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# Review on Ovine Respiratory Disease Complex in Ethiopia: Significance, Causes and Possible Management Methods

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**Abstract:** Ovine respiratory disease complex (ORDC) is a major disease problem of sheep, particularly in adverse environmental conditions and in intensive sheep management systems. The etiopathogenesis of ORDC is multifactorial and complex. Interaction among infectious agents and environmental stressors and lowered immune status of animals play great role for the occurrence of the respiratory diseases. The major etiological agents include the commensal upper respiratory tract bacteria like Pasteurella, Mannheimia spp and *Mycoplasmal ovipneumoniae*; viral pathogens like *Parainfluenza*-3 virus, Maedi-visna virus, Jaagsiekte sheep retrovirus (JSRV) and Pesti des petits ruminants (*PPR)*; and lung worm infections. However, several of these agents are not sufficient causes for the development of respiratory disease complex. In Ethiopia, respiratory diseases of sheep caused by concurrent infections have been identified as the leading health problem which accounts more than half of the overall mortality of sheep in the central highlands. Above all, ill managemental and husbandry practices have a great role for the initiation and progress of respiratory disease. Confirmatory diagnosis of respiratory disease complex is very difficult and costly as a result of the interaction of multiple agents. Therefore, it is very important to know the associated exposure factors so as to take an intervention at the possible weakest point. Due to involvement of many causal agents and stressors, control and prevention of the problem requires integration of various techniques like chemoprophylaxis, immunoprophylaxis, regular deworming and improved managemental measures. In this paper the major causal agents and their interactions as well as the possible management methods are highlighted.

**Key words:** Bacterial Infections · Control Strategy · Ethiopia · Lungworm Infections · Ovine Respiratory Disease Complex · Viral Infections

## INTRODUCTION

Sheep production plays a great role in the national economy and livelihood of smallholder farmers of Ethiopia. Ethiopia has about 25.02 million heads of sheep of which 75% is found in the highlands and the rest in the lowlands of the country [1].

Despite their importance as a component of the Ethiopian farming system, their contribution to food production, rural income and export revenue are far below than their expected potential. This is because small ruminant production is constrained by the compound effects of disease, poor feeding and poor management [2].

Among the different disease problems of sheep, respiratory diseases caused by different agents are indicated to be the major health problems in sheep industry. A respiratory disease syndrome caused by multiple etiological agents along with different environmental and managemental stressors is termed as respiratory disease complex [3].

Bronchopneumonia caused by *Mannheimia haemolytica* and sometimes by *Pasteurella multocida* develops when the immune system of the animal is compromised by stress factors. Observation on seasonal occurrence of ovine pasteurellosis in central Ethiopia has shown that it is featured by multi-aetological agents [4]. Infection with viruses and lungworms can suppress the animal's immune system, allowing opportunistic microorganisms (*M. haemolytic a*and rarely *P. multocida,* to colonize the lung and cause pasteurellosis [5]. When the immune system of the animal is compromised.

Peste des petits ruminants (PPR) is also another infectious viral disease of small ruminants in which goats are severely affected while sheep undergo a mild form of

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the disease [6]. Seasonal outbreaks of this disease were reported in many parts of the country [7]. Tibbo *et al.* [8], has detected serum antibodies in flocks of sheep with respiratory complex in central Ethiopia. [9], Waret-Szkuta *et al.* (2008), reported a very heterogeneous seroprevalence estimate ranging from 0% to 52.5% in a national survey conducted in different regions of Ethiopia. The key player in determining the susceptibility to any pathogen is the immune status of the animal which, in turn, depends on number of environmental variables for its fluctuations. The preceding immune status of the host is frequently critical in determining the occurrence of disease; for example, low virulence pathogens usually produce clinical disease only in immunocompromised hosts while highly virulent pathogens may show morbidity even in healthy host. Animals whose lungs are already compromised from previous diseases usually fall prey to toxicity by leukotoxins and lipopolysaccharides, both potent toxins that, in high levels, act as chemotactic factors for inflammatory cells and promote inflammation and severe lung damage [10].

