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Research Article

Prevalence and associated risk factors of Lungworm infection in small ruminants in west Dembiya district, Amhara national regional state, northwest Ethiopia

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Abstract

Lungworm infections are a major economic concern in small ruminants, reducing productivity, compromising animal welfare, and increasing prevention and treatment costs. Effective control is essential for maintaining healthy and profitable herds, especially in endemic areas. A cross-sectional study was conducted from December 2022 to July 2023 in West Dembiya, Northwest Ethiopia, to determine the prevalence of lungworm infection in sheep and goats, identify risk factors, and characterize the lungworm species involved. Using simple random sampling, fecal samples from 384 animals (219 sheep and 165 goats) were collected and examined with the modified Baermann technique. Chi-square tests and logistic regression were applied to assess associations. The overall prevalence was 28.91%, with 30.3% in goats and 27.9% in sheep. *Dictyocaulus filaria* was the most prevalent species (14.3%), followed by *Muellerius capillaris* (6.8%) and *Protostrongylus rufescens* (2.9%). Infection rates were significantly higher in females (34.2%) and adult animals (34.4%). Poor body condition and extensive management systems also increased the odds of infection ($P < 0.05$). These findings highlight the need for strategic deworming and awareness programs promoting improved management and feeding practices to reduce lungworm infections in the area.

Keywords: Lungworms, Prevalence, Risk factors, Small ruminants, West Dembiya

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1. INTRODUCTION

Ethiopia possesses the largest livestock population in Africa, with an estimated 65 million cattle, 40 million sheep, 51 million goats, 8 million camels, and 49 million chickens as of 2020 (Mekuriaw and Harris-Coble, 2021). Small ruminants (mainly sheep and goats) play a vital role in Ethiopia's livestock sector and rural livelihoods, contributing economically, nutritionally, and socially at both household and national levels. They are widely kept by smallholder and pastoral farmers because they require little capital, reproduce quickly, and can be sold easily to meet household cash needs, making them an important source of income and for many individuals specially women, small ruminants like sheep and goats offer a powerful entry point to improve their livelihoods. security (Wodajo *et al*., 2020; Jemberu *et al*., 2022; ILRI, 2025). Sheep and goats also provide meat and milk that supply essential nutrients, accounting for about 33% of the total meat and 14% of the milk produced nationally (CSA, 2023; Jemberu *et al*., 2022). Their role in supporting food security and nutrition across Ethiopia's diverse agro-ecological zones is well recognized (Wodajo *et al*., 2020).

However, their contribution is impaired by mismanagement, poor nutrition, and widespread disease challenges (Jemberu *et al*., 2022; Mijena and Getiso, 2022). Among these, parasitic infections particularly lungworms pose a major burden on productivity. Lungworm infections (mainly *Dictyocaulus filaria, Protostrongylus rufescens,* and *Muellerius capillaris*) cause respiratory distress, reduced feed efficiency, stunted growth, poor weight gain, and decreased milk and meat yield, leading to significant economic losses (Sissay *et al*., 2007; Regassa *et al*., 2010). The impact is more severe under traditional extensive systems where poor grazing management and lack of deworming practices favor continuous transmission and reinfection (Asmare *et al*., 2018).

Lungworms are distributed worldwide, particularly in regions where climatic and environmental factors favor the development and survival of the parasites and their intermediate hosts. Even though, lungworms are cosmopolitan in distribution, they are most common in temperate climates and in the highlands of tropical and subtropical countries (Kebede *et al*., 2018). The important ruminant species are divided into two families: the *Dictyocaulidae* and the *Metastrongylidae*. From *Dictyocaulidae* family*, Dictyocaulus filaria* is the most important species of lungworm found in sheep and goats (Nashiruddullah *et al*., 2007). The worm *D. filaria* measures about 5-10 cm long and live in the trachea and bronchi of the small ruminants (Habte

and Simeneh, 2019). Additionally, *Protostrongylus rufescens* (1.5-3.5 cm), a small worm found in the bronchioles (Hanks, 2021; Hansen and Perry, 1994), *Muellerius capillaris* (1.2-2.5 cm) in the alveoli (Teketel and Alemu, 2019, and *Cystocaulus ocreatus* (2-5 cm) in the terminal bronchioles (Ashango *et al*., 2020) are the three species belong to the family *Metastrongylidae* (Ashango *et al*., 2020; Zafari *et al*., 2022) are all reported in small ruminants.

