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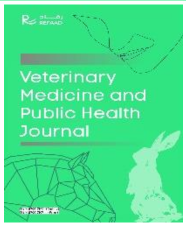

Lungworms in Small Ruminant: A Review with Emphasise on the Situation in Ethiopia

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Abstract

In Ethiopia, farm animals are confined to compounds year-round, and the climate is conducive to the development and survival of transmissible stages or vectors of several diseases. Therefore, helminth parasites are the primary cause of economic loss. Climate, ecology, and animal production. Systems are essential contributors to parasite reproduction and persistence. Important among diseases caused by infectious means is parasitic bronchitis Dictyocaulus filaria (D. filarial) is a lungworm of small ruminants that is found worldwide, including Ethiopia. The prevalence of D. filaria in sheep is maximum in Shoa (approximately 83-91.5 %), lowest in Tigray (approximately 11.24 %), and average in between 34.36% and 36. 24% in goats. In sheep, the prevalence of D. filaria is nearly 67.15 percent in females and 69.75 percent in males. In Gonder town, lungworm is prevalent in extensive management (approximately 43.40 %) and semi-intensive management (approximately 30.90 %). The diagnosis of lungworm is based on clinical symptoms, epidemiology, and laboratory conclusions of the first larvae gained by a range of larval recovery techniques. Guiding parasitic bronchitis in small ruminants can be talented through the use of anthelmintic, enhanced management practices, and the practice of using exposed larvae as a vaccine.

Keywords: *D.filaria; Small ruminant; Ethiopia; Control; lungworm.*

1 Introduction

Ethiopia is located in tropical Africa and has a highly diverse topography, climate, and agro ecological zones, creating it right for a variety of agricultural production strategies. This has contributed to the varied availability of genetic resources for domestic animals (Kassahun, et al, 2018).

Ethiopia is the third-largest country in Africa and eighth in the globe in relations to the number of sheep and goats. Occasionally, sheep and goats have helped as a basis of readily available currency and a replacement in times of economic and agricultural production difficulties (Adane & Girma, 2018). Sheep and goats are widely improved to a variety of climatic situations and are operated in all production techniques. 8–10%, 11–13%, and 14–16% of cattle, goats, and sheep are affected by disease annually. An estimated 700 million Birr (1 US dollar = 9.2 Birr) is lost annually due to helminthes (internal parasites) in domestic animals. Lungworm infection is one of the most significant parasitic diseases caused by these internal parasites (Sileshi & Desalegn, 2018).

Three-quarters of the national animal population resides in areas that obtain more than 700 millimetres of precipitation annually and are populated by three-quarters of the human population. One-fourth of the world's population resides in the remaining 25% of land area, which consists of lowlands (with annual precipitation below 700 mm). Despite the mathematical significance, the efficiency per animal and the actual involvement of the sub-sector in the national economy are far below prospects (Kassahun, et al, 2018).

Ethiopia is a country with extremes of temperature and rainfall, with altitude being the most important regulatory factor (FB Bekela, 2016), and these may be important fundamentals in controlling the pathogenicity of lungworm infections in sheep and goats. Some authors consider it to have a significant impact (Tewodros A, 2015), whereas others aspect it to temperate coughing and respiratory problems (Blood et al., 2019). D. filaria has been identified as the leading cause of lungworm infection in Ethiopian highland indigenous sheep breeds. A postmortem examination of sheep in Sheno, Northern Ethiopia, by Ayalew (2007) revealed a high proportion (80%) of D. filaria recovery. In the highlands of Wollo (Northern) and Arsi (Southern) Ethiopia, (Jamel A, 2016) found a prevalence of 53%.

