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Lung Worm Infection of Small Ruminant in Ethiopia

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SUMMERY
Small ruminant is high in number and economically very important animal in Ethiopia. However, it is less productive due to morbidity and mortality from different parasite infection. Among this parasite infection, lungworm is the common parasitic disease of sheep and goat which belong to one of the two superfamilies, Trichostrongyloidea or Metastrongyloidea. Of which, *Dictyocaulus* and *Protostrongylus* are causes of lungworm infection in ruminants. Inspite of its importance, there is little documentation and consideration in Ethiopia. To enhance the economic benefit of small ruminant, it is important to make proper diagnosis, treatment and control and prevention of lungworm. Therefore, this paper is to review the etiological characteristics, method of transmission, diagnosis, treatment and control of lungworm. The common causes of *verminous pneumonia* in sheep and goats are *Dictyocaulus filaria, Protostrongylus rufescens* and *Muellerius capillaris*. *Dictyocaulus filaria* belongs to the super family Trichostrongyloidea while the latter two belong to Metastrongyloidea. These pathogenic parasites highly affect lower respiratory tract of sheep and goats, and leads to a chronic and prolonged infection. The epidemiology of lungworm disease is largely concerned with factors determining the number of infective larvae on the pasture and the factors that facilitate viability and development of larvae. The most common sign in sheep and goats are pyrexia, coughing, rapid shallow breathing, nasal discharge and emaciation with retarded growth. Diagnosis can be done by taking history and clinical sign followed by faecal examination for presence of larvae using Bermann technique. Anthelmintic treatment with grazing management and its usage as prophylactic treatment before the onset of infective season is the most important method to control lungworm infection. So that proper grazing management and periodic deworming should be strictly practiced to increase the benefits from this economically important animal, and government should introduce vaccine for lungworm.
Keywords: Small ruminant, Lungworm, Anthelmintics, Control, Ethiopia

1 INTRODUCTION

Ethiopia has the largest livestock population in Africa. An estimate indicates that the country is a home for about 54 million cattle, 25.5 million sheep and 24.06 million goats. From the total cattle population 98.95% are local breeds and the remaining are hybrid and exotic breeds. 99.8% of the sheep and nearly all goat population of the country are local breeds (CSA, 2013). Sheep and goats are the most numerous of man's domestic livestock. In Ethiopia, sheep are the dominant livestock providing up to 63% of cash income and 23% of food substance value obtained from livestock production (Bogale et al., 2012; Ibrahim and Godefa, 2012). Small ruminants are especially important in the more extreme climates, and they are noted for their ability to convert low opportunity cost feed in to high value products including meat, milk, fiber, manure and hides (Wilsmore, 2006; Asaye and Alemneh, 2015).

In Ethiopia, Small ruminants provide 33% of meat and 14% of milk consumption, and accounts for 40% of cash income and 19% of the house hold meat consumption in the central high lands where mixed crop-livestock production system is practiced (Asaye and Alemneh, 2015). However, the productivity is much less when compared with the population size of small ruminant in Ethiopia (Tewodros *et al*., 2012), and the economic benefits to the farmers remain marginal due to prevailing disease, poor nutrition, poor animal production systems and general lack of veterinary care (Sissay *et al*., 2007).

About half of all sheep mortality and morbidity on farms in Ethiopian highlands are caused by pneumonia and endoparasitism including lung worms (ILRI, 2000; Asaye and Alemneh, 2015). Ovine lung worm is also called *Verminous Bronchitis* or *Verminous Pneumonia* which caused by *Dictyocaulus fiaria*, *Protostrongylus rufescens*, and *Muellerius capillaries* (Chakraborty *et al.,* 2014). Verminous pneumonia is a chronic and prolonged infection of sheep and goats caused by any of these parasitic nematodes, characterized clinically by respiratory distress and pathologically by bronchitis and bronchopneumonia due to infection of the lower respiratory tract, resulting in bronchitis or pneumonia or both (Gorski *et al.*, 2004; Tewodros, 2015).

The prevalence of lungworm infection of small ruminants depends on different factors like, the climate of area, altitude, intermediate hosts and favorable ecological conditions such as rain fall, humidity, temperature, and marshy area for grazing, sheep and goat management system for the development of lungworm species (Kebede *et al*., 2014). Infections of lung worm parasites of small ruminants are ubiquitous and prevalent within many tropical and sub-tropical environments of the world providing nearly perfect conditions for their survival and development. The pathogenic effect of lungworms depends on their location within the respiratory tract, the

number of infective larvae ingested and the immune system of the animals (Gebreyohannes *et al*., 2013).