Prevalence of lungworm infection in small ruminants varies across Ethiopia. In and around Bahir Dar City, Muluken (2009) and Asaye and Alemneh (2015) reported prevalence rates of 18.16% and 22.7%, respectively. Other studies have reported 39.6% in North and South Gondar (Tigist, 2009; Mengestom, 2008), 21.5% in Atsbi, Tigray (Alemu *et al*., 2006), 53.6% in northeast Ethiopia (Ibrahim and Degefa, 2012), 13.4% in Mekele (Fentahun et al., 2012), 29.04% in and around Jimma town (Beyene *et al*., 2013), and 34.9% in Ambo district.

The prevalence of lungworm infection is influenced by multiple factors, including climate, altitude, presence of intermediate hosts, and ecological conditions such as rainfall, humidity, temperature, and marshy grazing areas. Under optimal conditions, larvae can survive for more than one year (Tewodros and Mebratu, 2015). Lungworms specially *Dictyocaulus* species are host-specific and are most common in regions with mild temperatures, high rainfall, and abundant pasture (Radostits *et al*., 2007). Husbandry practices and the management of sheep and goats also affect the development and transmission of lungworm species (Kebede *et al*., 2014; Gebreyohannes *et al*., 2013). The incidence of parasitic diseases, including respiratory helminthosis, varies widely across Ethiopia due to ecological and climatic differences. *Dictyocaulus filaria* has a direct life cycle and reaches the infective stage relatively quickly; larvae can appear in feces within five weeks of ingestion whereas the transmission of *P. rufescens* and *M. capillaris* is epidemiologically more complex, involving the definitive host and an intermediate snail host. The development of larvae from first to infective stage within the snail takes 12–14 days, and the prepatent period ranges from 30 to 60 days (Soulsby, 1986; Radostits *et al*., 2007).

Proper diagnosis, treatment, control, and prevention are therefore critical to improve livestock productivity (Tewodros and Mebratu, 2015). Given the limited data and no such study has been done specifically in West Dembiya District, and the ecological suitability of the area for lungworms, this study was designed to estimate the prevalence of lungworms in small

ruminants, identify associated risk factors, and determine the species present in this district of the Amhara National Regional State, northwest Ethiopia.

2. MATERIALS AND METHODS

2.1.Study Area

The study was conducted in West Dembiya district (Figure 1), located in the Central Gondar Zone of the Amhara Region, approximately 30 km from Gondar town and 777 km from Addis Ababa. The district covers an area of 203,153 hectares and lies at an elevation of 1,800–2,000 m above sea level, between 35°50′ to 38°30′ E longitudes and 12°30′ to 13°38′ N latitudes. The area experiences summer rainfall, with a mean annual rainfall of 1,600 mm and a mean temperature of 20 °C. Rivers, streams, ponds, irrigation canals, and swampy or marshy water bodies are abundant throughout the district. The fertile agricultural land supports a large livestock population, with water and grazing pastures available year-round. According to west Dembiya Woreda Livestock Development Office (DWLDO) (2022), the livestock population includes 247,237 cattle, 40,293 sheep, 18,659 goats, 20,532 equines (20,205 donkeys, 269 mules, and 58 horses), 148,695 poultry, and 21,318 bee colonies. West Dembiya district employs both extensive and semi-intensive livestock farming systems.

2.2.Study population

The study population consisted of domestic small ruminants (sheep and goats) in the study area. All animals were local breeds kept under extensive and semi-intensive management systems. Animals of both sexes, different body condition scores, and all age groups were included in the study. The age of each animal was determined based on the eruption stages of permanent incisor teeth (Abebe and Yami, 2008) and through information provided by the owners. Animals younger than 2 years were categorized as young, whereas those aged 2 years and older were considered adults. Body condition was assessed based on the appearance of the ribs and dorsal spines and categorized as poor, medium, or good (Ullman-Culleré and Foltz, 1999) through visuall inspection and palpation.