Helminthes parasites of small ruminants are ubiquitous, with numerous tropical and subtropical environments around the globe providing nearly ideal conditions for their survival and development. Although these parasites are widespread, they may be less noticeable than the symptoms of other livestock diseases. Because of this, infection with helminthes parasites is one of the most widely recognized instances in which high prevalence rates of the infection with less obvious symptoms are associated with low production and laziness. Based on the relative location of the factors, the prevalence of parasitic diseases, such as respiratory helminths, varies greatly from area to area. Multiple lungworm species have been related to verminous pneumonia in sheep and goats, mainly in the Ethiopian highlands. Accordingly, prevention and control of lungworm are vital for increasing the production potential of small ruminants and taking their concentrated advantage (Nibret, et al., 2011). Consequently, the purpose of this article is to examine the prevalence of disease and its contributing factors, as well as to recommend effective means of prevention and control.

2 Biology of Small Ruminant Lungworms

2.1. Etiology

Lungworms are parasitic Strongylida nematode parasite worms that attack the lungs of vertebrates. Certain of these groups of nematodes also have additional common names; what they have in common is that they travel to the airways or respiratory tracts of their hosts and cause bronchitis or pneumonia (Andargachaw & Wudu, 2018).

D. filaria is the most prevalent lungworm parasitic infection in sheep and goats and is typically related with a protracted coughing and listlessness syndrome that affects lambs and kids. The disease is prevalent in temperate regions with abundant precipitation. The large lungworm of sheep and goats, Dictyocaulus filaria, is a slight, whitish worm measuring 3–10 cm in length. Adults reside primarily in the bronchi of the lung. Verminous (worm-related) pneumonia is chiefly a disease of mild, moist climates, as the additional development of feces-transmitted first-stage larvae into the infective third stage requires such conditions (Andargachaw & Wudu, 2018).

The parasitic nematode D. filaria is accountable for the disease in sheep and goats. Additional lungworm species that can infect sheep and goats are Muellerius capillaris and Protostrongylus rufipes. The nematode M. capillaris infestations are widespread (Salmaz, et al, 2022). D. filaria and P. rufescencens are encountered intermittently. This parasite belongs to the Animalia kingdom, the Nematode phylum, the Secementea class, the Strongylida order, the Dictyocaulidae family, the Dictyocaulus genus, and the D. filaria species (Haben & Mesfin, 2021).

2.2. Epidemiology

D. filaria is spread worldwide and roots severe root injury. The larvae require moisture for development and can survive moderately dry conditions for a few days, but can live in a moist environment for many months and are unaffected by low temperatures (Lora, 2022). On vegetation, infective D. filaria larvae are recognized. In the common of grazing seasons, immunity grows rapidly sufficient to defense labs and children from the number of infective grass larvae. Lungworm disease epidemiology attentions mainly on features that affect the number of intensive larvae on grasses and the degree to which they congregate. In humid and mild conditions, the third-stage larvae have a long lifespan. Warm, wet summers result in heavier burdens in the subsequent fall and spring. Sheep develop a healthy and durable immunity following routine exposure, whereas goats are not as resistant. In endemic regions, the larvae on the grass and the function of ewes as exporters are substantial factors in shaping the infection on the paddock from year to year. In ewes, it is likely that the parasites are recent as hypobiotic larvae in the lungs through the winter and develop in the spring (Debela & Yobsan, 2020) Development of the L3 only occurs from spring to fall.

The epidemiology is supplementary difficult, and infectious agents are further dominant and predictable than those of gastrointestinal nematodes, mainly because not all aspects of larval reality and communications are now understood. Infections are more prevalent in wet areas, and one of that the key changes between D. filaria and gastrointestinal nematodes disturbs the unpredictability of infections is that the female worm harvests eggs comprising wholly advanced larvae, which are then dispersed done the feces. These become infective much more fast than the eggs of gastrointestinal nematode parasites, and so, in ideal situations, they can cause a rapid increase in their departure from fecal pats (Tekalign, 2019).

There is speculation that earthworms or coprophagus insects may help as transport hosts, though this has not been definite. It has been exposed that infective larvae can live over the winter in the soil and on the grassland, and that small numbers of adult larvae and hypobiotic larvae can also survive. In addition, during the winter, infective animals provide their hosts with some immunity to further infection in order to mature and disperse larvae the following spring (Robel & Biruk, 2019).