However, the clinical signs in infected animals can be less obvious than signs of other livestock diseases (Muluken, 2009). Clinical signs in naturally affected animals are: loss of appetite, reduced growth, increase respiratory rate and coughing (Anmaw *et al*., 2015). It has been established that high prevalence rates of the infection with less obvious sign associate with poor production and unthriftness (Gebreyohannes *et al*., 2013).

The incidence of parasitic disease including respiratory helminthosis varies greatly from place to place depending on the relative importance of factors in Ethiopia, and proper diagnosis, treatment and control and prevention of these parasites is, therefore, critical to enhance the economic benefit from these species of livestock (Alemu *et al*., 2006). Therefore, the main objective of this paper is to review different literatures about the etiological characteristics of the parasite, its occurrence, its method of transmission, diagnosis, treatment and control of the disease.

2 LITERATURE REVIEW

2.1 Etiology

Lungworms of domestic ruminants are nematodes that belongs to the phylum Nemathelmenthes commonly named as round worms; classified under the super family Trichostrongyloidea and Metastrongyloidea (Tewodros, 2015). Of these round worms, *Dictyocaulus* and *Protostrongylus* are causes of lungworm infection in ruminants (Schneider, 2000). The common causes of verminous pneumonia in sheep and goats are *Dictyocaulus filaria, Protostrongylus rufescens* and *Muellerius capillaris*. *Dictyocaulus filaria* belongs to the super family Trichostrongyloidea while the latter two belong to Metastrongyloidea, which have direct and indirect life cycles respectively (Howard, 1993). Although infection with *D. filaria* predominates in most outbreaks and mixed infection may occur (Urquhart *et al.,* 1996).

The parasite generates a serious respiratory disease in sheep and goat which called parasitic bronchitis, husk or dictyocaulosis, which is endemic in temperate areas with high rainfall such as northern Europe (Taylor, *et al.*, 2007). In Sweden, 40% of the farms investigated in a national survey harboured the infection (Höglund, *et al.*, 2004) and dictyocaulosis is considered to be a potentially increasing, and costly problem (Ploeger, 2002).

The infection is contracted through ingestion of contaminated grass and, since protective immunity develops after infection, the disease primarily affects young animals during their first grazing season. Major outbreaks are seen from July to September, when sensitive lambs have been on pasture 2- 5 months and the parasites have had time to reproduce (Taylor, *et al.*, 2007).

2.2 Morphology

Adult Dictyocaulus worms are slender, medium sized roundworms and up to 8 cm long as indicated in figure 1(Dar *et al*., 2012). Females are about one third longer than males. They have a whitish to grayish color (Urquhart, *et al.,* 1996). As in other roundworms, the body of these worms is covered with a cuticle, which is flexible but rather tough. The worms have a tubular digestive system with two openings, the mouth and the anus (Mandal, 2006). They also have a nervous system but no excretory organs and no circulatory system, i.e. neither a heart nor blood vessels. The female ovaries are large and the uteri end in an opening called the vulva. Posterior end male lung worms have a copulatory bursa with two short and thick spicules for attaching to the female during copulation. Posterior end of an adult male lung worm *Dictyocaulus filaria* has short bursa having a short, stout, dark brown spicules " boot-shaped" as indicated in figure 2 (Dar *et al*., 2012). The eggs of *Dictyocaulus filaria* and *Dictyocaulus arnfieldi* is approximately 60x90 micrometers and that of *Dictyocaulus viviparous* approximately 35x85 micrometers. They have ovoid shape and contain a fully developed L_1 Dictyocaulus larva (Janquera, 2014).

Adult *Muellerius capillaris* are medium-sized (not longer than 3 cm) and thin worms (hence their common name hairworms),while adult *Protostrongylus rufescens* are slender, reddish to brownish color worms up to 70 mm (Janquera, 2015a & b).

Figure 1: Dictyocaulus fillaria lung worm of sheep and goats
Source: (Dar *et al*., 2012).

