worm removes about 0.05 ml of blood per day through ingestion and seepage from lesions so that a sheep with 5000 parasites may lose about 250 ml of blood per day (26). The pathogenic effect of *H. contortus* results from the inability of the host to compensate for blood loss. The spectacular depression of hemoglobin level accompanied by weakness and death are the classical features of haemonchosis (16).

2.1.5. Clinical manifestation and diagnostic methods

Haemonchosis in sheep may be classified as hyperacute, acute, or chronic. In the hyperacute form, death may occur within one week of heavy infection without significant signs. This form of the disease is very rare and appears only in highly susceptible lambs. The acute form is characterised by severe anaemia accompanied by edema (“bottle jaw”). In acute haemonchosis, grazing sheep develop a sudden onset of anemia. In the absence of treatment, the situation of the animals will progressively worsen. At first, the packed cell volume (PCV) drops gradually, followed by a rapid drop signaling exhaustion of the erythropoietic system. Death is the usual outcome if not treated. At necropsy, mucus membranes of these animals become pale and edematous due to loss of blood and plasma protein respectively. 2,000-20,000 worms may be found in the abomasum. Abomasal content will be brownish due to the presence of blood. Hemorrhagic lesions are also detected on the abomasal mucosa (25).

Anaemia is also characteristic of the chronic infection, often of low worm burdens and is accompanied by progressive weight loss (8). The chronic form is the most commonly observed during natural infections. The lesions are associated to anaemia resulting from blood loss. With the exception of the L3, all other stages of development feed on blood. *Haemonchus contortus* is known to produce calcium and a clotting factor binding substance known as calreticulin (27), enabling the parasite to feed easily on host blood and in so doing cause haemorrhagic lesions. At post mortem, the abomasum appears edematous with petecheal haemorrhages, occasional nodular developments and a rise in pH (28).

The case history provides useful information especially the data about the season and climate, managemental system, animal age and nutritional and physiological status of the animal (8).The clinical signs, mainly anaemia, edema and loss of weight in association with reduced haematocrit values might be characteristic of haemonchosis in sheep. The clinical signs may be tentatively used for the diagnosis of haemonchosis in areas and seasons in which the disease is predominant. South African researchers have also developed a visual colorimetric assessment (FAMACHA) of the level of anaemia caused by parasitic infections in sheep (29).

However, all these signs can be shared by a number of parasitic and non-parasitic diseases and hence must be supported by other diagnostic methods. In this regard, demonstration of parasite eggs in faecal material can prove the presence of infection and is the most commonly used diagnostic method. Nevertheless, this method does not always reveal the presence of the parasite during low level of parasitic burden and prepatent periods (30), requiring repeated examinations. Host resistance to GI helminths also delays egg laying (31) and a change in female worm size affects its fecundity (32). Hence, egg counts do not necessarily reflect the number of worms present. Other methods like measurement of parasite specific antibodies can be used as supplementary diagnostic tools (33). In general, a more accurate diagnosis lies on the utilization of all available information regarding the epidemiology, clinical manifestations and laboratory diagnostic methods (21).

2.1.6. Abomasal pathophysiology

In the parasitized abomasum, gastric dysfunction and superficial epithelial damages caused by the presence of larvae in the gastric glands (stretching the glands) and the movement of adult worms that feed on the mucosal surfaces presumably compromise the protective barrier to diffusion and allow parasite and luminal chemicals access to host tissues. The marked changes in gastrointestinal secretions that accompany abomasal nematode infections in ruminants are well established and include a reduction in gastric acid secretion and an increase in circulating pepsinogen and gastrin levels. The abomasal hypoacidity may reduce pepsinogen activation and appears to be responsible for increased gastrin secretion in the initial phase of infection. Increased serum pepsinogen concentration is attributed mainly to the increased back-diffusion of luminal pepsinogen through the more permeable mucosa (21).

Abomasal secretion begins to change around the time of parasite emergence from the glands. Because of the timing, dysfunction has been attributed to tissue damage during emergence (34). Parasites may inhibit the parietal cells inadvertently by provoking inflammation or disrupting the protective mucosal defense system or, alternatively, by targeting these cells through excretory/secretory chemicals. Therefore, inhibition of acid secretion and loss of parietal cells appears to be a key event responsible for both the secretory dysfunction and the altered cellular composition of the gastric glands (21).

The contributions of the host and the parasite to the pathophysiology of abomasal parasitism may have quite different costs and benefits to each of them. The ability to inhibit acid secretion may allow colonization of a hostile acid environment, which also contains proteolytic activity capable of digesting an unprotected parasite (35). Raising the pH may also enhance egg laying; e.g. for *H. contortus* it is maximal between pH 4 and 4.5 (36). A curious feature of the inflammation caused by parasites is that the parasites may themselves actively recruit granulocytes through secreted chemotaxins. Eosinophil chemotactic factors have been found in a wide range of parasites including *Ostertagia ostertagi* and *H. contortus* (37).