In general, only juvenile ruminants in their first perusing season are clinically affected, whereas older animals have robust developed immunity on farms where the disease is endemic. Sheep seem to be less vulnerable to infection than goats. When both animals are spent together, sheep play an important role in the range of infection (Tefera, et al, 2017). It has been probable that a single infected lamb and lambling can infect a pasture with 33 million larvae. Moisture (80–100%) is essential for the survival and development of the larvae, and a temperature range of 18–26 degrees Celsius permits their full development into the infective state in 3–7 days. In an optimal scenario, the larvae could survive a year in the pasture. They are moderately resistant to cold, which typically retards their growth. Larvae can overwinter in frigid climates (Mebratu & Tewodros, 2015). They can withstand temperatures of 4-5 degrees Celsius for a year. Few infective larvae leave the fecal cloth, and the majority of those that do remain within 5cm of the pad. Important characteristics that aid in spreading out the larvae on the grassland include diarrhea, mechanical dispersal, and a high concentration of animals (Serkalem, et al, 2014).

2.3. Economic Consequences

Lungs affected with lungworm may be demoted or rejected at the slaughterhouse based on the extent of damage. Animals with severe lungworm infestations gain less weight, develop pneumonia, and may perish. 11–13% of goats and 14–16% of sheep are affected by disease on an annual basis. Estimated annual losses owing to helminthes (internal parasites) in domestic animals are 700 million Birr (1 USD = 9.2 Birr) (Sileshi & Desalegn, 2018).

2.4. Life Cycle

Small ruminants contract parasitic bronchitis from D. filaria. Female worms are ovoviviparous, laying eggs containing fully developed progeny that hatch almost immediately. The L1 migrate up the trachea, are reswallowed, and are eliminated through the feces. The larvae are distinguished by their presence in fresh defecation, sluggishness, and the presence of dark brown food granules in their intestinal cells. In terms of importance, the parasitic stages do not require sustenance. In ideal conditions, the L3 stage is attained in five days, but in the field, it frequently takes longer. The fecal pats of L3 larvae disperse across the herbage either through their own motility or with the aid of the fungus Pilobolus. Subsequent to ingestion, L3 enters the intestinal mucosa and travels to the mesenteric lymph nodes, where it accumulates. The L4 virus then travels to the lungs via the lymph nodes and blood, followed by the collapse of capillaries in the alveoli approximately one week after infection. A few days later, the final mount occurs in the bronchioles, after which the young adults (L5) progress up the bronchi and mature. The prepatent period lasts approximately five weeks. D. filaria, the most prevalent lungworm in sheep and goats, is invariably associated with the chronic syndrome of coughing and unthriftiness that typically affects lambs and kids (Ephrem, et al, 2022).

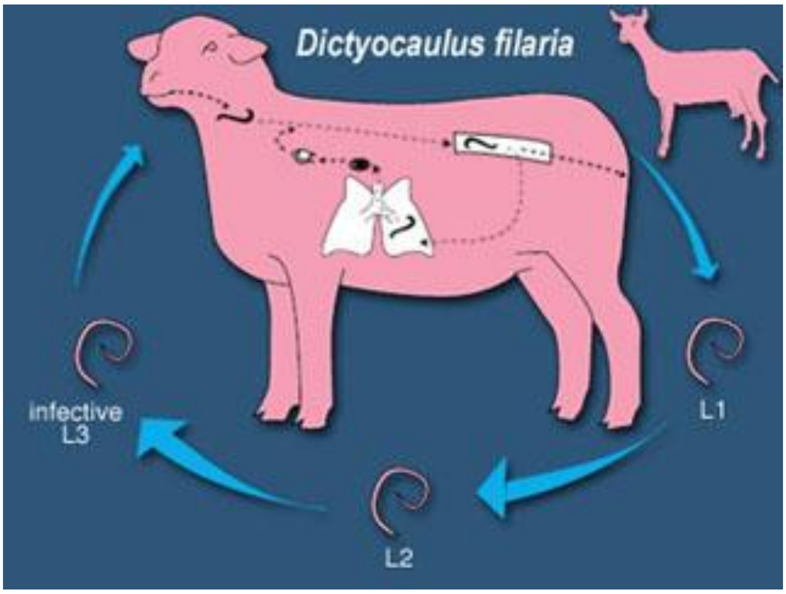

Fig. 1: Illustration of life cycle of *D.filaria*
Source: http://www.vetpdavis.edu/parasitology/images/LC/