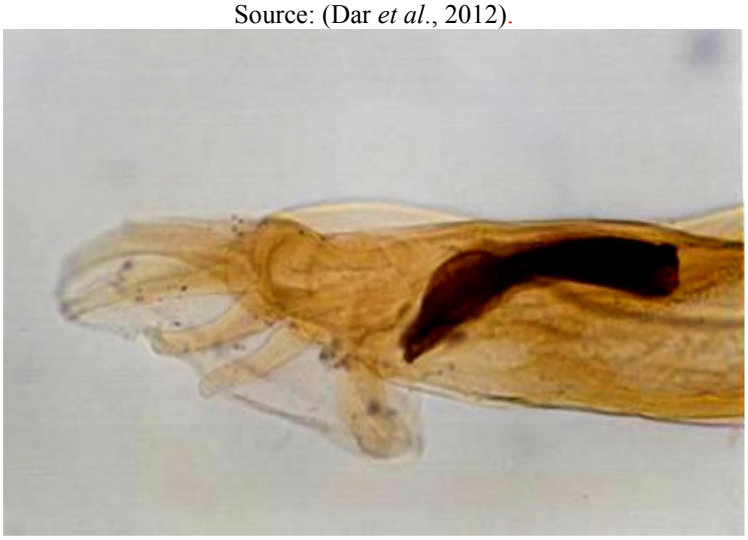

Figure 2: Posterior end of an adult male lung worm (Dictyocaulus filaria) with short bursa having a short, stout, darkbrown, "boot-shaped" spicules.
Source: (Dar *et al*., 2012).

2.3 Epidemiology

Epidemiological distribution of lung worm depends more on pasture contamination by carrier animals. Pasture infectivity is related to rainfall which stimulates the activity of both the larvae and the mollusk. Moisture is essential for the survival and development of the larvae. The larvae is active at moderate temperature of 10-21 °c. Larvae survive best in cool, damp surroundings especially when the environment is stabilized by the presence of long herbage of free water. Under optimum conditions the larvae can persist for over one year (Tewodros, 2015). Lungworm parasites are host specific and common in areas of mild high rain fall and abundant grass (Radostits et al., 2000). The prevalence of infection is low in spring and summer and rises rapidly in the autumn and winter. When most clinical cases are seen, wet summers give rise to heavier burden in the following autumn and winter. Over stocking, deficient feeding, previous or concurrent infections predispose to infection (Borji *et al*., 2012; Tewodros, 2015).

Prevalence of small ruminant lung worm is different based on geographical and climatic factor of spatial area. Some studies conducted at different location in Ethiopia gave different prevalence records as indicated in table1.

Table 1: Prevalence rate of ovine lungworm in different areas of Ethiopia

Place	Prevalence rate (%)	Reference
In and around Bahir Dar City	18.16% 22.7%	Muluken, 2009 Asaye and Alemneh, 2015
In North and South Gondar Zones.	39.6%	Tigist (2009)
Tigray (Atsbi)	21.5%	Mangistom (2008)
In North East Ethiopia	53.6%	Alemu *et al* (2006)
At Mekele Town	13.4%	Ibrahim and Degefa (2012)
In and around Jimma Town	29.04%	Fentahun *et al*., 2012
Ambo District	34.90%	Beyene *et al*., 2013

The variation in the overall prevalence rate in different areas might be due to differences in nutritional status, level of immunity, management practice of the animal, rain fall, humidity and temperature differences and season of examination on their respective study area (Kebede *et al*., 2014). These differences in the prevalence of lungworms of small ruminants might be associated with difference in nutritional status, level of immunity, management practice of the animal, rain fall, humidity, temperature and altitude differences (Borji *et al*., 2012).

Sheep of all age are susceptible, but lambs of 4-6 months of age are severely affected with lungworms (Tewodros, 2015). The prevalence of lungworm infection in young sheep (75.6%) was reported which is significantly greater than in adult sheep (51.8%). Similarly, the prevalence rate of lungworm infection in young goat (75.6%) is significantly higher than that of the adult goat (46.4%) in Dale District, Southern Ethiopia (Kebede *et al*., 2014). Radostitis *et al* (2007) and Mekonnen *et al* (2011) reported that young sheep were found to be infected more than adults and this might be associated with the naturally acquired immunity against infection in older animals which slowly developed due to the previous exposure and better immunity against re-infection after recovering from the disease. *M. capillaris* is prevalent worldwide and can cause severe signs in goats, although it usually less pathogenic in sheep (Khan, 2005**).**

Generally, only young ruminants in their first grazing season are clinically affected, since on farms where the disease is endemic older animals have a strong acquired immunity. Goats appear to be more susceptible to helminthes than sheep as they appear to develop less immunity. Sheep predominantly graze; pick up more parasites so have higher acquired resistance than goats which mostly consume browse. Goats with their browsing behavior consume uncontaminated matter with parasite larvae, so being less exposed to infective larvae, and may therefore have lower acquired resistance than sheep ((Borji *et al*., 2012; Tewodros, 2015).

