Surgical and Experimental Pathology

RESEARCH

Open Access

Pathological characterization of pulmonary lesion and identification of associated bacteria and parasite infection in sheep and goat slaughtered at Dessie municipal abattoir, North-East Ethiopia

Nuredin Teshale[1], Abadi Amare[1], Abdi Feyisa[2] and Jirata Shiferaw Abosse[3*]

Abstract

Background Lung is susceptible and vulnerable to many infectious and non-infectious agents. From this, a large number of specific and nonspecific diseases conditions can be diagnosed. A cross-sectional study design was conducted from December 2022 to May 2023 on major pulmonary lesion of sheep and goat slaughtered at Dessie municipal abattoir with the objective of characterizing the pulmonary pathological lesions, and isolating and identifying potential aerobic bacteria and parasite from pneumonic lung.

Materials and Methods A total of 420 (302 sheep and 118 goats) were examined for gross lung lesions and histopathological investigation using standard techniques. Additionally, detailed pathological investigation was conducted on purposively selected lung lesions. Besides, pneumonic lesions were subjected to routine bacteriological and parasitological analysis.

Results The overall abattoir prevalence of pulmonary abnormalities in sheep and goat was 81.2% (341/420). The common gross lesions encountered were Pneumonia (55.5%), emphysema (7.1%), atelectasis (3.3%), Hydatid cyst (4.3%), congestion (2.4%), haemorrhage (3.1%), Anthracosis (0.9%), adhesion (0.7%), and Bronchoectasis (0.7%) respectively. Pneumonia, hydatidosis, and pulmonary emphysema were significantly associated ($p < 0.05$) with animal age groups. Pneumonia was the most common disorder, accounting for 233 (55.5%). *Dictyocaulus filaria* (47.7%), *Mullerius capillaries* (23.2%) and *Protostrongylus rufescens* (17.16%) were isolated lung worm parasites; whereas *E. coli* (20.6%), *Klebsiella Pneumoniae* (12.7%), *Mannheimia haemolytica* (10.8%), *Streptococcus species* (4.9%), *Staphylococcus aurous* (7.8%) and *Pasteurella multocida* (2.9%), *Pseudomonas* (6.9%), *Proteus* (1.9%) and *Cornybacterium* (1%) were the isolated bacteria. Moreover, 18 (4.3%) *Hydatid cysts* were identified by cyst viability test. The pulmonary disorder of sheep and goats in the study are relatively high prevalent and posing great health and economic impacts.

Conclusion Pulmonary infection with different agents is very common in the study areas. Feasible and affordable control measures and using latest diagnostic techniques like molecular detections of bacteria, viruses, and fungi, is necessary.

*Correspondence:
Jirata Shiferaw Abosse
jirata474@gmail.com
Full list of author information is available at the end of the article

Keywords Abattoir, Bacteria, Histopathology, Parasite, Pulmonary Lesion, Sheep and Goats

Introduction

Livestock is vital and taken as the subsistence to the economic growth of many developing countries (Mohammed et al. 2022). Animals are a source of food, more specifically protein for human diets, income and employment. Among the predominant livestock species, sheep and goats play an important role in the socio-economic development of the majority of African countries,currently supporting and sustaining the livelihoods of an estimated 80 percent of the rural community of Ethiopia (Engdawork 2019). Small ruminants provide more than 30% of the country's meat needs and earn money from exporting meat, primarily in the form of live animals and skins. They also produce wool, milk, manures for the land, and serve as an investment for farmers (Adem 2016, Abatemam et al. 2018).

Factors that affect herd health are of great importance, as they represent financial and public health risks. The occurrence of lung diseases in small ruminants can cause major losses, as it compromises the feed conversion rate, reduces fertility and can lead to deaths. Furthermore, after slaughter, the discovery of such infections can cause the loss of organs or even the entire carcass, generating great economic loss. Diseases affecting the respiratory system are generally the leading causes of morbidity and mortality in sheep and goat. In addition to mortality, respiratory infections limit growth rate, compromise animal well-being, and induce carcass condemnation (Mohammed et al. 2022; Mekibib et al. 2019). Lung is a vital organ of the body and susceptible and vulnerable to many infectious and non-infectious agents causing several pathological changes indicative for disease conditions. This is because of their anatomical and histological particularities through the inhalation from the environment and or from the blood (Mekibib et al. 2019, Belkhiri et al. 2009).

At meat inspection a large number of specific diseases and nonspecific conditions might be diagnosed in the lungs. Animals showing no clinical signs of diseases may be detected at slaughter and the true picture of these diseases and conditions could be documented and made available to the public (Jibat et al. 2008). According to the report of. (Benavides et al. 2015), the pathological alterations in the lung were observed in different histological types that ranged in severity from mild to severe, acute to chronic and exudative to proliferative interstitial. Depending on the causative agents, different circumstances might lead to varieties of lung lesions. Pneumonia of different type, hydatidosis, pulmonary calcification, abscess, pulmonary emphysema, tuberculosis, adhesions (pleurisy), atelectasis, fibrosis, pulmonary haemorrhage and congestion are the main pulmonary pathology of the sheep (Radostits et al. 2007, Tsegaye et al. 2016), (Thannon 2018).

According to the report of (Adem 2016) pneumonia and endoparasitism, particularly lung worms, account for around half of all sheep mortality and morbidity in Ethiopia's highlands. "Pneumonia, among the inflammatory and non-inflammatory disease conditions of the lung tissues found in sheep all over the world, is regarded one of the leading causes of death in the small ruminant". It is regarded one of the leading causes of death in the small ruminant (Mohammed et al. 2022). Hydatidosis is one of the most important parasitic diseases of ruminants responsible for huge economic losses due to reduction in carcass weight gain and condemnation of organs (Abegaz and Mohammed 2018). Hydatid disease, is caused by infection with the larval stage of *Echinococcus granulosus*, about 5 mm long tapeworm found in dogs as a definitive host and sheep, cattle, goats, and pigs as an intermediate hosts. The emphysema lesions on lung can be examined grossly by appreciating pale, enlarged greyish-yellow, pearl like shiny, puffy, and crepitate feel upon observation and palpation of the lung. Atelectasis is result of collapse of the alveoli due to failure of the alveoli to inflate or because of compression of the alveoli (Zeryehun and Alemu 2017).

Different studies were undertaken to determine the prevalence, gross pathological lesions and economic significance of pulmonary diseases of sheep and goat in Ethiopia. The authors involved in the studies pulmonary gross pathological lesion were, (Denebo and Tafere 2022, Mandefro et al. 2015), (Assefa et al. 2017, Mekibib et al. 2019) and (Mishra et al. 2018) who reported 62.5%, 37%, 29.18%, 17.13% and 15.9% respectively. (Zeryehun and Alemu 2017) reported results of the "lung lesions ranks first among the major causes of organ condemnation each year". Similarly, there is a sizable economic loss as a result of mortality, inadequate weight gain, and the condemnation of edible organs and corpses at slaughter (Jibat et al. 2008). Pulmonary abnormality have also a significant financial impact on animal husbandry from chemotherapeutic and vaccination (Mohammed et al. 2022). Tuberculosis, hydatidosis, and several of pneumonia related lung conditions are zoonotic and have serious public health implications (Jibat et al. 2008), which needs to understand and design a better control strategy. Although different studies are conducted in different areas of Ethiopia, the gross and histological characterization of the lung disease specifically in sheep and goat at Dessie municipal Abattoir has not yet been studied. This study was therefore, conducted to identify the causes with histopathological characterization of respiratory diseases through identification of bacterial and parasitic agent of sheep and goat slaughtered at abattoir in the study area. In addition the proposed objectives of determining the prevalence and frequency of different pathological lesion on the lung, characterize gross and histopathological lesion of the lung and identifying the bacterial and parasitic agents causing pneumonic lung of sheep and goat slaughtered at Dessie municipal abattoir of the Northern Ethiopia. The study results was design for providing data that point to the need for better management of the local herd, with the aim of reducing the high prevalence of pneumonia, hydatidosis and the identified lung parasites.

Materials and methods

Description of study areas

The study was conducted at Dessie municipal abattoir. Dessie is located about 401 km North East of Addis Ababa and located at latitude of 11°07′59.81¨N and a longitude of 39°37′59.83″E. It is the main town and the capital city of South Wollo zone. Its elevation is between 2400 and 2550 m above sea level. There are 11.7 °C and 24 °C of mean minimum and maximum temperatures every year, respectively (Fig. 1). The annual rainfall ranges 1100- 1200 mm and the area experiences a bi-modal rainfall patterns with a short rainy season which occurs from February to March and long rainy season which starts at the end of June to September DFEDB, (DFEDB. 2015).

Study animals

The study animals were sheep and goat brought for slaughter at Dessie municipal abattoirs. A total of 420 animals (302 sheep and 118 goats) were included in the study. Animals brought to the abattoir were originated from the Oromiya Special Zone, South Wollo, North Wollo and Afar regions. All the sheep and goats brought to the abattoir were males, indigenous breeds raised for meat production and managed under extensive production system either as part of a mixed crop–livestock production system or a pastoral production system. Sheep and goats were kept mixed with other livestock species

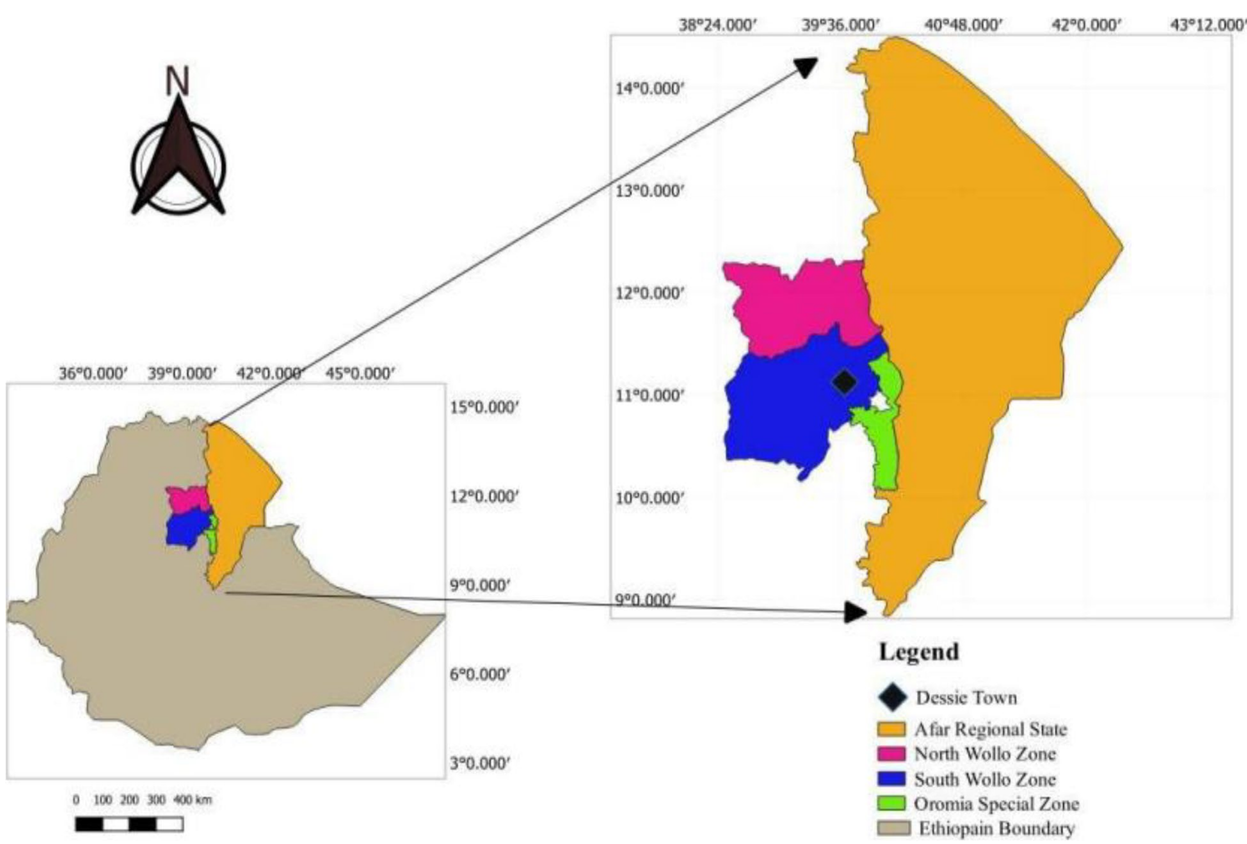

Fig. 1 Map of study area. Drawn by author

(cattle, camel, and donkeys) in communal grazing and watering areas.

Study design

A cross-sectional study design was conducted from December 2022 to May 2023 to estimate the prevalence of major gross pulmonary pathological lesions and to identify the associated bacterial and parasitic causes of pneumonia at Dessie municipal abattoirs.

Sample size determination and sampling methods

The total number of cattle required for this study was calculated based on the formula given by (Talukder 2007). By rule of thumb where there was no previous information regarding total pulmonary lesions in the study area 50% expected prevalence with 5% desired level of precision and 95% of confidence interval was considered.

$$N = (1.962 * Pexp(1 - Pexp))/d.2$$

Where; N = Sample size. Pexp = expected prevalence. d = desired absolute precision. By substituting these values in the formula, 384 sheep and goat were included. But 420 sheep and goat were selected to increase the precision of the estimated prevalence of the lesions.