The lungworm's overall life cycle commences with the ingestion of infected larvae. The infected larvae then infiltrate the intestinal wall and travel through the bloodstream to the lungs. The infected larvae reside in the lungs until reaching maturity. Adult larvae lay eggs, which hatch into lungworm. These eggs in the alveoli are coughed up, ingested back into the stomach, and then eliminated through the feces. Typically, this lungworm causes the most disease and requires treatment. Its lifecycle involves only the host and the surrounding atmosphere. The eggs hatch in the intestines after being deposited in the airways, coughed up, and swallowed. The larvae emerge from the decomposition. Eggs that have been directly embryonated are delivered by female worms. In this situation, the L1 is transmitted through defecation and moults twice to an infective L3. Infection is transmitted through the consumption of larvae (L3). Ingested L3s enter the lymphatic system and travel to the alveoli after penetrating the mucosa of the small intestine (Dagim & Tekalegn, 2020).

- **Transmission mode and pathogenesis**

Large lungworm larvae are consumed by sheep on grasslands. The larvae migrate from the intestinal tract to the bloodstream and airways. They reach maturity in the airways and windpipes. If inhaled from this location, they can affect a significant portion of the lung. They emerge in the intestines, and the larvae die in the excrement. They can survive for months in mild, humid conditions, but only a few days in hot, dry conditions (Emiyu & Lelisa, 2023).

According to (Animal Health Institute, 2022), the primary infection results in three phases of pathologic changes. These are the prepatent stages, during which eosinophilic exudates block small bronchi and bronchioles in response to the emerging and migrating larvae. At this stage, where adult worms cause bronchitis and primary pneumonia development. Adult worms are excluded during the post-patent phase, and the majority of animals steadily recover. Necropsy reveals the presence of atelectasis, emphysema, petechial hemorrhage, and consolidation of the lungs (Feyera & Tamene, 2021).

2.5. Clinical Results

Typically, different levels of clinical severity exist within the affected population. The severity of clinical symptoms is classified as minimal, moderate, or severe. A few animals are affected in moderate clinical cases, and there is intermittent coughing, especially during exercise. In moderate clinical cases, the majority of animals are exaggerated, and there is tachypnoea (>60 respirations per minute). In severe cases, respiration rates exceed 80 breaths per minute, indicating severe tachypnoea. Patients routinely accept the classic 'air-hunger' position of mouth respiration with the head and neck overstretched (Dessalew & Ananiya, 2019). In most cases, moderate to severe lungworm burdens irritate the airways, resulting in bronchitis and coughing. Heavy infestations also result in rapid breathing, nasal discharge, appetite loss, decreased milk production, ill thrift (reduced weight gain), pneumonia, suffocation, lethargy, nodular lesions (lung), coughing, and inability to nurse, diarrhea, exercise intolerance, fever, and ultimately mortality. Most severely affected are lambs aged 4-6 months, but sheep of any age can be affected. Lambs from the previous season are the primary source of infection in lambs from the following season. Autumn and spring are the worst seasons for lungworm (Mebrahten, et al, 2018).