Sex depended prevalence of lung worm in small ruminants is not significantly different in many studies. However, some difference had been reported in some studies. According to Ibrahim and Godefa (2012) 16.6% and 8.1% of lung worm prevalence rate in female and male respectively, and Terefe *et al* (2013) also reported small ruminant lungworm prevalence rate of 48% in female and 43.2% in male in north Gondar. Fentahun *et al* (2012) also found 25.44% in female and 25.09% in male sheep. In contrast to these finding, the higher prevalence was reported in males (27.23%) than female (23.75%) (Tegegne *et al*., 2015). However, there is no report that caused this difference but it may be immune suppression of female due to production and reproduction and other stress factor.

Among ovine lung worm parasites *Dictyocaulus filarial* (26%) is the most predominant lungworm species, followed by *Mulleries capillaries* (18%) and *Protostrongylus refescens* (10%) is the least prevalent (Kebede *et al*., 2014). The possible reason for the predominance of *D.filaria* might be attributed to the difference in the life cycles of the parasites. *D. filaria* has a direct life cycle and requires shorter time to develop to an infective stage. After ingestion, the larvae of these parasites can be shed with feces within 5 weeks. Unlike to *D. filaria,* the transmission of *P.rufescens* and *M.capillaris* is epidemiologically complex event involving host, parasite and intermediate host. Because, *P. refescens* has indirect life cycle that requires longer time and wet or rainy warmer season to complete their complex life cycle in the presence of suitable intermediate hosts that create favorable condition for sporadic distribution, dry or short rainy season does not favor the development of the snail intermediate hosts (Kahn, 2005; Kebede *et al*., 2014).

2.4 Life cycle

The life cycle of small ruminant Lungworms have two forms, direct and indirect. Direct form of life cycle is accompanied by Dictyocaulidae (D*ictyocaulus filaria)* in which the free living larvae undergo two moults after hatching and infection are by ingestion of the free L3. The other form is indirect life cycle (Protostronglidae) whereby the first two moults usually take place in an intermediate host (snails or slugs) and infection of the final host is by ingestion of intermediate host (Tewodros, 2015).

The adult females of *D. filaria* in the bronchi lay larvated eggs that hatch either in the bronchi or after being coughed up and swallowed and the hatched larvae passed with feces (Ballweber**,** 2014**)**. The eggs are coughed up and swallowed with mucus and the L1 hatch out during their passage through the gastrointestinal tract. The L1 are excreted in faeces. On pasture, the larvae moult into the second stage (L2) and develop further

to the infective L3 (Anmaw, *et al*., 2015).

The infective third-stage larvae (L3) can develop on pasture within 5–7 days in warm, moist conditions, but typically in summer in temperate northern climates will require 2–3 wk. Once larvae are infective, transmission depends on their dispersal away from the fecal pats. Dispersal mechanisms are, primarily, mechanical and include rain or, in the case of *D. viviparus* and possibly *D. arnfieldi*, by the sporangia of the fungus *Pilobolus*. A proportion of infective larvae survive on pasture throughout the winter until the following year but, in very cold conditions, most become nonviable. The principal source of new infections each year is from infected carrier animals, with overwintered larvae providing a secondary but not unimportant contribution in some countries (Kahn, 2005).

While the animals graze, the infective third stage larvae (L3) are ingested, penetrates the intestinal mucosa of the small intestine or the upper part of the colon (Fiedor, et al., 2009), and travel to the mesenteric lymph nodes, where they moult into stage four larvae (L4) (Taylor, *et al.*, 2007). The L4 then continue to the lungs via lymph and blood, and reach the lungs approximately seven days after ingestion with moderate infection doses, and as early as after 24 hours at very high infection doses, and in the lungs the larvae moult and develop to young adults, which migrate up through the bronchial tree as they mature (Anmaw *et al*., 2015). *Protostrongylus rufescens and Muellerius capillaries* has the same life cycle which is an **indirect involving intermediate hosts** of several **snails** (*Helix*, *Helicella*, *Theba*, *Abida*, *Zebrina*, etc.) and **slugs (***Limax*, *Agriolimax,* etc) (Junquera, 2015b; Kahn, 2005).