Irregular vaccination programs for different diseases such as ovine pastuerellosis and PPR, lack of strategic deworming programmes for helminthes such as lungworms and poor managemental practices have played significant roles for the persistence of respiratory infections in sheep of Ethiopia [4]. Despite how very serious the problem is, literatures targeting on multiple causal and stressors are limited. Having this in mind, this seminar paper is prepared with the main objectives of:

- Over viewing the different causal agents involved in the development of ovine RDC and assessing their interactions and possible control methods. Ovine Respiratory Disease Complex and Involved Etiological Agents

**Ovine Respiratory Disease Complex:** Respiratory diseases complex in sheep caused by concurrent infections have been identified as the leading health problems of sheep which accounts more than half of the overall mortality of sheep in Ethiopian central highlands [11]. The causes of this respiratory disease have partly been identified in the central highlands of Ethiopia [4, 8]. Involving multiple agents such as bacteria (Pasteurella, Manneheimia, Chlamydia, Mycoplasma species, etc.), viruses (PPR, Parainfulenza-3 virus, Maedi-visna, etc) and lungworms (*Dictyocaulus fillaria and Muelleris capillaries*). The predisposing factors are mainly environmental stresses including extreme of weather conditions, feed shortage usually assisted by inadequate management and husbandry practices [3].

**Common Bacterial Infections**

**Pasteurella and Mannheimia Infections**: Pneumonia due to pasteurella species is extremely common in sheep and can be responsible for enormous financial losses worldwide. Several works have been done on different parts of Ethiopia to determine the prevalence of pneumonic pasteurellosis. The results of those works showed that the disease is prevalent in Ethiopia and *M. haemolytica* is the major causative agent of the disease. The condition usually appears when sheep are exposed to combinations of predisposing factors such as adverse physical condition, physiological stress, bacterial and viral infections. As the exact nature of these combinations is unknown, much remain to be understood about why the disease occurs in the way it does [12, 13].

The term pasteurellosis was broadly used to designate a number of infections in domestic animals caused by Gram-negative non-motile facultative anaerobic rods or coccobacilli formerly grouped under the genus Pasteurella (after Louis Pasteur). For several decades, the genus *Pasteurella* was believed to be only one single genus with numerous species associated with a wide range of systemic, pulmonary and septicaemic infections in various species of farm animals, particularly ruminants [14]. However, a recent updating of phylogenetic data has resulted in renaming based on gene sequence analysis. In this respect, the former *Pasteurellahaemolytica* biotype A and T were reclassified as *M. haemolytca* and *P. trehalosi* respectively. This new genus (*Mannheimia)* now contains several species including *M. haemolytica, M. granulomatis, M. glucosida, M. ruminalis and M. varigena* [15].

In sheep *Mannheimia haemolytica*, the cause of ovine pasteurellosis contains about 12 serotypes (A1, A2, A5, A6, A7, A8, A9, A10, A12, A13, A14 and A16). Type T (*P. trehalosi)* comprises T3, T4, T10 and T15. Biotype A is particularly associated with pneumonic pasteurellosis in sheep, whereas biotype T causes systematic pasteurellosis in lambs. *P. multocida* can also be involved in pneumonic pasteurellosis [16]. All serotypes of *M. hemolytica* can be involved in pneumonic pasteurellosis in sheep, but serotype A2 is the most commonly isolated serotype from cases of ovine pneumonic pasteurellosis [17].

The majority of *M. hemolytica* infection mechanisms are mostly endogenous, initiated by the normally resident bacteria on the upper respiratory tract. By using

poor immune status and/or other stressors of the host, the bacteria from the nasopharynx will then reach the ventral bronchi, bronchioles and alveoli by gravitational drainage along the tracheal floor and thereby become deeply introduced into the lung tissue. Endotoxins produced by rapid growth and multiplication of the bacteria in infected lobules will cause extensive intravascular thrombosis of pulmonary veins, capillaries and lymphatics. These vascular disturbances eventually result in focal ischaemic necrosis of the pulmonary parenchyma accompanied by severe inflammatory reaction dominated by fibrinous exudates [18].