3 Diagnosis

Clinically, verminous pneumonia resembles bacterial bronchopneumonia, acute and chronic interstitial pneumonia, and viral pneumonia. In the summer and fall, the disease frequently manifests as an epidemic (Shiferaw, 2019). The diagnostic procedures for lungworms are designated as follows:

3.1. Clinical Diagnosis

Common symptoms include cough, fever, and auscultation findings indicating consolidation of the lungs and interstitial emphysema. Initial cases of viral and interstitial pneumonia are characterized by the absence of bronchial involvement; the frequency of secondary bacterial bronchopneumonia renders this parasite unreliable. The comparative fluidity and paroxysmal nature of the cough in parasitic pneumonia as opposed to viral pneumonia is a clinical characteristic that may be of some value in variation. (Shiferaw, 2019) the cough is harsher and drier in the latter group.

3.2. Colonoscope Exam

The feces of all animals in a group should be collected, and for a comprehensive investigation of pasture, preferably from moist lying areas, it should also be examined for larvae. Most fecal flotation methods with a suitable saline solution and suitable means for improving larvae are able to improve first-stage larvae. The Baermann apparatus or its modification is a practical method (Debela & Yobsan, 2020).

The Baermann apparatus is utilized to enhance roundworm larvae from excrement, soil, and animal tissues. The warm water encourages the larvae in the sample to move around the basin at the container's base. The Baermann apparatus is composed of a ring stand, the stem of a funnel, a rubber tube, and metal screen parts (Charles, et al., 2006). D. filaria is larger than other ovine lungworms and has a straight tail (Tekalign, 2019). Additionally, it has a cuticular protrusion at its anterior limit and a straight tail.

- **Laboratory Analysis of Mucus and Tracheal Rain**

A drop of mucus or nasal discharge is placed on a microscope slide and inspected to distinguish D. filaria eggs from larvae (Emiyu & Lelisa, 2023).

- **Serological Diagnosis**

The enzyme-linked immunosorbent assay (ELISA) test can detect antibodies five weeks after an animal has been exposed to the parasite, and it may be useful for identifying infested animals, especially in the fall when large loads of worms do not produce larvae in the feces. This period intends to conduct an ELISA based on the availability of microstate plates coated with antigen. If such plates are available, results can be obtained four hours after the serum is prepared. If not, antigen must be applied to the plates for up to 16 hours (Ephrem, et al, 2022).

- **Post-mortem outcomes**

The morphological change in the lungs includes a variety of dark pink areas of collapsed tissue, hemorrhagic bronchitis with abundant liquid filling the airways, and enlargement of the regional lymph nodes. In the bronchioles and alveoli, the characteristic lesions are edema, eosinophilic infiltration, detritus, and larvae. The bronchial epithelium is hyperplastic and heavily infiltrated with inflammatory cells, especially eosinophils (Lora, 2022).

Fig. 2: Shows Larvae of *D. filarial* parasite in Bronchial tract.
Source: http://www.extension.org/mediawiki/

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Table 1: Summary of the data of reports accompanied on prevalence of lungworm in diverse towns or districts of Ethiopia.

Prevalence in %	Studied areas	Sources
15.00 In sheep	Debrezeit	(Fesseha &Gebrenegus, 2009)
59.40 In sheep	Arsi&Wollo	(Bekele *et al.*, 1992)
64.70 In sheep	Debre Berhan	(Brook *et al.*, 2006)
73.25 In sheep	Debre Berhan	(Mihreteab, B. and A. Aman. 2010
39.79 In sheep	Asella	(Wondewosen, 1992)
15.47 In sheep	Dessie & Kombolcha	(Teffera, 2013)
11.24 In sheep	Tigray	(Frewengel, 1995)
83-91.5 In sheep	Shoa	(Jovanovic, 1995)
13.00 In sheep	Bahir Dar	(Sissay, 1996)
24.30 In sheep	Wollo	(Sefinew, 2009)
30.74 In sheep	Chilalo (Arsi)	(Paulos, 2000)
12.50 In sheep	Tse-Ada-Emba	(Dawit, 2009)
55.30 In sheep	Wogera	(Nibret *et al.*, 2011)
36.22 In goats	Gonder	(Mekonnen *et al.*, 2012)

Table 2: Prevalence of lungworm with of sexwise small ruminants.