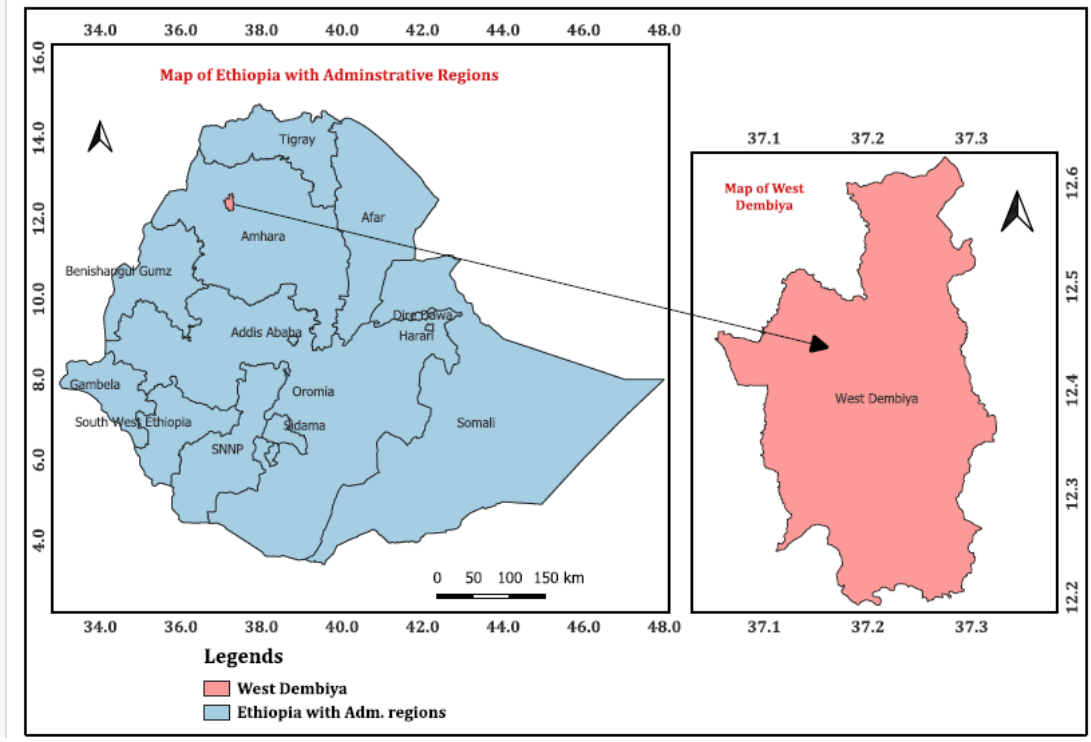


Figure 1. Map of the study Area (A map made by QGIS)

2.3.Study design, Sample size and sampling method

A cross-sectional study design was conducted from December 2022 to July 2023 to determine the prevalence of lungworm infection and assess its risk factors in small ruminants. The required sample size was calculated using the formula described by Thrusfield (2018). As there was no prior report of lungworm prevalence in the study area, an expected prevalence of 50% was assumed with a 5% absolute precision. The sample size was determined using the formula (Equ. 1):

$$n = [1.96^2 * Pexp(1 - P)] \div d\text{^}2 \quad \text{..... (Equ. 1)}$$

Where, n= Sample size, Pexp= expected Prevalence, d = desired level of precision (5%). Based on this calculation, the total sample size was 384 small ruminants. These animals were selected using a simple random sampling method (lottery method).

From the total 23 kebeles in the district, four kebeles were purposively selected based on accessibility, availability of sufficient sheep and goat populations, and ecological suitability for the intermediate host. The number of sheep and goats included in this study was determined

proportionally based on the population of the small ruminants in the district and the study kebeles.