A simple random sampling method was implemented to collect the required sample for major pathological lesion characterization. The sample from pneumonic lesion was emphasized for isolation and identification of bacteria and parasite. Regular visits were made to the abattoir four days per week. Species, age and body condition score (BCS) of the study animals were meticulously recorded and considered as variable of interest. The body condition score of animals were grouped according to. (Yami et al. 2008). Then, animals were grouped into medium (score 2 and 3) and good (score 4 and 5). In addition estimation of age was carried out by definition according to (Getenby 1996), subsequently, animals were grouped to < 1 years, 1–3 years and > 3 years age group. Sheep and goat lungs with noticeable lesions were grossly inspected and were purposefully chosen for detailed histopathological investigation and pneumonic lesions were subjected to bacteriological and parasitological analysis.

Sample collection, transportation and storage

A representative sample of lung tissues for each lesion types, including the active portion of the lesions and some of its surrounding, seemingly normal tissue were cut into pieces of 2–3 cm in size and placed in a bottle containing 10% Neutral Buffered Formalin (NBF). Then, NBF was replace and sample was stored at room temperature until process. Consequently, sample was transported to Animal Health Institute (AHI), Sebeta for histopathological investigation. Lung tissues exhibiting pneumonic lesion were aseptically collected, and then transported on cold chain to Wollo University School of Veterinary Medicine Microbiology Laboratory for bacterial isolation. For parasitological investigation, the lung was dissected for viewing and collection of adult parasite. Furthermore, the bronchi and bronchioles were checked, and careful gross examination of the whole lung was performed to check parasitic nodules. Visible worms were removed from the dissected lungs and small cut of parasitic nodules was transferred to universal bottle containing 70% alcohol. Then, collected samples were transported to Wollo University School of Veterinary Medicine Parasitology Laboratory. All samples were labeled based on species, age, body condition and date of sampling with permanent marker.

Gross pathological examination

Gross pathological examinations on lung were conducted by visualization, palpation, incisions, and dissection of bronchial tree. Accordingly, the presence of cyst or parasites, emphysema, pneumonia, atelectasis, and congestion were examined, following the standards for meat inspection and routine gross pathological examination guidelines (FAO, Food and Agriculture Organization. Manual on meat inspection for developing Countries. Animal and health production papers Food and Agriculture organization of the United Nations 2007). The lungs were inspected for changes in color, texture, distribution, consistency and the lesion types with their gross appearance recorded carefully.

Histopathological examination

The collected lung tissue sample processing and subjecting to histopathological evaluation were done according to the procedure described by (Talukder 2007). The samples were trimmed, fixed, dehydrated with ascending graded alcohol and cleared with xylene. The samples then impregnated with molten paraffin wax, sectioned at 5 μm thickness using the microtome, spread on warm water and attaching the tissue to microscopic glass slide. The slides were incubated at 60 °C to molten paraffin wax. The sectioned tissue were deparaffinized in three changes of xylene, rehydrated in the descending graded alcohol and stained with Hematoxylin and Eosin (H and E). Stained slides were mounted by Distrene plasticizer/

Dibutyl phthalate xylene (DPX) and finally examined under microscope.

Parasitological examination and identification

Lung worm

The recovered parasites were kept in 70% alcohol and were transferred on to petridish and were examined under the stereomicroscope. The nodule formed by parasite were trimmed off and worms extracted from the tissue by gentle pressing of a small non-calcified nodule or part of large nodule compressed between two glass slides or scrap by blunt object. Then the nodules incised, carefully teasing the worm out of the tissue, and examined under light microscope. Identification processes were made according to morphological and morphometric characteristics of parasites (Chilton et al. 2006).

Hydatid cyst

The lungs were examined for degeneration, and calcification grossly. The collected cysts were carefully incised by scalpel and scissors, and the contents were transferred into a sterile container. Then, the smear prepared from suspension was examined microscopically for the presence of protoscolices, in Hydatid fluid so as to classify cysts as fertile or infertile. Cysts which contained no protoscolices as well as heavily suppurative or calcified ones were considered unfertile. Fertile cysts (fluid filled cyst with protoscolices) were also further subjected for viability test and classified as dead or alive. The viability of protoscolices was assessed by morphology, motility and presence of flame cells activity like peristaltic movement and when necessary, a drop of 0.1% aqueous Eosin solution was added, and examined under a light microscope (living protoscolices did not take the dye, while dead one did). Then characteristics cystic fluid was microscopically examined (Abegaz and Mohammed 2018).

Bacterial isolation and identification

Lung samples were aseptically collected and placed in sterile plastic bags within an ice box and were submitted to Wollo University Microbiological laboratory. The external surface of the pneumonic lungs was first seared with a heated spatula followed by cutting and mincing of the inner surface of the lungs using sterile scissors and forceps. The cut inner surface of the lungs, if there were any supportive fluid, were taken by sterile swab and then inoculated into the tryptone soya broth, incubated at 37 °C for 24 h and growth were evaluated by turbidity. Loopful of the broth culture was taken by agitating cultured broth sample wisely to aid mixing and streaked over an identified Petridish containing blood agar base supplemented with 5% sterile sheep blood and immediately incubated aerobically at 37°C for 24 h. Typical suspected colonies from the culture were subjected to Gram's staining to study staining reactions and cellular morphology under light microscope. Gram-negative, coccobacilli bacteria were again sub cultured with due care, on both blood and MacConkey agar plates and Gram-positive bacteria colony sub cultured to blood agar and manitol salt agar at 37 °C for 24–48 h to get pure cultures for further analysis. The pure cultures of single colony type from pure cultures on blood agar were transferred to nutrient agar for a series of primary and secondary biochemical tests. Primary tests such as Grams staining, motility, catalase, and secondary test, Indole, methyl red, MR-VP test, TSI, citrate utilization tests and urease tests were conducted. General procedures for isolation and identification of Gram positive and Gram negative aerobic bacteria were performed as described by. (Quinn et al. 2011). All bacteriological procedures were conducted in a level two biological safety cabinet.

Data management and analysis

Prevalence of lung lesion was calculated as a percentage of the population screened (Thrusfield 2005). The data was entered, coded and scored in Microsoft Excel worksheet (Microsoft Corporation) and STATA version 14 was used for descriptive analysis of frequency and percentages of obtained results. The significant of difference of prevalence between different age groups, species and body conditions was determined using χ^2 test. The differences were regarded significant if p-value is < 0.05. Data obtained were summarized as gross, histopathological lesions and bacterial and parasitic agents observed were presented as tables showing frequencies of isolation.

Ethical clearance

The study considered direct observation of slaughter animals in the abattoir and took appropriate samples for further laboratory experiments and there are no procedures in the study that suffers animals/against animal welfare. Ethical approval was conducted by research ethical approval committee, with reference number "VM/ERC/03/19/03/15/2023", of Addis Ababa University, College of Veterinary Medicine and Agriculture, Bishoftu, Ethiopia.

Results

Prevalence of pulmonary lesions

In present investigation 420 (319 sheep and 101 goat) were observed and examined. The overall abattoir prevalence of pulmonary lesion in sheep and goat was 78.1% (328/420). Pulmonary lesions were studied in relation to the species, age and body condition of animals. From

319 sheep and 101 examined goats, 83.1% (265/319) sheep and 62.4% (63/319) goats were having gross lesion respectively.

Although different lesions sometimes sat on the same lung only dominant lesions has been considered. In the current study nine different types of pulmonary lesions were observed based on gross characteristics and lobular distribution; pneumonia 55.5% (233/420), hydatidosis 4.3% (18/420), Emphysema 7.1% (30/420), pulmonary atelectasis 3.33% (14/420), pulmonary congestion 2.83% (10/420), Pulmonary hemorrhage 3.1% (13/420), Bronchoectasis 0.71% (3/420), Anthracosis 0.95% (4/420) and Adhesion 0.71% (3). Different lung lesions were studied in relation to the species, age and body condition of animals.

Pneumonia were the only statically significant ($p < 0.05$) different pulmonary lesion with the species of animals. However, the other lesion were not associated with the species of the animals. Pneumonia, hydatidosis, and pulmonary emphysema were significantly different ($p < 0.05$) between animal age groups, however they were not significantly ($p > 0.05$) related to the animals' body condition. Species, age, and body condition of the animals, were not significantly ($p > 0.05$) associated with pulmonary congestion, pulmonary haemorrhage, Bronchoectasis, adhesion, and Anthracosis (Tables 1, 2 and 3). Pneumonia, hydatidosis, pulmonary congestion and pulmonary hemorrhage were statically significant association with the lobular distribution of the lesion (Table 4).

Table 1 Prevalence and percent of different gross pathological lesions in the lungs of sheep and goat examined at Dessie municipal abattoir

Gross lesion	Total examined ($n = 420$) and prevalence	Ovine ($n = 319$) and prevalence	Caprine ($n = 101$) and prevalence	χ^2	*p*-value
Pneumonia	233(55.5)	191(59.9)	42(41.6)	10.39	0.011
Hydatid cyst	18 (4.29)	15(4.7)	3(3)	0.57	0.45
Emphysema	30 (7.14)	24(7.5)	6(5.9)	0.29	0.59
Atelectasis	14 (3.33)	9(2.9)	5(5.1)	1.08	0.23
Congestion	10 (2.38)	7(2.2)	3(3)	0.20	0.66
Hemorrhage	13 (3.1)	10(3.1)	3(3)	0.07	0.94
Bronchoectasis	3 (0.71)	3(0.9)	0	1.18	0.27
Anthracosis	4 (0.95)	3(0.9)	1(1)	0.03	0.97
Adhesion	3 (0.71)	3(0.9)	0	0.96	0.33
Total	**328(78.1)**	**265(83.1)**	**63(62.4)**		

χ^2 = Chi-square

Table 2 Prevalence of gross pathological lesions in the lungs of sheep and goat with their perspective body condition examined at Dessie abattoir

Lung lesions	Body condition				χ^2	*p*-value
	Good ($n = 232$)		Moderate($n = 188$)			
	Frequency	Prevalence (%)	Frequency	Prevalence (%)		
Pneumonia	118	50.8	115	61.2	4.47	0.04
Hydatid cyst	14	6	4	2.1	3.34	0.06
Emphysema	16	6.9	14	7.4	0.16	0.68
Atelectasis	10	4.3	4	2.1	1.24	0.2
Congestion	4	1.7	6	3.2	1.19	0.27
Hemorrhage	7	3	6	3.2	0.05	0.82
Bronchoectasis	2	0.8	1	0.5	0.117	0.73
Anthracosis	3	1.3	1	0.5	0.12	0.73
Adhesion	2	0.8	1	0.5	0.54	0.55
Total	**176**	**75.8**	**152**	**80.8**		

χ^2 = Chi-square

Table 3 prevalence of different gross pathological lesions in the lungs of sheep and goat with their perspective age examined at Dessie abattoir

Lesions	< 1 years (*n* = 82)		1-3 years (*n* = 142)		> 3 years (*n* = 196)		χ^2	*p*-value
	Frequency	Prevalence (%)	Frequency	Prevalence (%)	Frequency	Prevalence (%)		
Pneumonia	39	47.5	96	65.6	98	50	8.49	0.01
Hydatid cyst	0	0	10	8.9	8	4.1	6.32	0.04
Emphysema	13	15.8	8	5.6	9	4.6	11.7	0.03
Atelectasis	4	4.9	7	4.9	3	1.5	3.70	0.16
Congestion	2	2.4	4	2.8	4	2	0.24	0.89
Hemorrhage	4	4.8	6	4.2	3	1.5		
Bronchoectasis	0	0	0	0	3	1.5	3.45	0.18
Adhesion	0	0	1	0.7	2	1	1.66	0.43
Anthracosis	0	0	1	0.7	3	15	1.57	0.45
Total	**62**	**75.6**	**133**	**93.7**	**133**	**67.8**		

χ^2 = Chi-square

Table 4 Frequency of different type of pneumonia based on gross characteristics

Type of pneumonia	Number	Proportion (%)
Bronchopneumonia	61	26.2
Interstitial pneumonia	21	9
Aspirational pneumonia	11	4.7
Granulomatous pneumonia	6	2.6
Verminous pneumonia	134	57.7
Total	**233**	**100**

Gross and microscopic pathological characterization of pulmonary lesions

Pneumonia

Pneumonia was the most prevalent pulmonary lesion in the present study. Based on macroscopic characteristics including distribution, texture, color, and appearance of the affected lungs, five different forms of pneumonic lesions were identified, including bronchopneumonia, aspiration pneumonia, interstitial pneumonia, granulomatous pneumonia, and verminous pneumonia. Verminous pneumonia were most frequent (57.5% (134/233)), followed by broncho-pneumonia (26.2% (61/233)). Suppurative broncho-pneumonia, fibrinous broncho-pneumonia, interstitial pneumonia, acute interstitial pnueumonia, broncho-interstitial pneumonia, hemorrhagic interstitial pneumonia, and granulomatous pneumonia were the additional classifications made on the basis of histopathological findings for the pneumonic lesions.

Broncho pneumonia

26.2% (61/233) cases from total pneumonic lesions, were found to have broncho pneumonia, which was accompanied by neutrophilic exudates, cell debris, neutrophils, and macrophages in the alveolar spaces and lumens of the bronchioles and bronchi. In bronchopneumonia the cranioventral portion of the lungs are mainly affected. Based on its gross and histological features, it was categorized as either suppurative or fibrinous.