Prevalence in % in		Studied areas	Sources
Female	Male		
29.20 In sheep	25.00 in sheep	Tse-Ada-Emba	(Dawit, 2009)
27.27 In sheep	39.91 in sheep	Gonder	(Mekonnen et a l., 2012)
31.22 In sheep	29.00 in sheep	Deneba	(Mersha et al., 2012)
67.15 In sheep	69.78 in sheep	Wogera	(Nibret et al., 2011)
24.70 In sheep	29.70 in sheep	Jimma	(Abdu & Dawit, 2012)

From Table 2, the prevalence of lungworm is greater in females than males, while Abdu & Dawit (2012), Nibret *et al.* (2011), and Mekonnen *et al.* (2011) differ. This dissimilarity in prevalence among female and male animals might be due to the fact that resistance to infection decreases at the time of parturition and throughout early lactation. Perparturient relaxation of resistance results in the female's capacity to expel adult worms at higher level larvae detection (Mebrahten, et al, 2018).

Table 3: Prevalence of lungworm with management system.

Prevalence in % in		Studied areas	Sources
Extensive	semi-intensive		
26.60 In sheep	28.60 in sheep	Jimma	(Abdu & Dawit, 2012)
30.43 In sheep	25.00 in sheep	Tse-Ada-Emba	(Dawit, 2009)
34.40 In goats	30.90 in goats	Gonder	(Mekonnen *et al.*, 2012)

Table 3 displays that the incidence of lungworm in extensive management methods is higher than in semi-intensive management systems, despite the fact that Abdu & Dawit (2012) vary from Dawit (2009) and Mekonnen *et al.* (2011). The high prevalence of lung worm infection in extensive farming systems might be due to the fact that poorly cultivated animals seem to be less capable of receiving ride-off lung worm; however, it is not uncommon for well-fed animals to succumb to the disease, provided the true ecological situation is obtainable (Ephrem, et al, 2022).

Table 4: Prevalence of lungworm in sheep and goats.

Prevalence in % in Sheep	goats	Studied areas	Sources
32.67	37.39	Jimma	(Abdu & Dawit, 2012)
30.43	36.22	Gonder	(Mekonnen et al., 2012)

Table 4 specifies that goats are more vulnerable than sheep. This deviation could be clarified by the fact that goats are more prone to helminthes than sheep due to their browsing behaviour. Goats, with their browsing behaviour, eat uncontaminated substances with parasite larvae, so they are less exposed to larvae and therefore have lower acquired resistance than sheep (Wilsmore, 2006).

Based on body condition, animals were classified into three groups: poor, medium, and good. The lungworm infection degree conferred.

By the physical body situation was recorded to be 26.8% in animals with poor body conditions, 25.6% in those with medium body conditions, and 28.3% in animals with good body conditions (Abdu & Dawit, 2012).

4 Prevention and Control

In conjunction with caring for the kids and calves through vaccination, pasture management, and preventative anthelmintics, control measures must certainly a goal to diminish the attention of larvae on the grassland. Kids and calves should not be left only with older animals, and lush, wet grasses or paddocks in marshy areas should be avoided. Where animals are kept during the winter, yearling sheep, which are the primary vectors, must be treated former in order to release the larvae. In stimulating areas, barn compost must be collected and turned many times to avoid the spread of larvae to pasture (Tefera, et al, 2017).

In Ethiopia, farm animals employ the whole year on grassland, and the climate is favorable to the growth and presence of infectious stages or vectors. Helminthes parasites are an important funder to economic loss. Climate, ecology, and animal production methods are the primary factors that contribute to the multiplication and persistence of parasites. Consequently, the spreading and attention of infection by helminth parasites vary from region to region due to these factors. As the vulnerability of animals differs with age, it is vital, mainly during the rainy season, to scratch juvenile stock to prevent the spread of disease to older stock. Cut-and-carry feeding systems can ominously limit the spread of worms. Overpopulation invites more parasites and forces animals to feed closer to the soil, which may upsurge the number of infective larvae consumed. All farmers and pastoralists with similar grasses must device yield control methods concurrently. Before letting the newly presented animals to circulate with the rest of the livestock, they must be dewormed and lonely for three days. Maintain tidy, dry barns (Desalegn & Silseshi, 2008).