Adult worms lay eggs in lungs or bronchioles and coughed up with sputum toward bronchi and trachea where hatched to L1-larvae. These larvae are coughed to the mouth together with the respiratory secretions and subsequently swallowed and passed in the feces. Once in the environment these larvae penetrate into the snails very quickly and develop to infective L3-larvae in a few weeks to several months, strongly depending on weather conditions and snail species. Such infective larvae can survive up to 2 years inside their intermediate host. Livestock becomes infected after eating contaminated snails or slugs while grazing. L3-larvae are released after digestion. They cross the gut's wall and migrate to the lungs through the lymphatic system and the blood stream. Once in the lungs the larvae cross the alveolar mucosa to the lumen of the alveoli and remain in the bronchi and bronchioles where they complete development to adults and start producing eggs. The host's lungs react and build **nodules** that contain necrotic material, eggs masses, worms, etc. surrounded by connective tissue (Junquera, 2015b)

2.5 Pathogenesis

The pathogenesis of lungworms depends on their location within the respiratory tract, the number of infective larvae ingested, the animal immune state, and on the nutritional status and age of the host. The relative pathogenicity of each lungworm depends on its predilection site. *D. filaria* lives in the trachea and bronchi so aspirated eggs, larvae and debris affect a large volume of lung tissue. It is therefore the most pathogenic species (Tewodros, 2015).

Adult *P. rufescens* are found in smaller bronchioles, so associated lesions are much smaller. *M. capillaris* is found in the lung parenchyma where it becomes encysted in fibrous nodules; lesions are therefore confined to its immediate surroundings. Consequently, this worm is generally considered as involves heavy mixed protostrongyloid infection and impair pulmonary gaseous exchange (Radostits *et al.,* 2000; Tewodros, 2015). It is suggested that when the larval stages of *M. capillaris* migrated through the walls of small intestine, the resulting damage may predispose to enterotoxaemia. Infection with more than one species is common and course of infection is usually chronic (Radostitis, *et al*., 2007).

Sever infection with lung worm can cause vasculitis and perivasculitis with ifiltration of inflammatory cells in and around the vascular wall and thickening of interalveolar walls and mononuclear cell infiltration due to inflammation response in lung (Dar *et al*., 2012).

Migrating *D. viviparous* larvae provoke little damage until they reach the lungs. Thereafter, passage of larvae up the bronchioles causes them to become blocked by mucus, eosinophils and other inflammatory cells, leading to collapse of the alveoli that they supply. Coughing and dyspnea occur if a sufficiently large volume of lung tissue is affected (Nashiruddullah *et al.,* 2007). This is accompanied by pulmonary edema and interstitial emphysema; as no structural damage has yet occurred, treatment at this stage in the disease produces an immediate clinical response. Later however when mature parasites are in the major bronchi, eggs and fragments of worms killed by immunity are aspirated and provoke foreign body pneumonia (Radostitis *et al.,* 2007).

2.6 Necropsy Findings

In necropsy examination, adult worm of *Dictyocaulus flarie* which is slender, threadlike, white, 3-10 cm in length and found mostly in bronchi of the caudal lung lobes associated with an excess of mucous (catarrhal bronchitis) are easily observable (Chilton *et al*., 2006). *Muellerius capillaris* are medium-sized (not longer than 3 cm) and thin worms (hence their common name hairworms),while adult *Protostrongylus rufescens* are slender,

reddish to brownish color worms up to 70 mm (Janquera, 2015a & b). Mostly sever cases, Dorsocaudal and ventrocaudal regions of lungs are affected and may be develop lesions characterized by large wedge-shaped, often depressed, red to grey colored consolidated foci at the posterior edge of the caudal lung lobes (Gardiner, 2006).

Grossly, the lungs revealed depressed consolidated areas and elevated emphysematous patches or dirty white to irregular or nodular lesions distributed in various lobes especially in the diaphragmatic lobes. On dissection, the trachea and bronchial tree revealed copious foamy froth in which numerous slender thread-like creamy white worms present. Bunches of the worms were also observed in terminal bronchioles of the diaphragmatic lobes (Dar *et al*., 2012).