2.4.Sample collection and transportation

Fecal samples of approximately 7–10 grams were collected directly from the rectum of each animal using a disposable glove covering two fingers. Each sample was placed in a labeled universal sampling bottle, and the animal's identification information including sex, age, body condition, species, and management system, was recorded on a data sheet. The samples were transported promptly to the Veterinary Parasitology Laboratory, College of Veterinary Medicine and Animal Sciences, University of Gondar. All fecal samples were processed within 24 hours.

2.5.Coprological Techniques and Larval Identification

Weighted fecal samples from each sample were processed using the modified Baermann technique to extract first-stage (L1) lungworm larvae. Briefly, each sample was enclosed in double-layered gauze secured to a string rod and submerged in a clean glass beaker containing lukewarm water which is 30–35°C in temperature as previously described by Yan *et al*. (2022). The apparatus was left undisturbed for 24 hours, during which larvae actively migrated out of the feces and collected at the bottom of the beaker by gravity. The supernatant was then discarded, and a small amount of sediment was transferred to a microscope slide using a pipette for examination under low power (10×).

L1 larvae were detected and identified following Bowman (2014) and previous studies (Asaye and Alemneh, 2015; Kadi *et al*., 2017; Bekele and Shibbiru, 2017). *D. filaria* L1 are large, with bluntly rounded tails, a "button" at the mouth, and prominent granules. *P. rufescens* larvae are stout with conically tapering tails and no spines, whereas *M. capillaris* larvae have a distinctly curved tail with a dorsal spine.

2.6.Data Management and analysis

Data were coded and entered into Microsoft Excel 2010 and subsequently analyzed using SPSS version 25 (IBM Corp., Armonk, NY, USA). The status of lungworm infection in small ruminants was the dependent variable, and all categorical risk factors, including age (young and adult), sex (male and female), host animal species (sheep and goats), body condition score (poor, median, and good), management system (extensive and semi-intensive), and deworming history

(dewormed and non-dewormed), were the independent variables. The Chi-square test (χ^2) was used to evaluate the association between categorical risk factors and the occurrence of lungworm infection. To assess the degree of associations between risk factors and infection, univariable logistic regression was applied to all risk factors that showed a significant statistical association with the infection by chi-square test statistics. The results were presented as odds ratios and 95% confidence intervals. Statistical significance was set at $P < 0.05$.

2.7.Ethical clearance

During sample collection, the best practice guidelines for veterinary care were followed in order not harm animals. The college of Veterinary Medicine and Animal Sciences, University of Gondar College Review and Ethical committee (CREC) approved the verbally informed consent process with reference number CVMASc: 77/2023 on 9/01/2023. Animal owners were informed about the purpose of the study for the collection of fecal samples and related data on the history of deworming. After providing adequate information and clarification, verbal/informed consent was obtained from each owner before sample collection.

3. RESULTS

3.1.Prevalence of lungworm infection in small ruminants

Out of 384 fecal samples collected (219 sheep and 165 goats), 111 were positive for lungworms, resulting in an overall prevalence of 28.91% (111/384; 95% CI: 24.2–33.6%). Among the infected animals, 55 (14.32%), 26 (6.77%), 11 (2.86%), and 19 (4.95%) were infected with *D. filaria*, *M. capillaris*, *P. rufescens*, and mixed infections, respectively. The prevalence rate in goats (30.3%; 50/165) was slightly higher than in sheep (27.85%; 61/219) (Table 1).

3.2. Risk factors of lungworm infection in small ruminants

Chi-square analysis revealed statistically significant associations between lungworm infection and sex, age, body condition, management system, and deworming history ($P < 0.05$). Infection was higher in females (34.17%) than in males (20.14%) ($\chi^2 = 8.618$; $P = 0.0033$). Adults had a higher prevalence (34.4%) compared to young animals (18.66%) ($\chi^2 = 10.522$; $P = 0.0012$). Animals with poor body condition showed the highest prevalence (45%) compared to those with medium or good body condition, with a statistically significant difference ($\chi^2 = 14.902$; $P = 0.001$) (Table 1). The prevalence was high (31.88%) in animals maintained under extensive management system as shown in Table 1.