4.1. Management in humid environments

Moist climates are always favorable to the growth of infectious larvae. To effectively control the occurrence and timing of strategic anthelmintic dosing in these climatic situations, it is vital to determine parasitism levels and the epidemiology of the species present. In moist climates, the alteration of stocking rates is a vital regulating factor. If a high supply rate is sustained, it may be essential to direct anthelmintics repeatedly. In contrast, frequent procedures throughout the year may not be economically possible; a planned anthelmintic routine must be scheduled based on ideal cost valuations (Desalegn & Sileshi, 2008).

4.2. Immunization

At several time intervals after vaccination, the resistance of sheep and goats immunized with illuminated D. filaria larvae to infection with weakened larvae was evaluated. Two doses of attenuated larvae are directed orally every four weeks. Preferably, the animals must be reserved during the treatment and for two weeks afterward to permit tolerable resistance to develop. The vaccines harvest robust immunity, which is sustained even if animals are continually reinfected. The vaccine is an aqueous suspension of partly inactivated third-stage infectious D. filaria larvae reduced inactive by ionizing irradiation. Along with the custom of using irradiated lungworm vaccine in less industrialized nations, the short shelf life of the vaccine, mainly in rural areas where entree is difficult, is one of the greatest obstacles (Robel & Biruk, 2019).

4.3. Use of Anthelmintic Medication

Various producers usually administer anthelmintic medicines in an effort to limit the spread of infection and diminish the severity of lungworm disease. While the majority of now available anthelmintics are effective against all stages of lungworms, their recurrent use reduces an animal's exposure to parasitic antigens, creating them more vulnerable to disease (Tekalign, 2019).

Table 5: Different modern broad-spectrum anthelmintic drugs used for Lungworm.

Drug groups	Anthelmintic drugs	Dose in mg/kg	Routs of Administration
Macrolides	Ivermectin	0.05	PO and SC
Benzimidazole	Oxfendazole	2.5	PO
	Fenbendazole	5.0	PO
	Albendazole	7.5	PO
	Febantele	10	PO
Imidathiazole	Levamisole	8.0	PO

Source: (Blood *et al*., 2000).

5 Conclusions and suggestions

Lungworm diseases in small ruminants are classically initiated by Dictyocaulus, Protostrongylus, and Muellerius, which occupy a diversity of respiratory tract scenes and harvest a number of pathological injuries. Dityocaulus, the highest major common small ruminant lungworm, poses a major danger to the making and fitness of infected animals. The occurrence of lungworm in the Ethiopian highlands is substantial, ranging between 83 and 91.5 percent in Shoa sheep. The infection is severe in females, young goats, and males, adults, and sheep, but not in young goats or young males.

In numerous states of the globe, the diagnosis of lungworm infection in ruminants is still mainly centered on clinical signs, disease epidemiology, and the detection of active L1 larvae, despite the prevalence of the Baermann technique. Despite the fact that serology harvests gifted results, its widespread field application has not yet materialized. The habit of exposed larvae as a vaccine alongside D. filaria in sheep and goats has been one of the most important attainments in the development of vaccines alongside helminth parasites. In light of this thought, the following suggestions can be advanced:

- Emphasis should be located on the Ethiopian highlands and the seasons (autumn and spring) with the highest incidence of D. filaria.
- Former to administering vaccines, it is important to avoid situations that quash the immune system, such as malnutrition, excessive parasite heaps, and general anxiety.
- For improved production gains and real parasite control, a combination of vaccination and anthelmintic treatment strategies is required.
- In order to control or disturb the life cycle of parasites, it is essential to pay glancing management techniques such as rotational feeding.

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