Suppurative bronchopneumonia

16.7% (39/233) cases from total pneumonic lesion and 63.9% (149/233) of bronchopneumonia were found to have suppurative bronchopneumonia. The lesions were red-brown to purple-grey and had a firm, meaty consistency and mainly involved the cranial lobes and distributed to the cranioventral aspects of the both right and left lungs, especially involving the right lung. The cut surface of the consolidated lobules was moist and purulent exudates leaked from bronchi and bronchioles (Fig. 2a) and in some cases, the exudates (Fig. 2c) were mucus and foamy exudates in bronchi and bronchioles (Fig. 2b). Microscopically, heavy and severe neutrophilic infiltrations were present into the bronchus, bronchiole, alveoli and alveolar spaces (Fig. 2d). In most case, the inflammatory process confined to the individual lobules and normal alveoli were seen adjacent to the alveoli filled with neutrophilic exudates. In few case presence heavy peribronchial lymphoid hyperplasia and the center of the nodule were less cellular or necrosis of central lymphocyte (Fig. 2e).

Fibrinous bronchopneumonia

Fibrinous bronchopneumonia was examined from 22 pneumonic lungs with the prevalence of 9.4% (22/2330. The lesions were mainly in the cranial lobes, especially the right lung, and included congestion, oedema and fibrin accumulation in addition to condensation. A thin

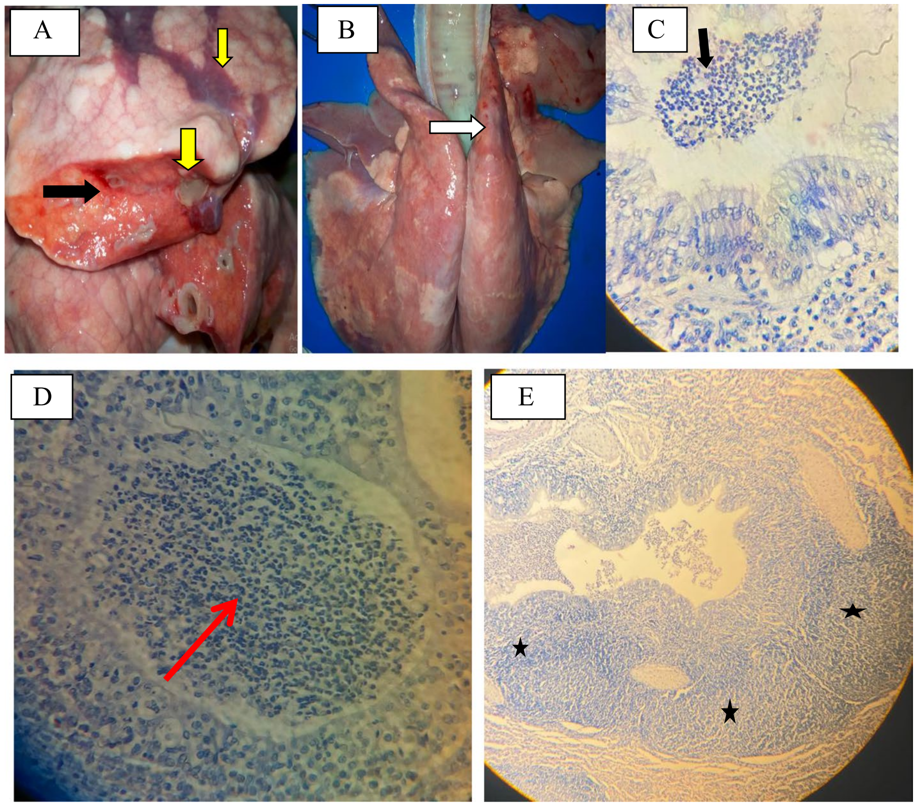

Fig. 2 Gross and Microscopic picture of suppurative broncho pneumonia sheep lung. **A** Edematous (yellow arrow) to grayish fluid (black arrow) from cut surface of right apical lobe, *Pasturella multocida* were isolated. **B** Consolidated area on both cranial lobe and foamy fluid from bronchi (whate arrow), *Pseudomonas* and *Staphylococcus aureus* were isolated. **C** Acute suppurative bronchopneumonia, exudates plugged in the bronchioles dominated by neutrophil (black arrow) **D** Excess neutrophilic infiltration (red arrow) within the bronchioles. **E** Chronic suppurative bronchopneumonia with peribronchial lymphoid hyperplasia (asterisks)

layer of fibrin usually covered the pleural surface accompanied with notable marbled appearance of the affected lung parenchyma (Fig. 3a and b). Microscopically, there was infiltration of neutrophils and fibrin in the lumen of bronchioles and alveoli, and alveolar necrosis in few cases (Fig. 3c).

Broncho-interstitial pneumonia

The lesions were not remarkable on gross examination. Microscopically, the characteristic features of both suppurative bronchopneumonia and interstitial pneumonia were found admixed (Fig. 4). Infiltration of inflammatory cell in the alveoli lumen and bronchiole (Fig. 4a). Peribronchiolar lymphoid hyperplasia with formation of prominent well-defined lymphoid nodules and excessive plasma cell growth (Fig. 4b).

Interstitial pneumonia

Grossly, the lungs were enlarged than normal, had a rubbery substance, looked meaty, and did not collapse when pressed (Fig. 5a). The lungs appeared more "meaty" when cut. On the pleural surface of the diaphragmatic lobes, rib imprints in caudal lobe were detected (Fig. 5a). Consistently, the mediastinal lymph nodes were enlarged (Fig. 5b and c). Mostly lesions distributed throughout lungs and not restricted only in cranial or caudal lobe. Microscopically, they were characterized by lymphocytic infiltration in the inter-alveolar septa or interstitial tissue and macrophages within the alveolar lumina. The alveolar spaces and airways lacked exudates (Fig. 5d and e). Alveolar and bronchial epithelial hyperplasias were seen. Numerous cases of interstitial pneumonia were found to have peribronchial and peribronchiolar lymphocyte proliferation, excessive plasma cell growth, and significant alveolar tissue necrosis (Fig. 5f).

Hemorrhagic interstitial pneumonia

Grossly, remarkably red area was seen in the affected lungs. Leukocytic infiltration and RBC were observed in the alveoli and inter-alveolar septa (Fig. 6a and b).

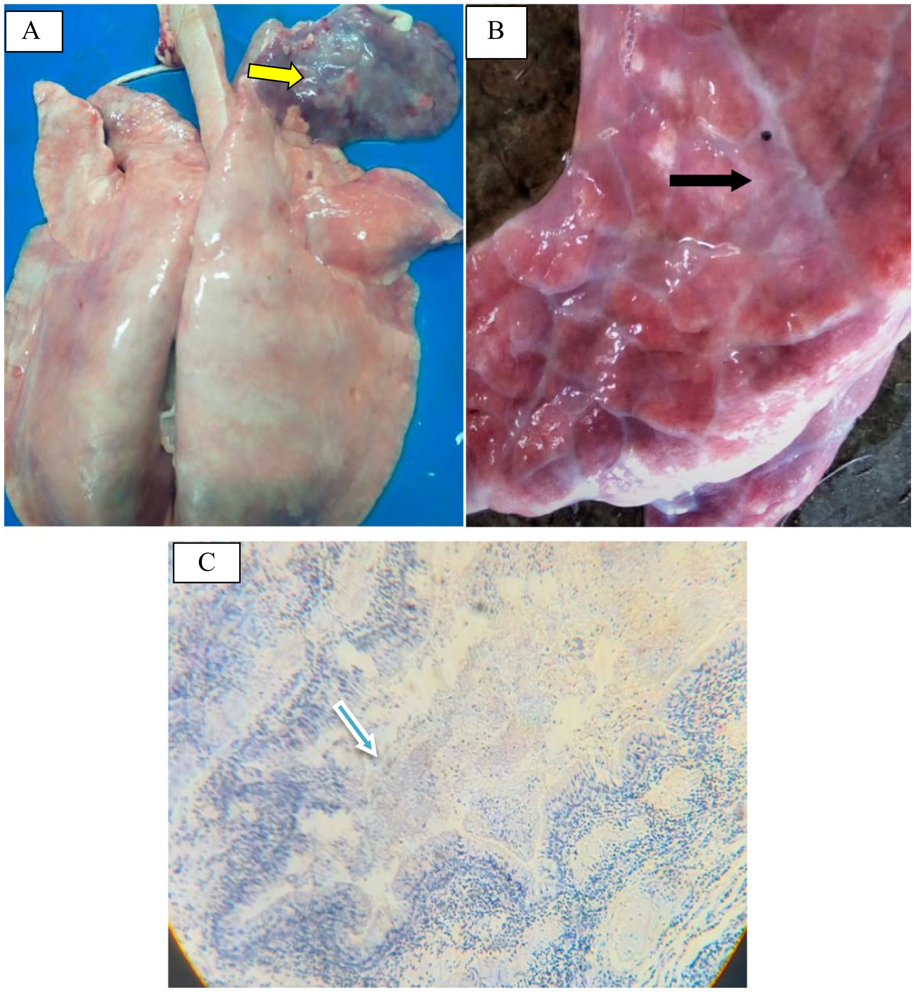

Fig. 3 Gross and Microscopic picture of fibrinous bronchopneumonia. **A** Consolidation of right cranial lobe with fibrin on the plural surface (yellow arrow); *M. haemolytica* were isolated. **B** Marbling appearance (black arrow) of cranial lobe of sheep. **C** Infiltration of neutrophils and fibrin in the lumen (blue arow) of bronchioles and alveoli, and alveolar necrosis

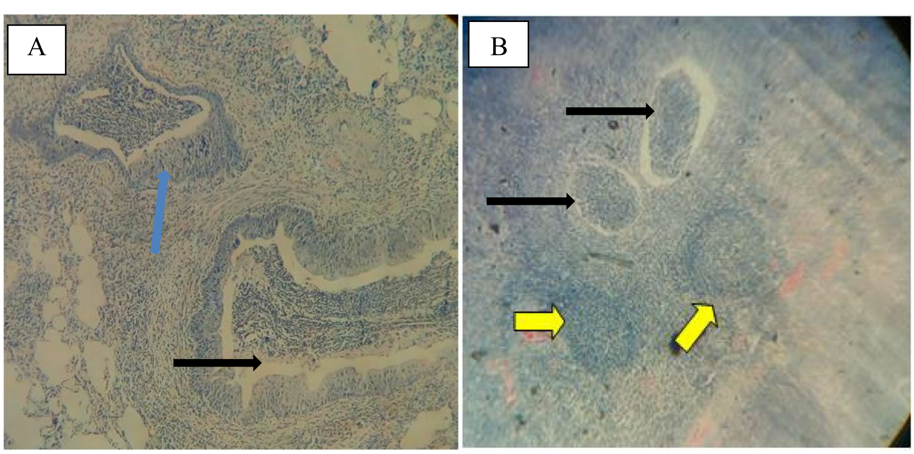

Fig. 4 Microscopic picture of broncho-interstitial pneumonia. **A** Thickening of intra alveolar septa (blue arrow) with prominent exudates in the alveoli and bronchiole (black arrow). **B** Infiltration of inflammatory cell in bronchiolar lumen and intestitium (black arrow), with granule formation (yellow arrows)

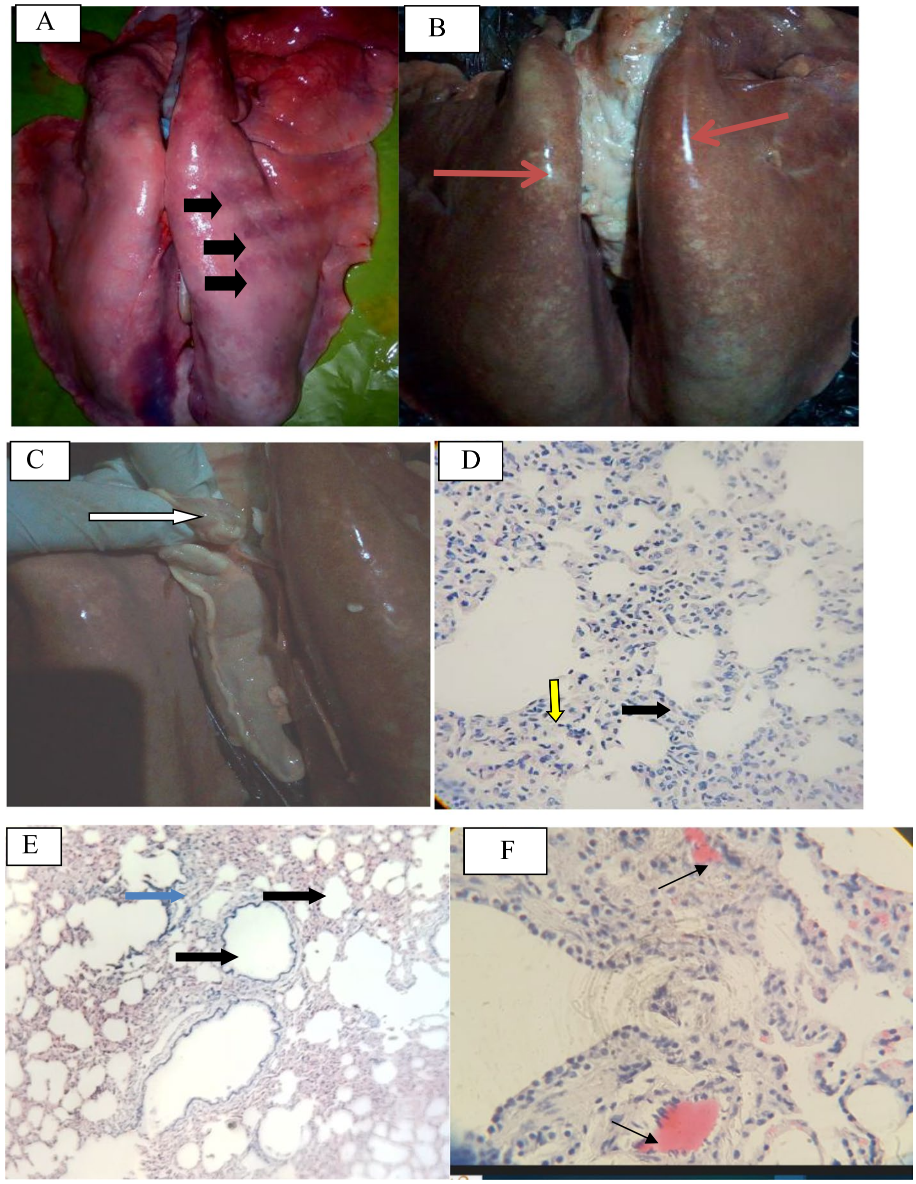

Fig. 5 Gross and Microscopic picture of interstitial pneumonia (gross and microscopic). **A** Ribs imprint (black arrows). **B** Enlarged, ruby, meaty appearance (red arrows), *E. coli* were isolated. **C** Enlarged Mediastinal lymph nodes (white arrow). **D** Thickening of inter-alvelar septa (black arrow), mononuclear infiltration in the interstisium (yellow arrow). **E** Thickening of inter-alvelar septa (blue arrow), no exudates on bronchioles (black arrows). **F** Thick inter-alvelar septa and engorged blood vessels with red blood cell (black arrows)

Granulomatous pneumonia

Granulomatous pneumonia was characterized by formation of nodules which were diffusely or a multifocal distribution on the pleural surface (Fig. 7a). Microscopically, the granulomatous pneumonia was recognized by the presence of cellular granulomatous rim zone of layers consists of various inflammatory cells and few fibrosis in outer layer which were surrounding the central caseous necrotic area. Multifocal and locally extensive large granulomatous inflammatory lesions were observed. The centers of granuloma were made up of dead lymphocyte with nuclear rhexis (Fig. 7b &c). There were also swollen and lack nucleus vacuolated cytoplasm found when distant increase from the center (Fig. 7d).