In acute cases, morphological changes include: Enlargement of the lungs due to edema and emphysema (Tibor,1999), widespread areas of collapsed tissue of a dark pink color Hemorrhagic bronchitis with much fluid filling all the air passages enlargement of the regional lymph nodes. Histologically, the characteristic signs are: Edema, Eosinophilic Infiltration, Dilatation of lymphatics and filling of the alveoli and bronchi with inflammatory debris of Larvae in the bronchioles and alveoli (Janquera, 2014), and the eggs and larvae can be seen in the air passages, the bronchial epithelium is much thickened, the bronchioles are obstructed with exudates and the alveoli show epithelialization (Kahn, 2005). The bronchial and bronchiolar epithelium become markedly hyperplastic and desquamated as well as peribronchiolar lymphoid hyperplasia can occur. Vasculitis and perivasculitis characterized by infiltration of inflammatory cells in the vascular wall and around the bronchiole (Dar *et al*., 2012).

2.7 Clinical signs

The clinical course of lungworm infection depends on severity of infection, age and immunological status of the animal. Signs of lungworm infection can range in many cases from moderate coughing with slightly increased respiratory rates to severe persistent coughing and respiratory distress and even failure (Tewodros, 2015). Reduced weight gains, reduced milk yields, and weight loss accompany many infections in cattle, sheep, and goats, and patent subclinical infections can occur in all species (Elsheikh and Khan, 2011).

The most common sign in sheep and goats are pyrexia, coughing, rapid shallow breathing, nasal discharge, and emaciation with retarded growth (Chakraborty *et al.,* 2014). Initially,the animals experience the sign of rapid, shallow breathing which accompanied by a cough that is exacerbated by exercise. Respiratory difficulty may proceed, and heavily infected animals stand with their heads stretched forward and mouths open and drool. Lung sounds are particularly prominent at the bronchial bifurcation. Such sever pulmonary signs usually are associated with *D. filarial* (more pathogenic) in sheep while *M. capillaries* (more pathogenic in goats) can affect goats similarly (Foreyt, 2001**)**.

2.8 Diagnosis

Diagnosis can be based on the clinical signs and grazing history. The disease occurs typically in young which feed on the grass for the first time when all members of a group may be affected to some degree that leads to pasture contamination. Usually, the clinical signs, the time of the year and a history of grazing on permanent or semi-permanent pastures are sufficient to enable a diagnosis to be made (COWS, 2014).

However, the confirmation of lungworm disease can alternatively confirmed by detecting the L1 stage in faecal samples using the Baermann technique. It carried out in laboratory by taking about 15-25 gram of fresh faeces from each sample for the extraction of L1 larvae using modified Baermann technique. The paste enclosed in gauze fixed on string rod and submerged in clean glass tube filled with fresh water. The whole apparatus will be left for 24 hours. The larvae leave the faeces and migrate through the gauzes and settle at the bottom of the glass. After siphoning of the supernatant, the sediment is examined under the lower power of the microscope (Fraser *et al*., 1991; COWS, 2014; Tewodros, 2015). Examination of sputum for eggs and larvae is rapid and sensitive, and the presence of patent infections can often be detected one or two days earlier than with fecal examination (COWS, 2014).

The larval identification of small ruminant lungworm is then takes place based on their morphological characteristics. The larvae of *Protostrongylus rufescens* is confirmed by larvae found in the feces which elongate 300 to 400 micrometers with a characteristic tapering tail and a wavy outline but without dorsal spine (Elsheikhand Khan, 2011; Junquera, 2015b), and that of *M. capillaries* (250 to 300 micrometers long) is also confirmed in the feces with its characteristic tapering and a wavy ouline tail and a dorsal spine (Junquera, 2015a) and larva of *D. flarie* (550-585 µm in length) could be identified by having head with protruding knob, bluntly pointed tail and brownish intestinal granules (Elsheikhand Khan, 2011; Khan, 2005).

Kebede *et al* (2014) performed microscopic examination and identification of lungworms in their study and performed identification of lungworm using its features. In accordance, they reported *D. filarial* which is slender, thread like nematodes, white in color with knob on head was occured in the trachea, bronchi and bronchioles of sheep and goats; *M. capillaris* was occured in the lung (bronchi, bronchioles and alveoli) of sheep

and goat which is small hair like with bent tail, while the adults of *P. refescens* were found within the bronchioles, grey reddish in color and have wavy tail.