The prevalence of lungworm infection in dewormed and non-dewormed small ruminants was 22.22% (30/135) and 32.53% (76/249), respectively, with a statistically significant difference (χ^2 = 4.526; P = 0.0334). Even though higher prevalence rate was observed in goats than in sheep, there was no significant association between infection and species of host animals (P > 0.05) (Table 1). Owners reported that anthelmintic treatments included subcutaneous injections of 1% ivermectin and oral albendazole. Of the 30 infected animals that had been dewormed, 4 received ivermectin and 24 received albendazole. Treatments were reportedly administered in the afternoon.

Table 1. Association lungworm infection in small ruminants and associated potential risk factors

Risk factors	**Category**	**No. of examined animal**	**No. positive n (%)**	**χ^2**	**P-value**
Species	Sheep	219	61 (27.85)	0.275	0.600
	Goats	165	50 (30.3)		
Sex	Male	144	29 (20.14)	8.618	0.0033
	Female	240	82(34.17)		
Age	Young	134	25(18.66)	10.522	0.0012
	adult	250	86 (34.4)		
BCS	Good	209	44 (21.05)	14.902	0.001
	Medium	135	49 (36.3)		
	Poor	40	18 (45.0)		
Management	Extensive	323	103 (31.88)	8.800	0.003
	Semi-intensive	61	8 (13.11)		
DewormHis[@]	Dewormed	135	30(22.22)	4.526	0.0334
	Not dewormed	249	81(32.53)		
TAHused[*] (n=135)	Ivermectin	44	6(13.64)	6.6121	0.012
	Albendazole	91	24(26.37)		
Total		384	111(28.91)		

Key: BCS = Body Condition Scores, χ^2= Chi-square test, DewormHis[@] = Deworming history, TAHused[*] = Type of Antihelmintic used.

Variables that were significant in the Chi-square analysis were further assessed using univariable logistic regression to determine the strength of associations. The odds of lungworm infection in females was 0.566 times lower than that of males (OR = 0.566; P < 0.05) and similarly the odds of lungworm infection in young was 0.437 times lower than that of the adults (OR = 0.437; P < 0.05) (Table 2). Animals with poor and medium body condition had higher odds of infection than those with good body condition (OR = 0.696 and 0.326, respectively; P < 0.05). The odds of infection in animals under an extensive management system were 3.102 times higher than in

those under a semi-intensive system (P < 0.05; OR = 3.102). Dewormed animals had lower (0.602 times) odds of infection compared to non-dewormed animals (OR = 0.602; P < 0.05) (Table 2).

Table 2. Association of Prevalence of lungworm infection and associated factors using univariable logistic regression

Risk factors	Category	Odds ratio (OR)	P-value	95% CI
Sex	Male	*		
	Female	0.566	0.022	0.347-0.922
Age	Young	*	0.000	
	Adult	0.437	0.001	0.263-0.726
BCS	Good	*		
	Medium	0.326	0.001	0.161-0.660
	Poor	0.696		0.341-1.423
Management system	Semi-intensive	*		
	Extensive	3.102	0.004	1.423-6.762
Deworm history	Dewormed	*		
	Not-dewormed	0.602	0.040	0.371-0.977

Key; *= Reference, CI = Confidence Interval for Odds ratio

3.3. Identification of larvae of lungworm

Among the 111 positive for lungworms, the most prevalent lungworm species was *D. filaria* (14.32%), followed by *M. capillaris* (6.77%). *P. rufescens* was the least prevalent species in the study area (Table 3).

Table 3. Species of lungworms identified by fecal examination and their prevalence

Lungworm species	Total examined animal number N= 384	Total number of positive animal N= 111
	Prevalence n(%), [95%CI]	Relative percentage n (%), [95%CI]
Dictyocaulus filaria	55(14.32), [10.8 – 17.9]	55 (49.5), [39.6-58.6]
Muellerius capillaris	26(6.77), [4.2 – 9.3[	26 (23.4), [15.3-32.4]
Protostrongylus rufescens	11(2.86),[1.2 – 4.5]	11 (9.9), [4.5-15.3]
Mixed	19(4.95), [2.8 – 7.1]	19 (17.1), [10.8-24.3]

Some representative first-stage (L1) lungworm larvae are shown in Figure 2. *D. filaria*, recovered from sheep and goat fecal samples, has bluntly rounded tails and prominent granules (Figure 2A). *M. capillaris* has an undulating tail tip with a dorsal spine (Figure 2B). In contrast, *P. rufescens* larvae have conically tapering tails without spines (Figure 2C).