Aspirational pneumonia

Blood plaque was scattered in sheep lung with aspirated blood with no presence of inflammatory signs (Fig. 8a). The affected portions of the lungs were

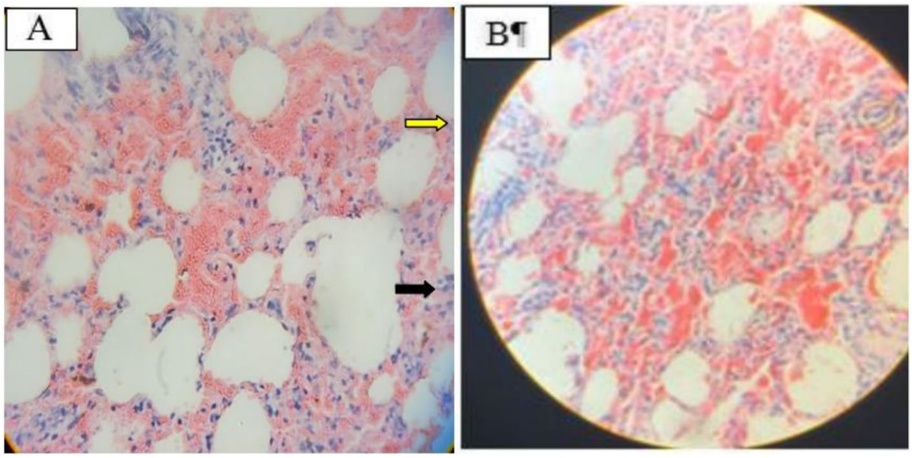

Fig. 6 Microscopic picture of hemorrhagic interstitial pneumonia in sheep lung. **A** Large number of RBC was seen in alveoli and inter-alveolar septa (black arrow), leukocytic infiltration (yellow arrow) and **B** thickening of interlobular septa

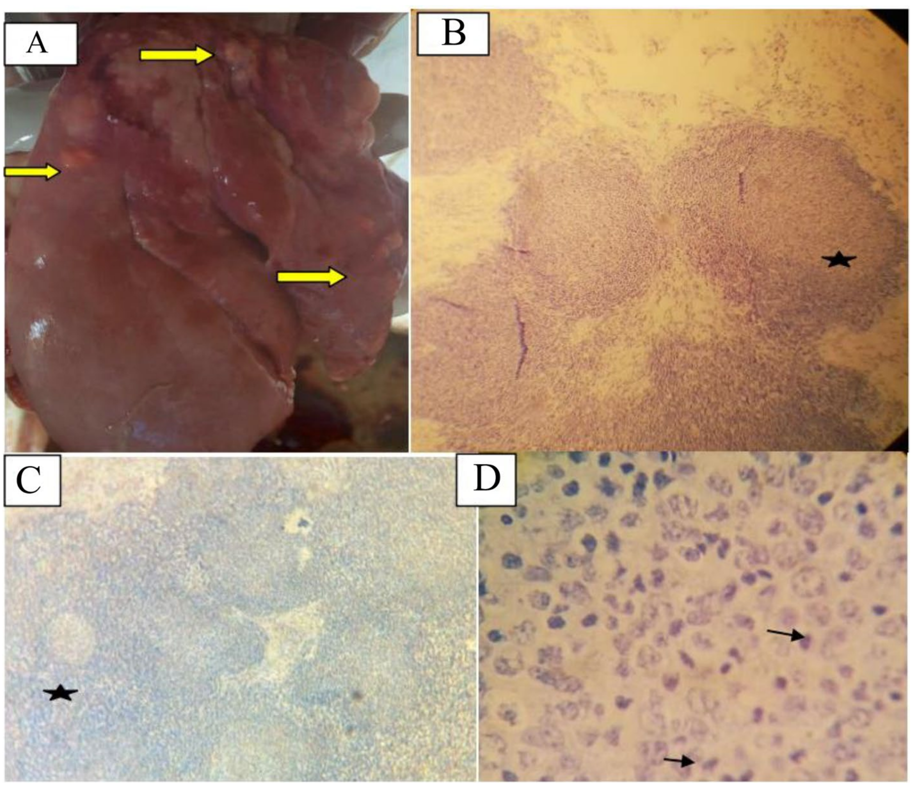

Fig. 7 Gross and Microscopic picture of granulomatous pneumonia in sheep lung. **A** Multifocal, variable sized nodules diffusely disseminated on the surface of lungs. Granulomatous involves most of the lung lobe (yellow arrow). **B** and **C** Granulomatous reaction consists of central area of necrosis (asterisks) surrounded by inflammatory cells and fibrous connective tissue. **D** Swollen and vacuolated cytoplasm cells with no nucleus (black arrows)

congested and somewhat meaty in consistency. Upon incisions the aspirated food material of rumen content was inside bronchi (Fig. 8b).

Verminous pneumonia

The lungs with parasitic pneumonic lesion may reveal raised emphysematous patches, depressed consolidated areas, and

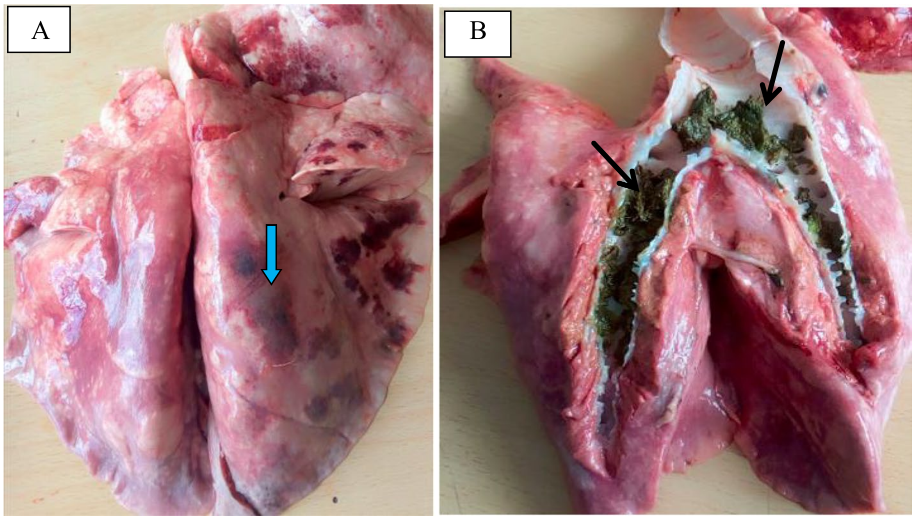

Fig. 8 Gross and microscopic picture of aspirational pneumonia in sheep lung. **A** Aspirated blood plaque scattered on right lung particularly caudal lobe (blue arrow). **B** Aspirated food material of rumen content inside bronchi (black arrows), consolidation of parenchyma sheep lung

dirty white to irregular nodular lesions dispersed throughout the various lobes, particularly in the caudal lobe. There was lots of foamy froth that was blood-tinged that contained several slender, creamy white worms as well as groups of worms that were seen in the terminal bronchioles of the diaphragmatic lobes (Fig. 9a). *Protostrongylus rufescens* infected bronchioles frequently have worms and exudates covering them (Fig. 9b). The diaphragmatic lobes of infected lungs with *Mullerius capillaries* feature red, grey, or green nodules that vary in size and consistency. In some instances, they did not develop into nodules and instead appeared as hard, grey to black patches that covered a significant portion of the lung surfaces. Verminous pneumonia was normally distributed mostly on the dorsal part of the caudal lobes of the lungs, with the disease occasionally extending onto the dorsal half of the cranial lobe (Fig. 9c).

Microscopically, cross section of a lung worm in the lumen of a bronchus, rupture of the alveolar walls, infiltration of neutrophils, macrophages, and giant cells, as well as eosinophils- the most noticeable inflammatory cell (Fig. 9d). Around the adult worms, eggs, and larvae of the parasites, particular alterations in the lung parenchyma and interstitium are demonstrated to progress. Multifocal granule with cross section of parasite cuticle at the center and inflammatory cell forming the next layer, presence of lymphocyte, plasma cell and giant cell (Fig. 9e). Peribronchiolar lymphoid hyperplasia was observed (Fig. 9f and g).

Hydatidosis

The lungs revealed single to multiple Hydatid cysts of varying sizes. These cysts were either confined mainly tp diaphragmatic lobe or to all over the lobes of the lung. The cysts were soft to touch and filled with clear translucent to slightly turbid fluid contents (Fig. 10a). However, some cysts were appearing firm and contained inspissated contents (Fig. 10c) and some were calcified, gritty and hard to cut. The cysts were either fully embedded in the lung parenchyma (Fig. 10b) or were partially embedded when they were visible from the lung surface. On aspiration of fluid, the cyst collapsed (Fig. 10a double arrow) and the cyst membrane, appearing creamy white, could be easily removed from the organ and its fluid contents were found clear to slightly turbid or semi-solid material (Fig. 10b).

Emphysema

The emphysematous lungs were large, dry, pale in colour, pearl-like shiny lesions with puffy and crepitate feel upon palpation and easily compressed by finger (Fig. 11a). Sharply defined foci of pale and enlarged emphysematous areas involving one or more lobes of the lungs were observed, and they appeared to be slightly projecting from the surrounding areas (Fig. 11b). The texture of these lungs was notably crepitus due to the accumulation of air in the pulmonary parenchyma. Microscopically, sections of lung revealed distended alveoli, ruptured inter-alveolar septa forming giant alveoli or bullae and the alveolar wall atrophic and very thin (Fig. 11c and d).

Atelectasis

Lungs were homogeneously dark-red and depressed below the surface with firm texture in one or more lobes of the lungs, and the texture was fleshy or firmer and non-spongy