Grossly on the postmortem diagnosis, the lungs may reveal depressed consolidated areas and elevated emphysematous patches or dirty white to irregular nodular lesions distributed in various lobes especially in the diaphragmatic lobes. On dissection, the trachea and bronchial tree revealed copious foamy froth in which numerous slender thread-like creamy white worms may found and bunches of worms often observed in terminal bronchioles of the diaphragmatic lobes (Dar *et al*., 2012). Lungs infected with *M. capillaris* contain red, grey or green lobules 1 to 2 mm in diameter (Tewodros, 2015).

Another method which is alternative to faecal analysis to detect parasite-specific serum antibodies by enzyme linked immune sorbent assay (ELISA) in cattle (Feider, *et al,.*2009) . In practical terms, when investigating an avail outbreak, it is advisable to analyze faecal and serum samples collected from a group of 6-10 animals that have been showing clinical signs of disease the longest. The ELISA is the preferred option when large numbers of samples are being tested (White *et al.,* 2014).

2.9 Treatment

Thre are only a few drugs approved to treat parasites in sheep and goats. According to Villarroel (2013) the effctive drugs currently approved for use in sheep and goats for treatment of lung worm are Albendazole, Ivermectin and Levamisole. ESGPIP (2007) also reported Albendazole is active against nematodes such as Haemonchus, and other trichostrongyles (round worms), to some extent liver flukes (Fasciola hepatica), tapeworms (Moniezia, Taenia saginata) with the dosage 5 mg/kg for round worms and 10 mg/kg for flat worms (trematodes), Levamisole hydrochloride is active against gastrointestinal and lungworm with recommended dose of 7.5 mg/kg and Ivermectin is active against gastrointestinal and lung worms with recommended dose of 0.2 mg / kg for sheep and goat.

However, some dewormers that used to be effective against a specific parasite are no longer effective, due to the development of resistance in some worms. Therefore, just because you apply a dewormer doesn't mean you've killed the worms; you have to be sure to use the right dewormer for your specific situation. Sheep and goats have a much higher metabolism rate than cattle. Therefore, drug dosages will likely be higher than those listed for cattle (Villarroel, 2013).

2.10 Control and Prevention

The objective of control and prevention of lungworm can be achieved most effectively by integration of three interrelated approaches of anthelmentic drugs, immunization and improved management practice (Howard, 1993; Tewodros, 2015).

Clinical disease in ruminants usually develops on first exposure to sufficient infective larvae; the severity of disease and stimulation of an immune response is related to the number of larvae ingested. In cattle and sheep, this usually occurs during their first season at pasture; however, an increase in the number of older cattle affected has been reported and is attributed to the efficiency of some prophylactic anthelmintic regimens, which eliminates infection and prevents development of a protective immune response (Kahn, 2005).

Villarroel (2013) had reported the principle of anthihelmintic treatment for control and prevention of lungworm in clinically affected sheep and goat as the following: Affected animals should be separated from unaffected animals at the time of treatment. Treated animals should be moved into an area that can be easily cleaned and disinfected. After treating affected animals, wait 3 to 4 weeks and retest to determine the effectiveness of the treatment. Animals those still have high burdens after treatment should be retreated and then retested 3 to 4 weeks later. Animals that still have high burdens after a second treatment are likely to be very susceptible and can act as carriers for parasites, infecting other animals in the flock. These animals should be culled from the flock to decrease the burden of parasites in the entire flock

and to increase the susceptibility of parasites in the flock to dewormers. This action can prevent animals' reinfestation and need for treatment. Treatment of parasitism should include eliminating risk factors that will contribute to future re infestation, as well as selecting animals that are resistant to parasite infestation.

In Ethiopia the relatively best method to control and prevention is to graze young stock in advance of older stock especially in the rainy season since the susceptibility of animals varies with age and using cut and carry feeding systems can significantly limit worm infestation. Overpopulation increases the concentration of parasites and also forces animals to graze closer to the ground, and may result in consumption of a higher number of infective larvae. So it is recommended that all farmers/pastoralists in Ethiopia using the same pasture have to take control measures at the same time and deworm all newly introduced animals and keep them separate for three days before allowing them to mix with the rest of the flock (ESGPIP, 2007).

In addition to this, ESGPIP (2007) also recommended the better deworming strategy for control of sheep and goat parasite including lungworm in Ethiopia based on rainy season of different altitudes as the following:

- In highland areas, with short rains followed by long rains: Deworm all sheep and goats at the end of the rainy season when the pasture becomes dry (December) and deworm all sheep and goats at the end of the dry season before the rain starts (April).
- In lowland areas where there are two distinct rainy seasons: Deworm all sheep and goats at the end of the dry season (February) before the rains start and deworm all sheep and goats at the end of each of the rainy seasons (September and April).
- In mid-altitude areas where there is one long rainy season giving long crop growing periods: Deworm all sheep and goats after the rainy season (November) and deworm all sheep and goats before the beginning of the rains (May).