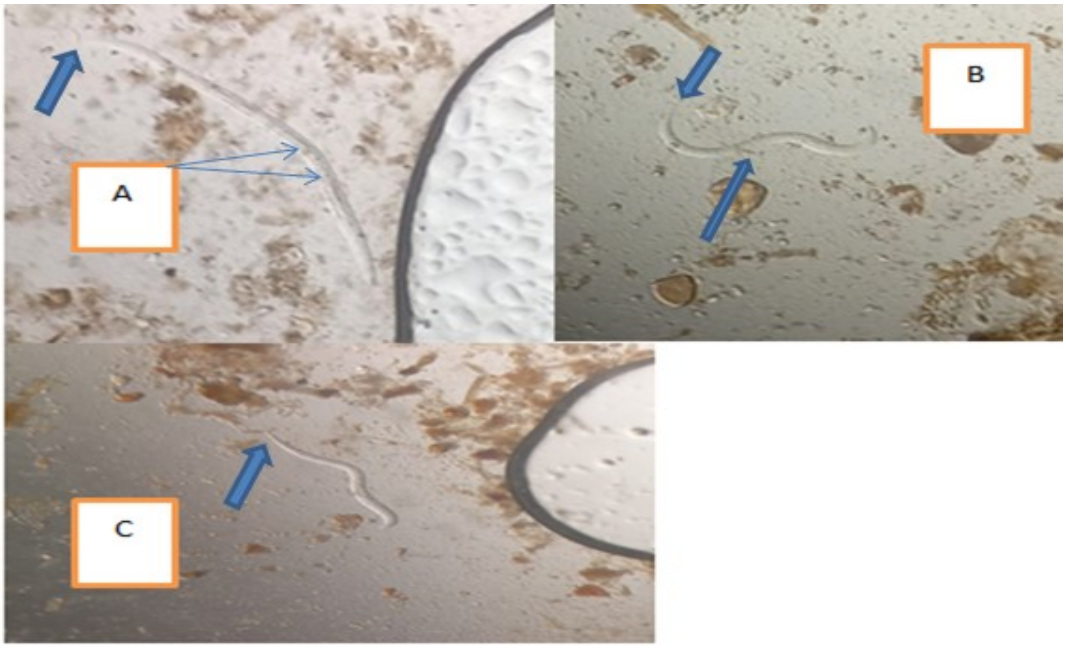


Figure 2. Species of lungworm L1larvae identified (A) *Dictyocaulus filarial (*bluntly rounded tails and granules)*, (B) Muellerius capillaris (*undulating tail tip with a dorsal spine)*, (C) Protostrongylus rufescens (*tapering tails without spines)

4. DISCUSSION

4.1.Prevalence of Lungworm infection in small ruminants

In this cross-sectional study, the overall prevalence of lungworm infection in small ruminants was 28.91% (111/384; 95% CI: 24.2–33.6%)**.** This finding aligns with previous reports, including Kassa *et al*. (2017) who recorded 31.2% in three districts of South Wollo, Uqubazghi (1990) with 27.6% in Hamas Awraja, Fentahun *et al*. (2012) with 25.24**%** around Jimma Town, and Weldesenebet and Mohammed (2012) with 26.**7%** in Jimma Town.