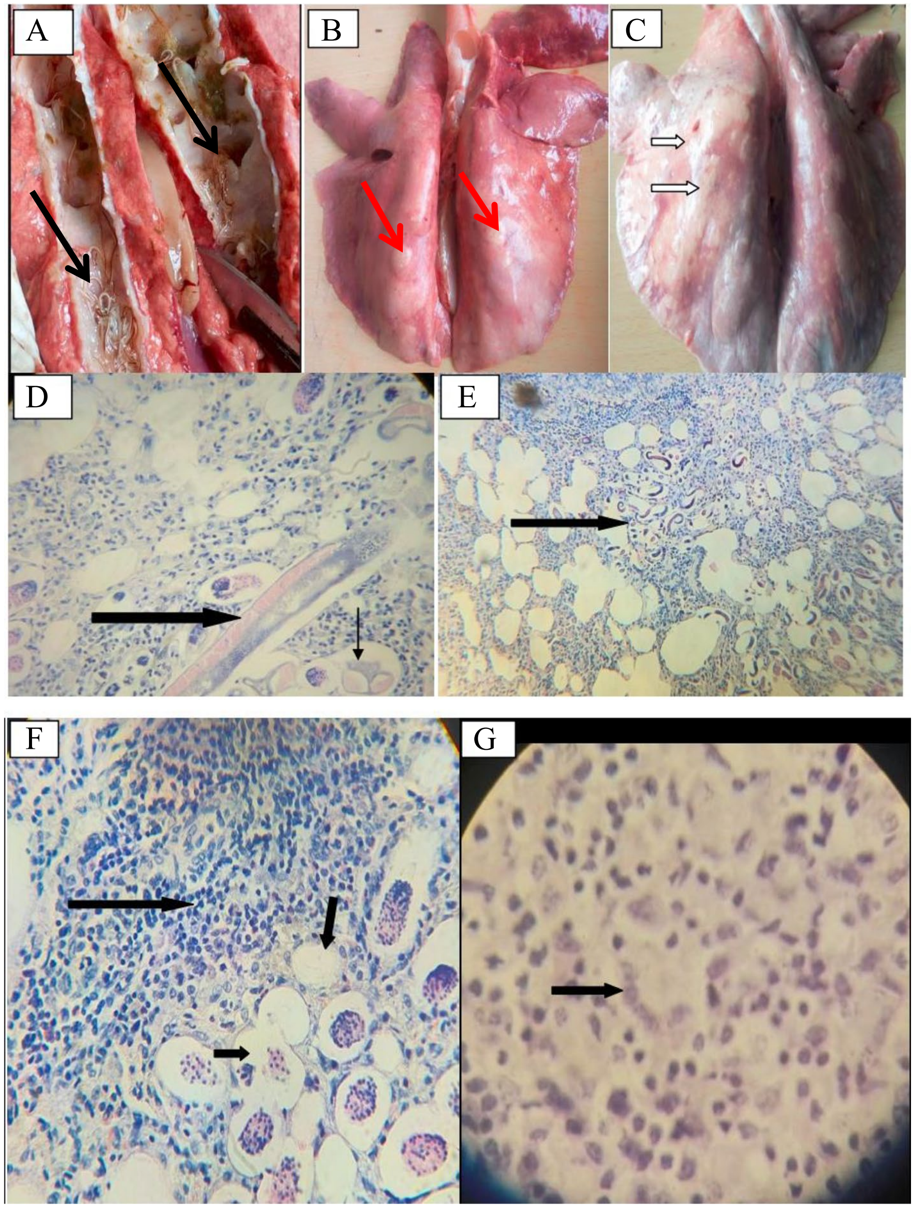

Fig. 9 Gross and Microscopic picture of verminous pneumonia. Verminous pneumonia of sheep lung with nodule and *Protostrongylus rufescens* isolated. **A** Mixed infection of adult *Dictyocaulus filaria* and *Protostrongylus rufescens* discovered on bronchi and bronchioles (black arrows). **B** *Protostrongylus rufescence* nodules on both right and left caudal lobe of lung parenchyma (red arrows). **C** Grayish nodule of *Mulerius capillaries*, consolidated and emphysematous patches area on surface of caudal lobe (white arrows). **D** Eggs and larvae in various stages of development (thin arrow) and cut section of adult parasite (thick arrows). **E** More prominent are the nodular accumulations of larva (black arrow), accompanied by lymphocytic or granulomatous inflammation. **F** Infiltration of mononuclear cells and eosinophils (large arrow) with presence of parasite egg in the dilated alveolar lumen (small arrow) and thinking of interalveolar septa. **G** Inflammatory cell including giant cell (arrow)

(Fig. 12). The cut sank into the water after the cut surface showed a smooth, dry surface. Microscopically, atelectasis areas revealed collapsed alveoli with the narrow lumen-alveolar walls appear parallel and close together and with emphysematous foci in the adjacent areas (Fig. 12).

Pulmonary Congestion

Pulmonary congestion was distributed into all lobes of the lung and in animals with good body condition. Microscopically, blood vessels were engorged and filled with blood (Fig. 13).

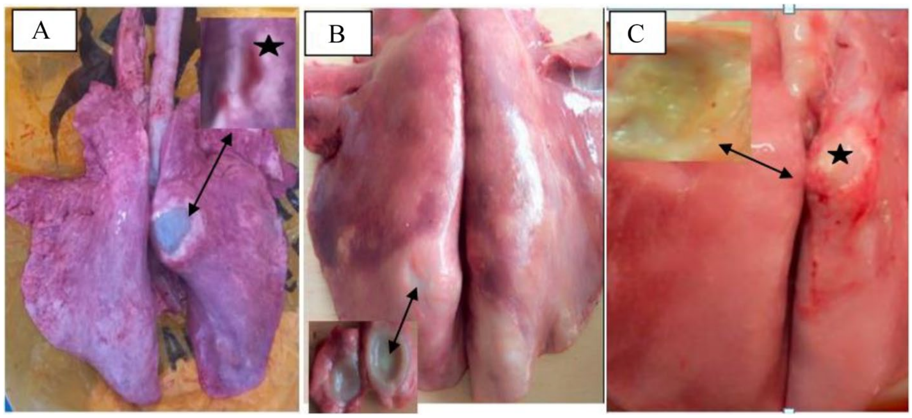

Fig. 10 Gross and Microscopic picture cyst from of sheep and goat lung. **A** Fertile cyst with fine fluid (double headed arrow) in goat lung, after fluid removed (*). **B** Fully embedded sterile cyst in both right and left caudal lobe of sheep lung with semi solid fluid (double headed arrow). **C** Calcified cyst in left lung of goat lung (*)

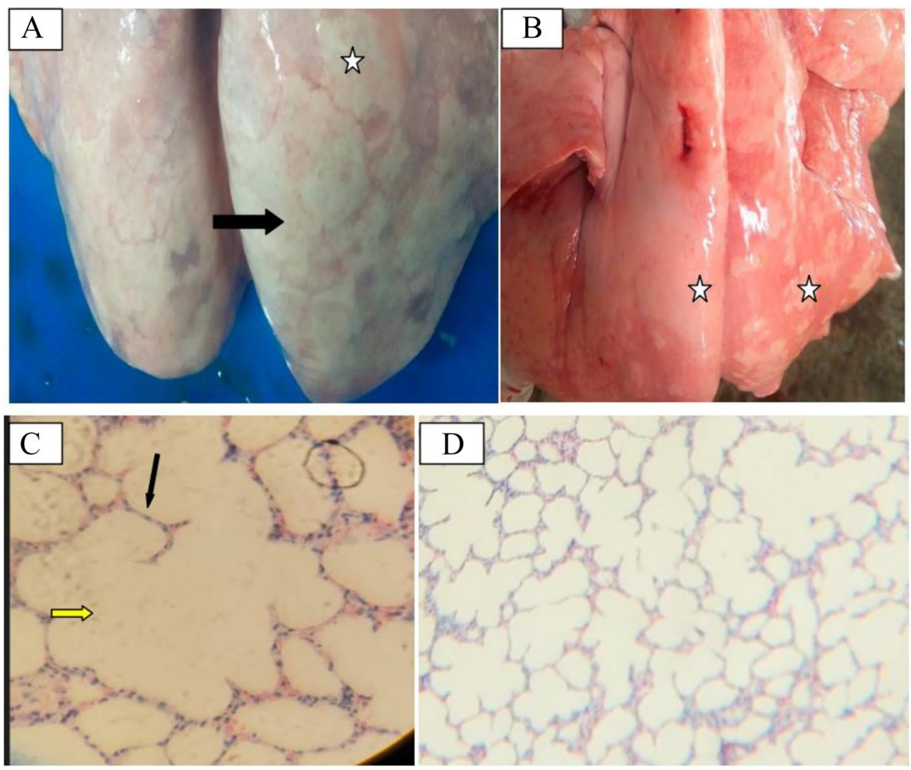

Fig. 11 Gross and Microscopic picture of emphysematous in sheep lung. **A**. grossly enlarged emphysematous lung (black arrow and white asterisk). **B** Grossly multifocal emphysematous area on lung (asterisks). **C** Enlarged alveoli space (yellow arrow), accompanied by destruction of alveolar walls (black arrow). **D** Emphysematous lung at low magnification

Pulmonary Hemorrhage

The lungs showed dark red patches on the plural surfaces (Fig. 14). Microscopically, the presences of a large number of RBC out of the blood vessels were prominent. When seen under a microscope, it was clear that there were several RBCs present outside of the blood arteries. Additionally, transudate was abundant in the alveolar lumen, giving it reddish to pinkish color.

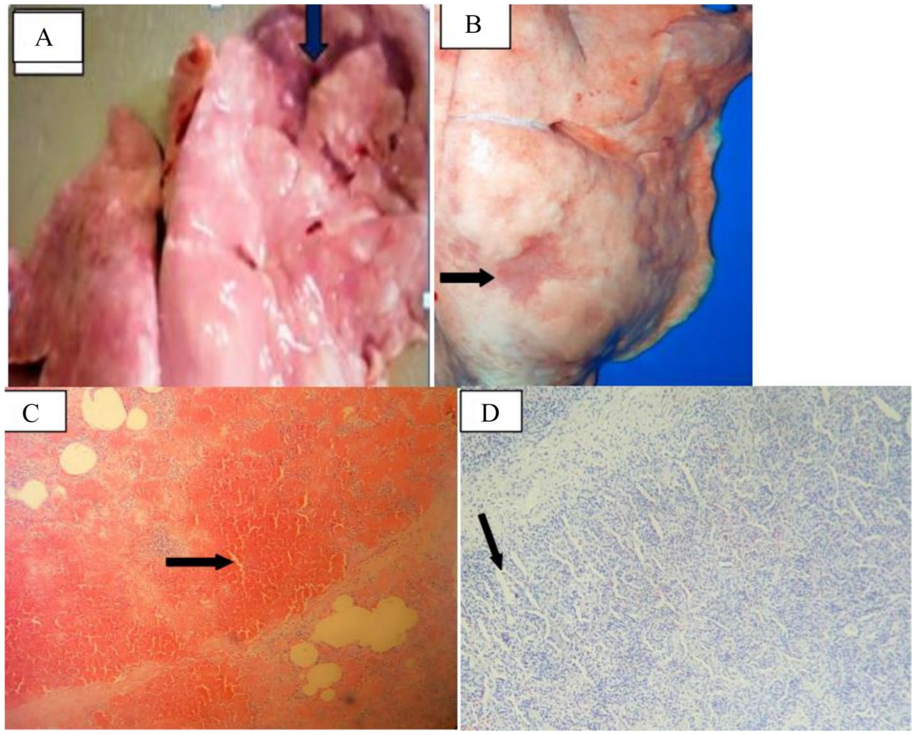

Fig. 12 Gross and Microscopic picture of atelectasis in goat lung. **A** Depressed area in the apical lobe. **B** Depressed area in the caudal lobe. **C**) Congested alveolar wall lying in close apposition with slit like residual Lumina and having sharp angular ends. **D**) Massive infiltration of inflammatory cell in the interstitial and alveolar walls closes apposition and appears parallel

Adhesion (pleuritis)

The pleura were inflamed, and fibrinous adhesions of the lung surface with parietal pleura which lining coastal or diaphragm (Fig. 15).

Anthracosis

Grossly, the lungs were usually speckled with fine sub pleural black foci. Microscopically, fine black carbon granules were observed within the lung parenchyma and alveoli (Fig. 16). The lobular distribution of different polmunary lesions are depicted in Table 5.

Parasite Identification and Examination

Lung worm identification and examination

The three lung worms (*Dictyocaulus filarial, Protostrongylus rufescens*, and *Mullerius capillary*) were detected in verminous pneumonia**.** Out of 135 positive lung worm infection during postmortem examination, *Dictyocaulus filarial* 48.1% (65/135) is the most predominant lungworm species, followed by *Mulleries capillaries* 23% (31/135) and *Protostrongylus refescens* 17% (23/135) is the least frequent and co-infection 11.85% (16/135) (Fig. 17), were either with two or more different parasites together (Table 6).

The occurrence of verminous pneumonia in both species was statistically significant difference ($P < 0.05$) with 25.24% in sheep and 6.67% in goat and there were highly associate ($p < 0.005$) with age group (1–3 years) and age > 3 years were high occurrence than age group < 1 years. Lungworm infections were assessed in relation to body condition, and it was shown that infection was not significantly associated ($p > 0.05$).

There were significant association ($p < 0.001$) of lung worm parasites with species and age however, no significant difference ($p > 0.001$) with the occurrence of different between lung worm species and body condition of the animal (Table 6).

Hydatiwc cyst examination

From the total 18 cysts collected and examined, 61.1% (11/18) were fertile, 50% (9/18) viable and 11.1% (2/18) non-viable) and 38.9% (7/18) were infertile, 22.23% (4/18) sterile and 16.7% (3/18) calcified. Cyst fertility or viability was observed on both sheep and goat and no no-viable cyst was observed in the goat (Table 7).