Villarroel (2013) also forwarded the best prevention method to reduce exposure to parasites as the following:

- Providing a clean environment beginning at birth and avoiding overcrowding of pens
- Providing balanced nutrition is very important to keep animals healthy and help them to develop appropriate resistance to external pathogens, especially for dams before and after lambing/kidding.
- Avoid pasturing in damp areas and during early morning and evening hours, when there is dew on the pasture.
- Rotate pastures to avoid high burdens of parasites.

The other most important to control and prevention of lung worm is vaccination. Vaccine was developed from larvae of *D. flarie.* Larvae are separated from feces by Baermann technique and cultured to L3 in water and attenuated with X-radiation or gamma-radiation and packed in a single dose containing 1000 attenuated larvae, need two dose four weeks apart, provide 97% protection (Bain, 1999). Vaccine is given for 8-week-old lambs (Urquhart *et al*., 1996).

The kids were more susceptible to lungworm infections than adult goats. In experimental studies conducted by Sharma (1994), it was reported that goats were more susceptible to *Dictyocaulus filaria* infection than sheep and two vaccine doses comprising 1000 and 2000 gamma-attenuated *D. filaria* (ovine strain) infective larvae conferred 97% protection in male Beetal kids against a homologous challenge dose of 4200 normal larvae of *D. filarial*.

Vaccinated animals should be protected from new infection challenge until two weeks after their second dose, and the residual effects of long-acting endectocides or sustained release bolus preparations will interfere with the development of immunity following lungworm vaccination. Therefore, it needs to avoid vaccination during the period of their activity, and do not use it until 14 days after the second vaccine dose (COWS, 2014). However, until know there is no report of using lungworm vaccine in Ethiopia.

3 CONCLUSIONS AND RECOMMENDATIONS

Small ruminant is economically very important animal which sometimes considered as immediate source of cash for smallholder family. Lungworm of small ruminant is widely distributed in Ethiopia and affecting this economically most important animal. Lungworms of domestic ruminants are nematodes that belongs to the phylum Nemathelmenthes commonly named as round worms; classified under the super family Trichostrongyloidea and Metastrongyloidea. Among these, *Dictyocaulus* and *Protostrongylus* are causes of lungworm infection in ruminants. The respiratory nematodes, *Dictyocaulus filaria, Muellerius capillaris* and *Protostrongylus rufescens,* are the species of lungworms most commonly affecting small ruminants. Dictyocaulus filarial has a direct life cycle while the Muellerius and Protostrongylus have indirect life cycle.

Lungworm distribution is mainly based on climate of an area, rain fall or marsh and intermediate host snail and slug, so the infection is more common during rainy season. Goat is more susceptible than sheep for lungworm because it is less infected due to its grazing behavior. Commonly, female animals, young animals of less than one year of age, poorly conditioned animals, and those managed under extensive system of production are more prone to lungworm infection. It highly damage lung, bronchi and bronchioles and mostly present clinical sign like pyrexia, coughing, rapid shallow breathing, nasal discharge, and emaciation with retarded growth, may be up to sever respiratory distress and failure.

Diagnosis can be done by taking history and clinical sign followed by faecal examination for presence of larvae using Bermann technique. The available anthelmintics for treatment of lungworm are Albendazole, Ivermectin and Levamisole. Treatment is not enough for control and prevention but treatment with grazing management and its usage as prophylactic treatment before the onset of infective season is the most important method to control lungworm infection.

Grazing young stock in advance of older stock, rotational grazing, decreasing overcrowding, separating sheep and goat stock and regular deworming before and after rainy season are best management practice to control and prevention of lungworm in Ethiopia.

Based on the above conclusion the following points are forwarded:

- Proper diagnosis and treatment should be given for sick animal
- Awareness should be given for farmers about lung worm effect by veterinary health servants.

- Young animal should be kept separately from older animal
- Sheep and goat should be kept separately
- Grazing on marshy area should be avoided or cutting or feeding strategy should be followed.
- Regular deworming should be practiced before and after rainy season.
- Newly introduced animal to the flock should be dewormed.
- Government should introduce vaccine for lungworm.

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