Conversely, the current prevalence was lower than findings from several Ethiopian regions: Negash *et al*. (2018) reported 44.8% in Gedeb Asasa District (West Arsi Zone); Sisay (1996), 44.7% in Bahir Dar; Alemayehu *et al*. (2010), 40.4% in Dessie and Kombolcha; Fentahun *et al*.(2016), 43.76% around Gondar; Muhammed *et al*. (2016), 45% in Hitosa Woreda; Abera *et al*. (2016), 57.6% in Bale and Arsi highlands; Haile *et al*. (2018), 43% in and around Eteya town; Yacob and Alemu (2019), 54.16% in Debre Berhan; Addis *et al*. (2011), 33.83% in Gondar; and Mihret and Firesbhat (2018), 38.80% in and around Kombolcha. However, the present prevalence was higher than reports by Assaye and Alemneh (2015) in and around Bahir Dar City (22.7%), Tenaw and Jemberu (2018) in Burie District (23%), Mengestom (2008) in Atsbi, Tigray

(21.5%), Frewengel (1995) in and around Mekele (13.24%), Tamire and Mohamed (2013) in and around Bahir Dar (20.2%), and Muluken (2009) in and around Bahir Dar (18.16%).

Variations in lungworm prevalence among studies could be attributed to differences in diagnostic techniques, ecological conditions (favoring larval or intermediate host survival), and sample sizes. Other contributing factors may include animal nutrition, which affects immunity, management practices, and environmental conditions such as rainfall, humidity, temperature, and season of sampling.

4.2.Associated risk factors of Lungworm infection in small ruminants

The prevalence of lungworm infection was higher in females (34.17%) than in males (20.14%), showing a statistically significant difference ($P < 0.05$). This result agrees with findings by Alemu *et al*. (2006), Denbarga *et al*. (2013), and Asaye and Alemneh (2015), who also reported a higher prevalence in females than in males. However, several studies from different parts of Ethiopia, such as those by Regassa *et al*. (2010), Weldesenebet and Mohammed (2012), Moges *et al*. (2011), Bogale *et al*. (2012), and Addis *et al*. (2011) showed that there was no statistical significance difference in prevalence between male and female animals. The higher lungworm infection rate in females may be linked to hormonal influences, pregnancy and lactation stress, and reduced immunity. Elevated progesterone levels and physiological stress during reproduction can suppress immune responses, increasing susceptibility to parasitic infections.

In terms of age, there was a statistically significant difference ($P < 0.05$) between the prevalence of infection in adult animals (34.4%) and young animals (18.66%). This finding corroborates the results of Regassa *et al*. (2010), who reported 22.5% infection in young and 77.5% in adult animals in Dessie and Kombolcha districts, northeastern Ethiopia. The present study indicated that infection rate increased with age. According to Berrag and Urquhart (1996), development of *Muellerius* species in the lungs induces cellular reactions and tissue damage. As *Muellerius capillaris* infections accumulate over time, older animals are more likely than younger ones to exhibit clinical signs such as coughing and malaise resulting from severe infestation.

However, Muluken (2009), and Tigist (2009) reported a higher prevalence in young animals than in adults, further contrasting with the present result. Similarly, the current finding contradicts studies from Northern Ethiopia (Alemu *et al*., 2006), Asela in the Arsi Zone (Muktar *et al*., 2015**),** and Ambo Town (Kadie *et al*., 2017) who reported a higher prevalence in young animals than in adults.

Body condition score was another factor significantly associated with lungworm infection ($P < 0.05$). The parasites were more prevalent in animals with poor body condition (45%), compared with those in medium (36.29%) and good (21.05%) condition. Similar trends were reported by Hussien *et al*. (2017), Tenaw and Jemberu (2018), Teketel and Alemu (2019), Muktar *et al*. (2015) and Yacob and Alemu (2019) who observed markedly higher infection rates among poorly conditioned small ruminants compared to those in good body condition.

The higher prevalence in poorly conditioned animals may be explained by immunosuppression resulting from malnutrition or concurrent parasitic infections. Malnourished sheep and goats are less capable of eliminating lungworm larvae, leading to reduced resistance and consequently higher infection rates (Radostits *et al*., 2007; Fentaw *et al*., 2018).