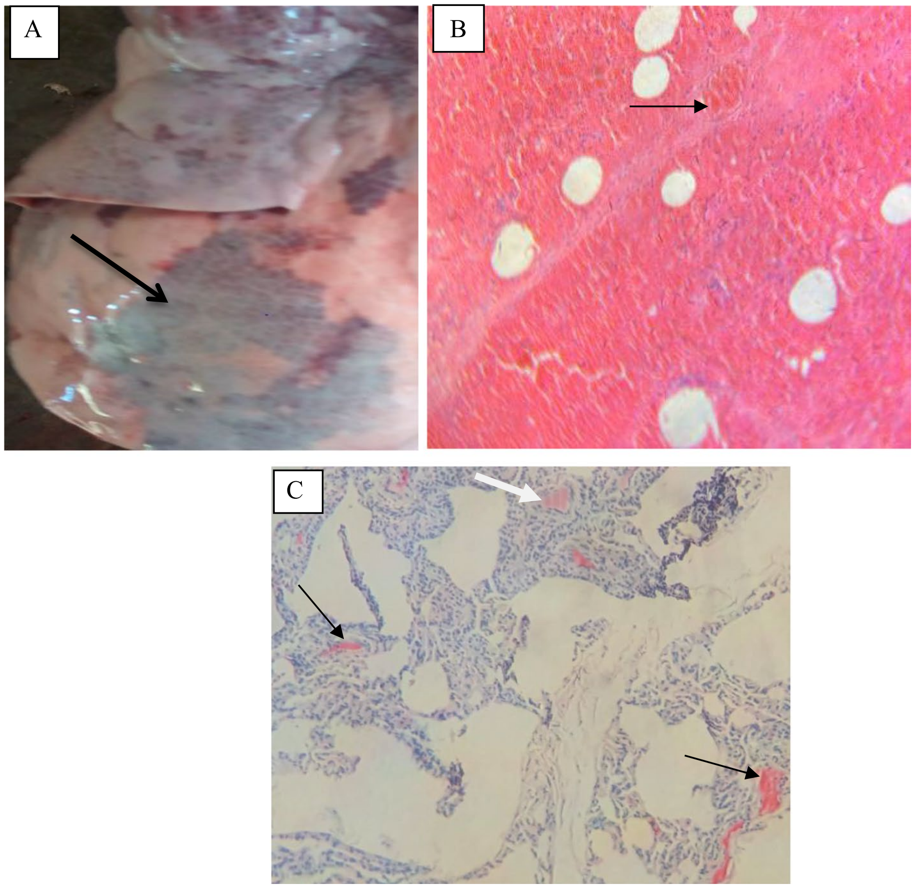

Fig. 13 Gross and Microscopic picture of congestion in sheep lung. **A** Presence of a large brown color on plural surface (black arrow). **B** Massive congested lung (black arrow). **C** Presence of a large number of RBC inside the blood vessel (black arrows) and enlarged alveolar septa (white arrow)

Bacterial isolation

The bacteria isolation was conducted on 99 lungs with pneumonia except verminous pneumonia. However, 102 bacterial colonies with nine bacterial species were isolated from 85 pneumonic lungs and were not isolated bacteria from the 14 pneumonic lungs. Nine species of bacteria isolated include; *E. coli* 20.6% (21/102), *Klebsiella Pneumoniae* 12.7% (13/102), *Mannheimia haemolytica* 10.8% (11/102), *Streptococcus species* 4.9%(5/102), *Staphylococcus aureus* 7.8%(8/102), *Pasteurella multocida* 2.9% (3/102), Pseudomonas 6.9% (7/102), Proteus 1.9% (2/102) and Cornybacterium 1% (1/102) respectively. In 13.7% (14/102) pneumonic lung, bacteria was occurred as co-infections. Gram negative bacteria were dominant over Gram positive (Fig. 18).

From 98 isolated bacteria; 68 bacteria were isolated from broncho pneumonia, 25 from interstitial pneumonia, 3 from embolic pneumonia and 2 bacteria were isolated from aspirational pneumonia. *E. coli* and *Mannheimia haemolytica* were the most frequently isolated bacteria from lungs with pneumonic lesions of both bronchopneumonia and interstitial pneumonia.

Discussion

Pneumonia is one of the major complex condition involving interaction between the host (i.e. immunological and physiological), multiple agents (e.g. bacterial, viral, mycoplasma) and environmental factors (Hashemnia et al. 2019). These factors result in pathological changes in lungs which leads to decreased productivity and growth performances, serious financial losses, and mortality of sheep and goats.

The overall prevalence of lung lesion of sheep and goat in Dessie municipal abattoirs in the current study was 78.1%. The result was higher than the previous study reported by different researcher in Ethiopia;. (Mandefro et al. 2015, Assefa et al. 2017) and (Denebo and Tafere 2022) who had reported 37.4%, 29.18%, and 62.5%, prevalence of pulmonary lesions in Bishoftu, Addis Ababa, and Bishoftu respectively. The current finding suggesting that, pulmonary lesion is an important cause of organ

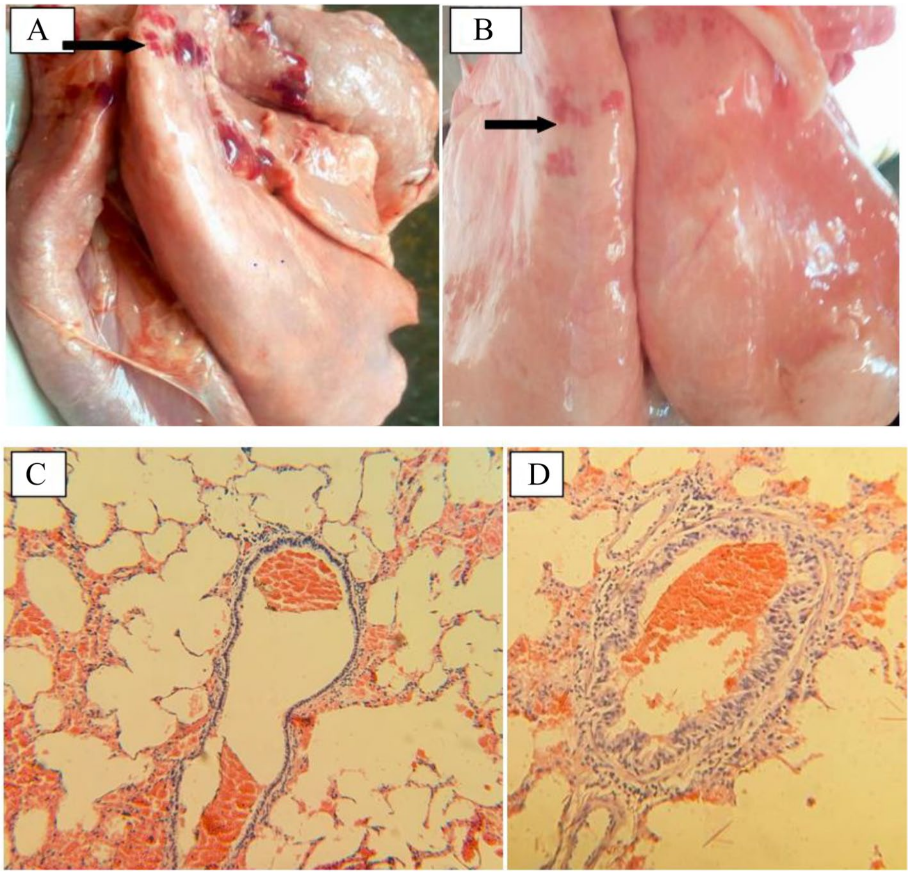

Fig. 14 Gross and Microscopic picture of congestion and hemorrhage in sheep lung. **A** Dark red patches on the pulmonary surfaces of dorsocranial lobe (arrow). **B** Red patches on the pulmonary surfaces dorsocranial lobe (arrow). **C** Presence of a large number of RBC outside the blood vessel in the alveolar lumen or interstitial. **D** Bronchiole filled with erythrocyte

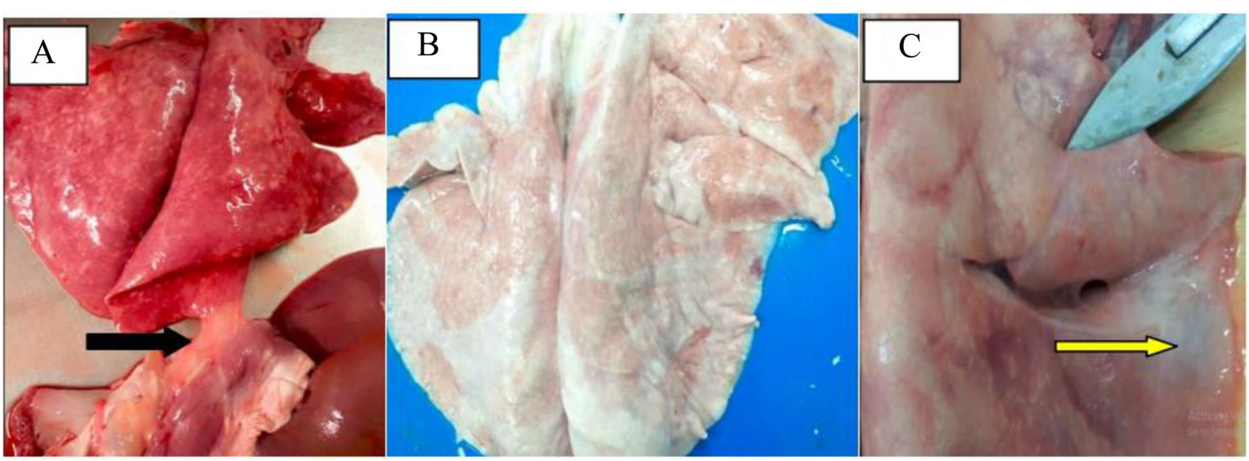

Fig. 15 Gross picture of pleuritis/adhesion in goat and sheep lung. **A** Goat lung adhesion to thoracic cavity (diaphragm). **B** Fibrin loosely adheres with the pleura surface and cloudiness in pleura of affected lungs. **C** Adhesion between lobes (arrow) of sheep lung

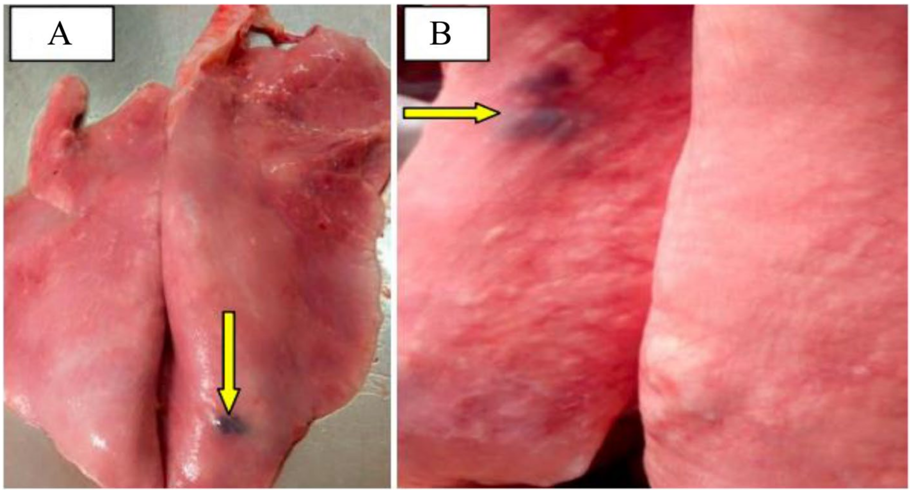

Fig. 16 Gross picture of Anthracosis and abscess in goat lung. **A** Black area on right caudal lobe (yellow arrow) **B** Fine black carbon granules (yellow arrow) in the lung parenchyma

condemnation and thereby economic losses. The variation in prevalence might be due to management system, geographical location, meteorological situations, sanitation, and age of animals came to abattoir.

Gross and histopathological lesions characterized in this study unveiled that more than 55.5% of sheep and goats slaughtered at Dessie municipal abattoir were affected with different forms of pneumonia. In agreement with the present finding, previous investigations also reported by. (Mandefro et al. 2015. Assefa et al. 2017), and (Hashemnia et al.2019) as pneumonia is the most known lung lesion in sheep and goats. The high prevalence reported in the current study include variability in the sampling season, geographical locations and stress factors such as long travel before being slaughter at abattoir, poor housing and overcrowding that result in opportunistic bacteria like *Pasteurella* species and parasites.

The different types of pneumonia observed based on their gross and microscopic feature in this study were confirmed that pneumonia is continues to be one of the most important causes of sheep and goat morbidity and mortality in Ethiopia. Hemorrhagic interstitial pneumonia, broncho-interstitial pneumonia, acute interstitial pneumonia, suppurative and fibrinous broncho pneumonia were diagnosed by histopathological techniques. This suggests that histopathology is better sensitive and specific for diagnosis of lungs potentially helped to classify the various forms of pneumonia (Yousif and Dawood 2019).

Bronchopneumonia (61%) was the most frequently observed pneumonic lesions next to verminous pneumonia. This is in agreement with the report of (Mekibib et al. 2019), and (Mishra et al. 2018) and disagreed with the report of (Mohammed et al. 2022) who reported

Table 5 Lobular distribution of different pulmonary lesion

Gross lesion	RCC	CrL	RM	RCdL	LCdL	CdL	Diffuse	p- value
Pneumonia	20	5	4	24	7	39	9	0.04
Hydatid cyst	-	-	-	10	2	6	-	0.03
Emphysema	4	2	1	3	1	14	5	0.26
Atelectasis	3	1	-	-	4	4	-	0.28
Congestion	-	-	-	6	2	-	2	0.05
Hemorrhage	-	2	7	-	4	-	-	0.06
Bronchoectasis	-	-	-	-	-	1	2	0.22
Adhesion	1	-	-	1	-	-	1	0.79
Anthracosis	-	-	-	1	2	1	-	0.30
Total	**28**	**10**	**12**	**42**	**22**	**65**	**19**	

RCC right crania cranial, *CrL* cranial lobe (both right and left), *RM* right middle, *RCdL* right caudal lobe, *LCdL* left caudal lobe, *CdL* caudal lobe, diffuse: distributed more than two lobe in multifocal or diffuse feature

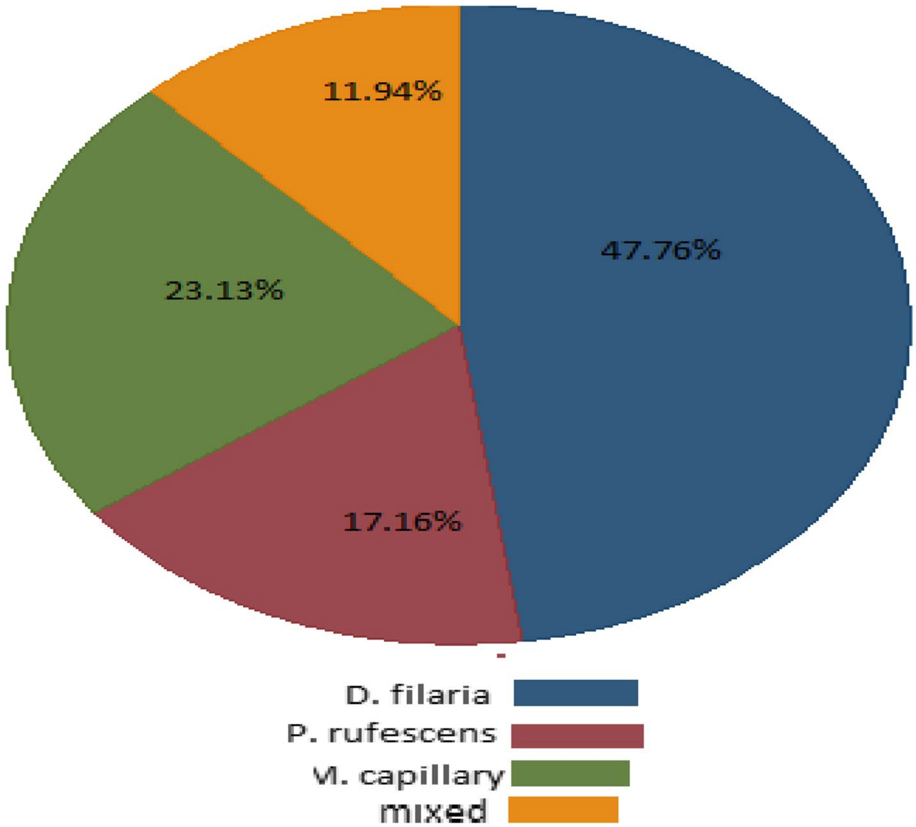

Fig. 17 Lung worm species that identified from verminous pneumonia

interstitial pneumonia were frequent pneumonia. The gross and microscopic lesions observed with bronchopneumonia were in agreement with the description of (Yousif and Dawood 2019, Kumari et al. 2017) and (Mekibib et al. 2019). The authors reported that this type of pneumonic lesion associated with pneumonic pasteurellosis and other respiratory bacteria are characterized by fibrinous and suppurative bronchopneumonia.