The cellular response to abomasal nematodes involves the accumulation of inflammatory cells such as mast cells, globule leucocytes, eosinophils and lymphocytes (38). Cell pattern and time course of this cellular infiltration may vary according to host factors such as age, immune status, genetic predisposition, reproductive status and plane of nutrition (39).

Lymphocytes, eosinophils etc. began accumulating 1-2 days after adult parasite transfer and were present in large numbers after 8 days (40). Most studies of the cellular changes in the GI mucosa of sheep infected with nematode larvae rely on post mortem sampling of groups of animals at specified time during the infection. Sequential abomasal or intestinal biopsy also offers the advantages of more frequent sampling than is practical with killing groups of sheep and enables to study mucosal inflammatory responses throughout the course of the infection (39).

2.1.7. Treatment

Various anthelmintic drugs are used for the treatment of animals infected with *H. contortus*. The most important are the nematocides group such as thiabendazole, benzimidazole, levamisole, morantel and naphthalphos. Also many trematodocides such as closantel, clioxanide, rafoxanide and nitroxynil had significant high efficiency against *H. contortus* (41). When an acute outbreak has occurred the sheep should be treated with one of the benzimidazoles, levamisole, an avermectinimilbemycin or salicylanilide and immediately moved to pasture not recently grazed by sheep. When the original pasture is grazed again, prophylactic measures should be undertaken, as enough larvae may have survived to institute a fresh cycle of infection. Chronic haemonchosis is dealt with in a similar fashion (26).

However, recent studies indicated that many strains of *H. contortus* showed resistance to various anthelmintics. The anthelmintic resistance is measured by the inability of the drug to reduce the faecal egg count of infected animals. Less than 85% reduction in faecal egg count suggests that the parasite strain may be resistant to the drug used (42).

2.1.8. Control methods of haemonchosis

The aim of most parasite control strategies is not to totally eliminate the parasites in livestock, but to keep the population under a threshold, above which it would otherwise inflict harmful effects on the host population (43). The relative success or failure of any control strategy can be judged in terms of immediate and/or long-term objectives, the ultimate goals being increased production, minimizing risks of drug resistance and addressing consumer and environment associated problems. Generally, nematode control strategies can be directed against the parasite in the host and/or in the environment (21).

Commercial anthelmintics have been used for some decades throughout the world to minimize the losses caused by helminth infections (44). However, the threats of anthelmintic resistance, risk of residue, availability and high cost especially to farmers of low income in developing countries have led to the notion that sustainable helminth control cannot be achieved with commercial anthelmintics alone. Therefore, today the strategy of helminth control has shifted to integrated control scheme involving grazing management, utilization of natural immunity together with anthelmintics for sustainable control of helminth parasites (45). Other options like, biological control, vaccine and traditional medicinal plants are being examined in different parts of the world (46).

6. CONCLUSION AND RECOMMENDATIONS

Among the parasites of sheep and goats that restraint the survival and productivity, *H. contortus* being of overwhelming significance and is one of the most pathogenic helminths belonging to gastrointestinal parasites. *Haemonchus contortus* is a highly pathogenic, blood-feeding nematode of small ruminants and a significant cause of mortalities worldwide. Haemonchosis is a particularly significant threat in tropical, subtropical and warm temperate regions, where warm and moist conditions favour the free-living stages, but periodic outbreaks occur more widely during periods of transient environmental favorability. The clinical diagnosis of haemonchosis is based mostly on the detection of anaemia in association with a characteristic epidemiological picture, and confirmed at postmortem by the finding of large numbers of *H. contortus* in the abomasum. The detection of impending haemonchosis relies chiefly on periodic monitoring for anaemia, including through the 'FAMACHA' conjunctival-colour index, or through faecal worm egg counts and other laboratory procedures. A range of anthelmintics for use against *H. contortus* is available, but in most endemic situations anthelmintic resistance significantly limits the available treatment options. Appropriate strategies include animal management programmes to avoid excessive *H. contortus* challenge, genetic and nutritional approaches to enhance resistance and resilience to infection, and the monitoring of *H. contortus* infection on an individual animal or flock basis. Alternative approaches, such as biological control, may also prove useful, and vaccination against *H. contortus* appears to have significant potential in control programmes.

Based on the above conclusive remarks the following recommendations are forwarded:

- There should be strategic and regular anthelmintic treatment and pasture management that enable to control of the disease.
- Animals should be kept in high plane of nutrition in order to develop disease resistance.
- Farmers should be educated regularly and should be prepared to enhance and update the awareness of the professionals and stalk holders to the status of the disease and its control strategies.

Corresponding Author:
Dr. Eyachew Ayana
Bahirdar Animal Health Investigation And Diagnostic Laboratory, P.O.Box 70, Bahirdar, Ethiopia
Telephone: (+251)918575003
E-mail: eyuelayana83@gmail.com

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