Regarding management system, lungworm infection was significantly higher ($P < 0.05$) in animals kept under the extensive management system (31.88%) than those under semi-intensive management (13.11%). This finding is consistent with the findings of Terefe *et al*. (2013) in North Gondar, Addis *et al*. (2011) in Gondar, Bekele and Shibbiru (2017) in Debre Berhan, and Mihret and Firesbhat (2018) in Kombolcha, who reported prevalence of (51.8% vs. 24.5%), (34.40% vs. 30.90%), (15.3% vs. 2.9%), and (42.20% vs. 19.29%), respectively. The reason for this could be increased cultivation of land which restricts animals on communal grazing land so that large numbers of the animals are kept together. This could increase the degree of pasture contamination leading to higher prevalence rate. Management practice such as provision of ample nutrition increases the resistance of the host under the semi-intensive system, contrary to this malnutrition which reduces the host-parasite response and favors the fecundity of the parasites that allows the animals for continuous larvae exposure under extensive system, so result in high prevalence (Soulsby, 1986; Denbarga *et al*., 2013; Terefe *et al*., 2013).

Regarding deworming history, lungworm prevalence was lower in dewormed animals (22.22%) than in non-dewormed animals (32.53%), and this difference was statistically significant ($P < 0.05$). This significant difference may be attributed to the reduction of larvae in dewormed animals following the anthelmintic effect of treatment.

Species-wise analysis showed no statistically significant difference ($P > 0.05$) in lungworm prevalence between goats and sheep, although the rate was slightly higher in goats. Even though, goats are usually browsers and less exposed to pasture-borne larvae than sheep, habitat

degradation and limited browse availability in the study area may force goats to graze alongside sheep, increasing exposure and explaining the comparable infection rates (Fentahun *et al*., 2016).

In this study, the major lungworm species identified were *Dictyocaulus filaria* (14.32%; 55/384), *Muellerius capillaris* (6.77%; 26/384), and *Protostrongylus rufescens* (2.86%; 11/384), while mixed infections accounted for 4.95% (19/384) of cases. Of the three species of lungworms found, *Dictyocaulus filaria* was the most common and *Protostrongylus rufescens* the least. This finding is consistent with Alemu *et al.* (2006) and López and Martinson (2017), who also reported *D. filaria* as the most prevalent species. Furthermore, Asmare *et al.* (2018) confirmed the dominance of *D. filaria* through a systematic review and meta-analysis conducted in Ethiopia.

Differences in the prevalence of *D. filaria*, *M. capillaris*, and *P. rufescens* are likely related to variations in their life cycles**.** *Dictyocaulus filaria* has a direct life cycle and reaches the infective stage relatively quickly; larvae can appear in feces within five weeks of ingestion (Soulsby, 1986). In contrast, transmission of *P. rufescens* and *M. capillaris* is epidemiologically more complex, involving the definitive host, parasite, and an intermediate snail host. The development of larvae from first to infective stage within the snail takes 12–14 days, and the prepatent period ranges from 30 to 60 days. Consequently, the probability of infection, transmission, and reinfection is lower for *M. capillaris* and *P. rufescens* compared with *D. filaria* (Radostits *et al*., 2007).

5. CONCLUSION AND RECOMMENDATIONS

This study revealed a relatively high overall prevalence of lungworm infection in small ruminants. The prevalence was slightly higher in goats than in sheep. The study also demonstrated the coexistence of multiple lungworm species within the small ruminant population. The lungworm species identified were *Dictyocaulus filaria, Muellerius capillaris,* and *Protostrongylus rufescens*. The most prevalent species was *Dictyocaulus filaria*. Several risk factors were found to be significantly associated with lungworm infection, including age group, sex, body condition, management system, and deworming history.

Based on the findings of this study, several recommendations are proposed to reduce the prevalence and impact of lungworm infection in small ruminants. Further research should be conducted using advanced diagnostic techniques, including molecular and serological methods,

to enable accurate identification of lungworm species and to enhance understanding of their epidemiology. In addition, awareness creation programs should be organized for animal owners and animal health professionals to improve their knowledge of the transmission, prevention, and control of lungworm infections. Strategic and periodic deworming programs should also be implemented in consultation with veterinary experts and adapted to local epidemiological conditions. Finally, regular surveillance and monitoring systems should be established to evaluate the effectiveness of control strategies and to detect the possible emergence of anthelmintic resistance.

Conflict of interests

The authors have not declared any conflict of interests.

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