In cases of bronchopneumonia, the cranioventral consolidation of the right side lungs in the majority of the cases, this was in agreement with the observation of earlier researcher like (Kumar et al. 2014) and (Kumari et al. 2017). The lesion distribution may due to the topographic location which gives tendency to the gravitational sedimentation and deposition of the exudates and infectious pathogens. It is reported that the lesion on bronchopneumonia starts at the bronchio-alveolar junction and then the inflammatory lesions can spread downward to the lower portion of the alveoli and upward to the bronchi (Zachary 2017).

The microscopic appearance of broncho-interstitial pneumonia were showed the thickening of intra-alveolar septa with infiltration of inflammatory cell in the bronchi, bronchiole and alveoli. These were in consistent with

Table 6 Association of lungworm parasites with species, age and body condition of animal

Lung worm species	No	Species		Age			Body condition	
		Sheep	Goat	< 1 year	1–3 year	> 3 year	Moderate	Good
D. filaria	**65**	56	9	30	23	12	34	31
P. rufescens	**23**	23	0	4	4	15	15	8
M. capillary	**31**	18	13	5	12	14	17	14
Co-infection	**16**	10	6	1	10	5	10	6
Total	**135**	107	28	40	49	46	76	59
***P*-value**	**0.000**			**0.000**			**1.60**	

Table 7 Prevalence of Hydatid cyst with fertility test

Species	No of cyst examined	Fertile		Infertile	
		No. Viable (%)	No. Non-viable (%)	No. Sterile (%)	No. Calcified (%)
Sheep Goat	144	8(57.14) 1(25)	2(14.28)	3(21.42) 1(25)	1(7.1) 2(50)
Total	**18**	**9(50)**	**2(11.1)**	**4(22.23)**	**3(16.7)**

the reports of (Mekibib et al. 2019). Bronchointerstitial pneumonia happens when viral agents affect the lungs as the primary etiology of interstitial pneumonia with further invasion of the infected lungs by bacteria (Kumari et al. 2017). The frequency of interstitial pneumonia in the present study was observed in 21 cases with the characteristic gross lesions of enlarged, rubbery, meaty, and distributed throughout the lungs and the microscopic lesions of lymphocytic infiltration and macrophages in the alveolar lumen and thickening of alveolar septa. The characteristic gross and microscopic lesions described was in accordance with the description of (Mekibib et al. 2019) and (Mohammed et al. 2022).

The occurrence of aspirational pneumonia was observed in 11 cases (4.7%) out of 233 examined pneumonic lesions. The gross and microscopic features detected in this study were consistent with the previous reports by (Mekibib et al. 2019). The gross and microscopic lesions of aspiration pneumonia are greatly variable and usually depend on the physical and chemical nature of the aspirated material. Apart from the inherent inflammatory and necrotic nature of the aspirated fluid, most bacteria from the nasopharynx is fused down the respiratory tree and reach the lungs by gravitational drainage and cause lesions ranging from broncho-pneumonia to granulomatous in type (Mekibib et al. 2019, Fentahun et al. 2017).

The present study revealed the association between the type of pneumonia and the isolated aerobic bacteria in sheep. *E. coli* was the most frequently isolated bacteria from lungs with pneumonic lesions of sheep and goat in this study and it is agreement with the previous

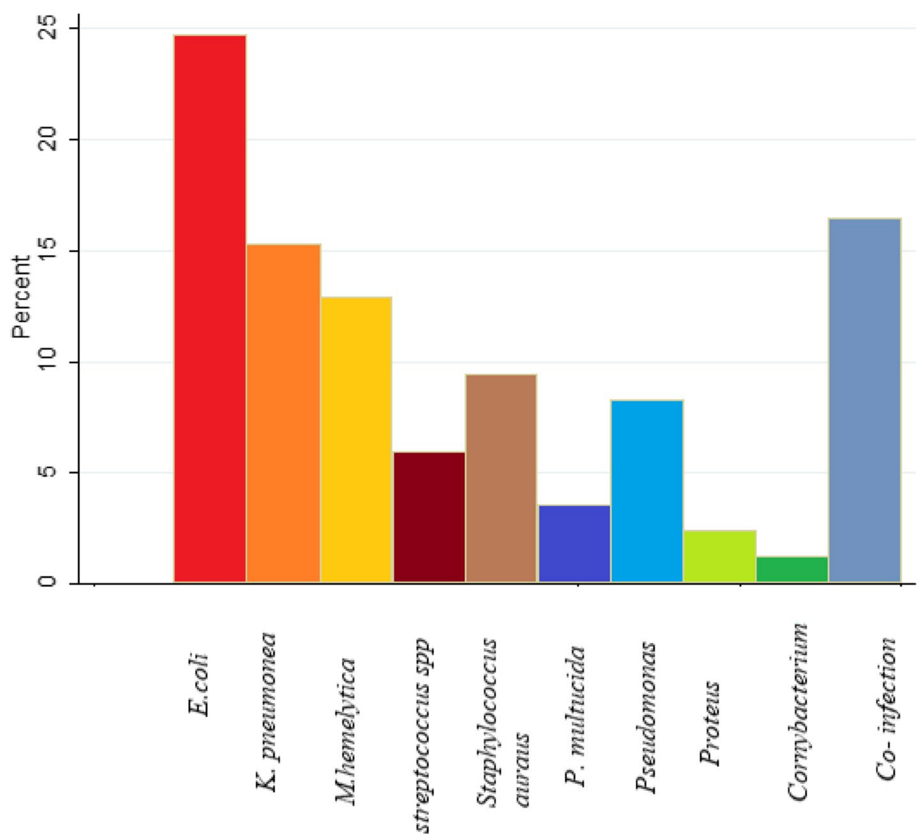

Fig. 18 Frequency of aerobic bacterial species isolated from caprine and ovine pneumonic lungs in Dessie municipal abattoir

study of (Yimer and Asseged 2007) at Dessie municipal abattoir and (Tijjani et al. 2012) at North-East Nigeria while, it is disagreed with the result reported by (Addisu et al. 2017) at Addis Ababa abattoir enterprise. The isolated rate of *M. haemolytica* were higher than *Pasteurella multocida*, which is agreed with the report of (Demissie et al. 2014, Addisu et al. 2017) and (Marru et al. 2013). Mixed infections of different bacterial agent were detected since the respiratory air pathways act as a reservoir for potentially pathogenic micro-organisms which develop into pneumonia following stress, poor hygienic measures or climatic conditions. No bacteria were isolated from 14 sampled pneumonic lungs in the present study and this result supported by the findings of Yimer and Asseged (Azizi et al. 2013) in Dessie, and (Azizi et al. 2013) in south western Iran. This may be due to antibiotic therapy before slaughter on transportation of animals.

Among the examined lungs of sheep and goat, the overall prevalence (31.9%) of verminous pneumonia was recorded and the most frequent lesion (57.5%) observed pneumonic lesion in the current study. This finding was in accordance with the findings of (Addis et al. 2011) from Gonder Ethiopia and (Ayana and Chanie 2013) from Bahirdar and (Mulate and Mamo 2016) in south Wollo. However, it is higher than reports in other parts of country by (Dar et al. 2012) and (Mekonnen et al. 2011). This may be attributed to the different methodology and sample size researchers used to determine prevalence, geographical variation (the climate of area, altitude), intermediate hosts and favorable ecological conditions (rain fall, humidity, temperature), and marshy area for grazing of sheep and goat and management system for survival of the larvae of lungworms, nutritional status and season of the study (Dar et al. 2012, Kebede et al. 2014).

The prevalence of lungworm infection was higher in sheep than goat in the present study. This may be due to the sample size and the grazing system of sheep exposed to parasite and goats with their browsing behavior consume uncontaminated matter with parasite larvae, so being less exposed to infective larvae. With regard to age, the overall prevalence of lungworm infection was higher in adult (> 1 year) than young (< 1 year). The result in present study was in agreement with the report of (Ayana and Chanie 2013) in Bahirdar however, disagreed with the findings of (Radostits et al. 2007) and (Dar et al. 2012) who reported that young sheep were found to be infected more than adults. This may related to adults could be carrier of infections which leads to high attributes of parasite multiplications (Ayana and Chanie 2013).

Dictyocaulus filaria was the most frequent lungworm species than *Mullerius capillaries* and *Protostrongylus rufescence*. The present findings were not in agreement with (Mulate and Mamo 2016) in south (Basaznew et al. 2012) in and around Dessie zuria. The variation might be season of sample collection, methods followed to detect the parasitic larvae and in the life cycle of the lungworm species. For instance, *Dictyocaulus filaria* has a direct life cycle and takes less time to reach the infective stage, and after ingestion, larvae can appear in feces within 5 weeks (Adem 2016). Whereas *P. rufescens* and *Mullerius capillaries* have an indirect life cycle that requires longer time and a wet or rainy season to complete their complex life cycle. The combinations of the two or three of them were present together in the specific area of examined lung.

Gross appearances of lungs with verminous pneumonia include presence of adult parasite in bronchi and bronchiole, formation of different size and color and appearance of nodule in the lung parenchyma. The affected lung also show different lesion such as atelectasis, emphysema and congestion. Microscopically, cross section of lung worm in the lumen of bronchi, bronchiole and alveoli, rupture of the alveolar walls, neutrophil, macrophage, and eosinophils infiltration, hyperplasia of the connective tissue and smooth muscle cells were observed. Similar findings were described by (Adem 2016, Ayana and Chanie 2013) and (Mekonnen et al. 2011).

The overall prevalence of Hydatid cyst in the present study was 4.3%. This value was slightly lower prevalence (10.2%) than report of Denebo and Tafere (Denebo and Tafere 2022) in ELFORA export abattoir. These differences may be associated with agro-ecological and socio-cultural factors, and the contact between large numbers of stray dogs with sheep and goats grazing land (Abegaz and Mohammed 2018).

In the present study sheep were more infected with hydatid cyst than goats, which is in agreement with (Abegaz and Mohammed 2018) and (Denebo and Tafere 2022). This is associated with the nature of the grazing type and patterns of animals, where sheep is grazer while goats are browsers, thus why sheep become potential consumers of the eggs from contaminated grazing lands (Abegaz and Mohammed 2018; Nyero et al. 2015). In the present study with regard to cyst fertility, fertile cysts were higher than infertile cyst, this may related with lung has relatively softer constancy which allows easier development of the pressure by cysts and fertility of hydatid cyst. Cyst fertility were higher in sheep than goats, which is the indicators of the importance of sheep as a potential source of infection than goats for the final hosts. The gross and microscopic features of pulmonary hydatidosis characterization in the current study were consistent with the previous reports by (Nyero et al. 2015) and (Ibrahim et al. February 2014).

In the present study abnormal inflation included emphysema and atelectasis were observed. The overall prevalence for pulmonary emphysema in present study was 7.1%. The result was in agreement with (Gill et al. 2022) who reported 7.1% however, slightly lower than the report of (Denebo and Tafere 2022) in bishoftu Elfora export Abattoir. Emphysema was the second prevalent lesion next to pneumonia. Pulmonary emphysema in animals is taken as the secondary infection to respiratory disease conditions and due to a well-developed interlobular septa and lack of collateral ventilation in sheep is susceptible to interstitial emphysema (Mellau et al. 2010).

In the current study overall prevalence of pulmonary atelectasis was 3.33%. The result was in agreement with the report of (Gill et al. 2022). The gross and microscopic features of pulmonary emphysema and pulmonary atelectasis detected in the current study were in line with the reports of (Mellau et al. 2010) and (Gill et al. 2022).

The overall prevalence of pulmonary congestion and hemorrhage was 2.38% and 3.1% respectively. The prevalence of hemorrhage was in agreement with the 3.7% prevalent report by (Singh et al. 2017). Pulmonary congestion was distributed into all lobes of the lung in animals with good body condition. This may be due to poor pre-slaughter treatments, improper stunning and improper bleeding. Since the abattoir were used all animals came to the areas for slaughtering all together, the large number of animals slaughtered at a time affect the bleeding time, which was taken as the major problem for the occurrences of congestion. Without a known cause, this is almost always the result of blood pooling in the lungs after being forced out of the muscles by rigor mortis. The gross and microscopic features of pulmonary hemorrhage and pulmonary congestion detected in the current study were consistent with the previous reports of (El-Mashad et al. 2020).

In the present study the prevalence of bronchoectasis and bronchioleitis was 1.5%(3/196) in older age animals. Prevalence of bronchoectasis and bronchioleitis was found only in sheep and no in the goats. Grossly, the lungs showed prominence of the pleural surface and a grayish-white discoloration. Leukocyte infiltration and fibrous tissue proliferation were visible in the lung sections under a microscope. Pleurisy was recorded contributing prevalence (0.7%) of total lungs examined. The pleurisy in this study is significantly lower than the reported prevalence by (Mohammed et al. 2022). The total prevalence of pulmonary Anthracosis among the samples examined was 0.95%. This prevalence was in line with the 0.25% prevalence reported by (Mohammed et al. 2022).

Conclusion

From the current observation we concluded that prevalence of pulmonary lesions in slaughtered sheep and goat is relatively high. Pulmonary lesion can be consider an important ovine disease impairing the function of the respiratory system and leading to economic losses. Although the sheep slaughtered are apparently healthy, large percentages were found either to harbor certain pathological lesions or being infected with different diseases. Pneumonia was the highest prevalent pathological disorder in sheep and goat lungs followed by emphysema. *E. coli* and *Menhemia haemolytica* from bacteria and *Dictyocaulus filaria* from parasites was the most frequent causative agents of pneumonia in the sheep and goats at present study area. The gross observations could be used to identify subclinical pneumonia and histopathological examination was a more reliable examination to identify pulmonary lesion and particularly to classify pneumonia in the present study.

Abbreviations

AHI	Animal Health Institute
CSA	Central statistical Authority
DPX	Dibutyl phthalate xylene
HP	Histopathology
HE	Hematoxyline and Eosin
NBF	Neutral Buffered Formaline

Acknowledgements
Not applicable.

Authors' contributions
NT analyzed and interpreted the sampled data and contributed in writing and editing the manuscript. JSA conceptualized, analyzed and edited the manuscript. AA & AF review and edited manuscript. All the authors read and approved the final manuscript.

Funding
None.

Availability of data and materials
All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]School of Veterinary Medicine, Wollo University, Wollo, Ethiopia. [2]Department of Clinical Studies, College of Veterinary Medicine and Agriculture, Addis Ababa University, Bishoftu, Ethiopia. [3]Department of Veterinary Pathology and Parasitology, College of Veterinary Medicine and Agriculture, Addis Ababa University, Bishoftu, Ethiopia.

Received: 25 August 2023 Accepted: 17 February 2024
Published online: 17 March 2024

References

Abatemam M, Taye E, Urji A, Belina D. Survey on pathological lesion and its financial Losses in ovine slaughtered at Jimma municipal abattoir, Jimma, Ethiopia. Concepts of Dairy and Veterinary Sciences. 2018;1(1):1–12.
Abegaz S, Mohammed A. Cross-sectional study on the prevalence and economic significance of hydatidosis in slaughtered ruminants at Debrezeit Elfora export abattoir Oromia region Eastern Showa Zone, Ethiopia. Biomedical Journal of Scientific and Technical Research. 2018;3(3):3273–82.
Addis M, Fromsa A, Ebuy Y. Study on the prevalence of lungworm infection in small ruminants in Gondar town, Ethiopia. J Anim Vet Adv. 2011;10(13):1683–7.
Addisu A, Addis K, Tesfaye S, Biruk T. Aerobic and anaerobic bacteria isolates from the respiratory tract of sheep slaughtered at Addis Ababa Abattoirs Enterprises, Central Ethiopia. Journal of Veterinary Medicine and Animal Health. 2017;9(10):284–9.
Adem J. Lung worm infection of small ruminant in Ethiopia. A review. Wjpls, 2016, Vol. 2, Issue 3, 22–43.
Assefa D., Gezaheng E., Abera, B., Eticha E., Lemma D., and Hailemariam T. Major cause of organ and carcass condemnation in apparently healthy small ruminant slaughtered at Addis Ababa Abattoir enterprise, Ethiopia. Journal of Veterinary Science and Technology. 2017; 8(419).
Ayana K, Chanie M. Study on the prevalence and pathological features of lung worm of sheep inbahirdar, Ethiopia. Acta, Parasitologica Globalis. 2013;4:41–8.
Azizi S, Koran FS, Oryan A. Pneumonia in slaughtered sheep in south-western Iran: pathological characteristics and aerobic bacterial aetiology. Veterinaria Italiana. 2013;49(1):109–18.
Basaznew B, Ayalew E, Achenef M. Ovine Lungworm Infection: Prevalence, Species Composition and Associated Risk Factors in Dessie Zuria District, Northeastern Ethiopia. African Journal of Basic Applied Scince. 2012;4(3):73–6.
Belkhiri M, Tlidjane M, Benhathat Y, Meziane T. Histopathological study and pulmonary classification of bovine lesions. Afr J Agric Res. 2009;4:584–91.
Benavides J, González L, Dagleish M, Pérez V. Diagnostic pathology in microbial diseases of sheep or goats. Vet Microbiol. 2015;181(1–2):15–26.
Chilton NB, Huby-Chilton F, Gasser RB, Beveridge I. The evolutionary origins of nematodes within the order Strongylida are related to predilection sites within hosts. Mol Phylogenet Evol. 2006;40(1):118–28.
Dar LM, Darzi MM, Mir MS, Kamil SA, Rashid A, Abdullah S, Hussain SA, Bhat AA, Reshi PA. Prevalence and pathology of lung worm infection in sheep in Kashmir Valley. Indian Journal of Animl Scince Advance. 2012;2(8):678–85.
Demissie T, Dawo F, Sisay T. Biochemical and antigenic characterization of Mannheimia, Pasteurella and Mycoplasma species from naturally infected pneumonic sheep and goats, Bishoftu, Ethiopia. African Journal of Basic Applied Scince. 2014;6(6):198–204.
Denebo I, Tafere A. Study on Major Gross Lesions in Lung of Small Ruminants Slaughtered at Elfora Export Abattior Bishoftu. Central Ethiopia. 2022;4(4):32–8.
DFEDB, (Dessie Finance and Economic Development Bureau). Overall Environmental Condition and Livestock Wealth Assessment of Dessie. Annual Report. 2015; 28–36.
El-Mashad A-B, Moustafa S, Amin A, Samy E. Pathological Studies on lung affections in sheep and goat at Kalubia Governorate. Benha Veterinary Medical Journal. 2020;38(1):17–23.
Engdawork A. Lungworms of Sheep and Cattle Slaughtered at Abattoir. 2019
FAO, Food and Agriculture Organization. Manual on meat inspection for developing Countries. Animal and health production papers Food and Agriculture organization of the United Nations. 2007.
Fentahun M, Tsegaw F, Zenebe T, Tadesse M, Robel A. Review on ovine respiratory disease complex in Ethiopia: Significance, causes and possible management methods. Academic Journal of Animal Diseases. 2017;6:13–22.
Getenby RM. Sheep in the tropics Agriculturalist. London: McMillan education Ltd.; 1996. p. 34–201.
Gill D., Dadhich R., Shringi N., Chotiya A., and Kumar V. Histopathological studies of emphysema and atelectasis in lungs of goats in southern region of Rajasthan. 2022.
Hashemnia M, Chalechale A, Malmir E. Pulmonary lesions in slaughtered sheep in Western Iran: gross and histopathological findings. Veterinary Italia. 2019;55(1):47–56.
Ibrahim SEA, Gameel AA. Pathological, histochemical and immunohistochemical studies of lungs and livers of cattle and sheep infected with hydatid disease. The 5th annual conference-agricultural and veterinary research February 2014 Khartoum. Sudan, Conference Proceedings. 2014;2014(2):1–17.
Jibat T, Ejeta G, Asfaw Y, Wudie A. Causes of abattoir condemnation in apparently healthy slaughtered sheep and goats at HELMEX abattoir, Debre Zeit, Ethiopia. Revue De Médecine Vétérinaire. 2008;159(5):305.
Kebede S, Menkir S, Desta M. On farm and Abattoir study of Lungworm infection of small ruminants in selected areas of Dale District, Southern Ethiopia. International Journal of Current Microbiology and Applied Science. 2014;3(4):1139–52.
Kumar A., Tikoo S.K., Malik P. and Kumar A.T. (2014). Respiratory diseases of small ruminants. Veterinary medicine international, 2014.
Kumari S., Singh R., Kumar A., Singh S. and Yadav, J.P. Pathomorphological Diagnosis of Hydatidosis in Slaughtered Sheep. 2017
Mandefro A, Aragaw K, Hailu B, Alemayehu G, Chala G. Major cause of organ and carcass condemnation and its financial loss at Bishoftu Elfora Export Abattoir. International Journal of Nutrition and Food Sciences. 2015;4(3):364–72.
Marru HD, Anijajo TT, Hassen AA. A study on Ovine pneumonic pasteurellosis: Isolation and Identification of Pasteurellae and their antibiogram susceptibility pattern in Haramaya District, Eastern Hararghe. Ethiopia BMC Veterinary Research. 2013;9(1):1–8.
Mekibib B., Mikir T., Fekadu A. and Abebe R. Prevalence of pneumonia in sheep and goats slaughtered at Elfora Bishoftu export abattoir, Ethiopia: A pathological investigation. Journal of veterinary medicine, 2019.
Mekonnen A, Abebe F, Yohanes E. Study on prevalence of Lungworm infection in small ruminants in Gondar town. Ethiopia Veterinary Advance. 2011;10(13):1683–7.
Mellau LSB, Nonga HE, Karimuribo ED. A slaughterhouse survey of lung lesions in slaughtered stocks at Arusha. Tanzania Preventive Veterinary Medicine. 2010;97(2):77–82.
Mishra S, Kumar P, George N, Singh R, Singh V, Singh R. Survey of lung affections in sheep and goats: a slaughterhouse study. Prevalence. 2018;7(12):16–9.
Mohammed ZM, Ibrahim WM, Abdalla IO. Pneumonia in Slaughtered Sheep in Libya: Gross and Histopathological Findings. European Journal of Veterinary Medicine. 2022;2(1):4–9.
Mulate B, Mamo M. Prevalence and financial losses of lungworm infection in sheep in South Wollo Zone. Ethiopia Journal of Animal Research. 2016;6(1):53–8.
Nyero D., Zirintunda G., Omadang L. and Ekou J. Prevalence of hydatid cysts in goats and sheep a slaughtered in Soroti Municipal Abattoir Eastern Uganda. 2015
Quinn PJ, Markey BK, Leonard FC, Hartigan P, Fanning S. and Fitzpatrick E. Veterinary Microbiology Microbial Disease: John Wiley and Sons; 2011.
Radostits OM, Gay CC, Hinchcliff KW, Constable PD. A textbook of the diseases of cattle, horses, sheep, pigs and goats. Veterinary Medicine. 2007;10:2045–50.
Singh R, Kumar P, Sahoo M, Bind RB, Kumar MA, Das T, Kumari S, Kasyap G, Yadav JP, Saminatham M, Singh KP. Spontaneously occurring lung lesions in sheep and goats. Indian Journal of Veterinary Pathology. 2017;41(1):18–24.
Talukder S. Histopathology technique: tissue processing and staining. www.talukder.com The Tropical Agriculturist, Macmillan Education Ltd., London. 2007; Wageningen.

Thannon HB. Pulmonary and Hepatic lesions in slaughtered sheep in Mosul city. Tikrit Journal of Pure Science. 2018;22(6):25–33.
Thrusfield M. Veterinary Epidemiology. 3rd Ed, Blackwell science Ltd, UK, 2005; Pp. 233–250.
Tijjani AN, Ameh JA, Gambo HI, Hassan SU, Sadiq MA, Gulani I. Studies on the bacterial flora and pathologic lesions of caprine pneumonic lungs in Maiduguri North-Eastern Nigeria. African Journal of Microbiology Research. 2012;6(48):7417–22.
Tsegaye S, Tessema D, Asebe G. Gross Pulmonary Lesions of Bovine. Lung 2016
Yami A., Shee E. and Merkel R.C. Sheep and goat production handbook for Ethiopia. 2008
Yimer N, Asseged B. Aerobic bacterial flora of the respiratory tract of healthy sheep slaughtered in Dessie municipal abattoir, northeastern Ethiopia. Review onVéterinary Médicine. 2007;158:473.
Yousif NH, Dawood MS. Morphometric Comparative Anatomical Study of Lower Respiratory Tract between Sheep (Ovis aris) And Goat (Caprus hircus) in Baghdad provence. Kufa Journal for Veterinary Medical Sciences. 2019;10(2):26–36.
Zachary J. F. Mechanisms of microbial infections. Pathologic basis of veterinary disease, 132. 2017
Zeryehun T. and Alemu B. Major gross lesions of lung in cattle slaughtered at hawassa municipal abattoir, Southern Ethiopia. Journal of veterinary medicine. 2017.

Publisher's Note