Pneumonic pasteurellosis is one of the priority diseases that deserve control. However, control of the disease is a difficult task that requires integration of various techniques. Developed and developing countries practice various control mechanisms for primary diseases. While developing countries including Ethiopia could not apply the strategies used by developed countries because of economic and sheep management reasons. The most economic and feasible control method for developing nations is the use of vaccine [13].

**Mycoplasmal Infections:** Mycoplasmal pneumonia also is known as enzootic pneumonia, chronic non progressive pneumonia and atypical pneumonia. Typically, *Mycoplasma ovipneumoniae* is thought tobe the primary organism, along with *M. hemolytica,* other Mycoplasmal organisms and Chlamydia psittaci [19].

In Ethiopia, an attempt was made to determine the distribution of Mycoplasma causing mass respiratory disease outbreaks in small ruminants. The prevalence of different Mycoplasma strains including *M. ovipneumoniae* was recorded. The natural resistance of sheep to clinical Mccp in the Ethiopian condition is assessed. The majority of these strains were directly detected by dot blot test on pneumonic lung extracts and pleural exudate samples collected from respiratory cases that occurred in different regions in Ethiopia [20].

Mycoplasmas have a worldwide distribution. Infection principally occurs in housed or densely stocked store lambs, particularly following two months of housing. Outbreaks can take place following the mixing of market-bought lambs, particularly in the autumn and winter and also during periods of high temperatures during the summer. Although acute disease has been seen in young lambs, a chronic infection is often found in older lambs and adults. It usually causes an interstitial bronchopneumonia that is often subclinical [21].

The disease occurs in intensively reared lambs that live in areas with poor ventilation and in assembled groups of lambs in feedlots; it most commonly develops as maternal antibody level starts to decrease. Reservoirs such as older animals and convalescent adults infect lambs mainly after weaning. Encapsulation allows the organism to evade the host's immune response and promotes long-term colonization of the upper respiratory tract. The organism can be effectively eliminated with oxytetracyclin and tilmicosin. Prevention and control rely on reducing the density of housed lambs, ensuring adequate ventilation and separating batches of assembled lambs, but no vaccines are available [22].

**Viral Infections**

**Peste Des Petits Ruminants:** Peste des petits ruminant is a contagious viral disease of small ruminants in Africa and Asia. It is a severe and highly contagious trans-boundary disease of sheep and goats, caused by a virus belonging to the genus Morbillivirus of the family *Paramyxoviridae.* The virus has the potential to cause severe epidemics or even pandemics in small ruminants in an increasingly expanding area of the developing world [5]. In 1999, probably the largest survey on PPR ever conducted in Africa was initiated in Ethiopia where serum samples from 7 out of the 11 regions were collected and analyzed by competitive Enzyme-linked Immunosorbent Assay test [9].

It was confirmed that PPRV exhibited different levels of virulence between sheep and goats. Goats were severely affected while sheep generally underwent a mild form. However, the virus circulation in both species was the same level, suggesting a difference in host susceptibility. This difference may result from a difference in cell susceptibility to the virus. The cell susceptibility can be affected by the rate of infection, the affinity of the virus for its cell membrane receptor, the efficiency of intercellular spreading of the virus and capacity to induce damages in infected cells. Such characteristics may account for the milder clinical disease and lower mortality in sheep. The capability of cells to be infected and support active virus replication has important implications on the pathogenesis of the disease [7].

To prevent PPR new animals should be quarantined for three weeks before allowing them to mix with the flock. In a case of PPR outbreak, animals with signs of PPR should be isolated immediately and sheep and goats around the outbreak area should be vaccinated as soon as possible. Vaccine for PPR is effective. Vaccinate before start of the rainy season. In endemic areas sheep and

goats should be vaccinated annually. Vaccine for PPR is produced by the National Veterinary Institute. Carcasses of dead animals and contaminated items should be buried or burned [23].

**Maedi-Visna Infections:** The emergence of MVV in Ethiopia was serologically detected for the first time in imported Merino Sheep in 1986 and followed by the report of 3.7% prevalence around Debre Berhan in indigenous sheep [4]. Tibbo *et al.* and Woldemeskel and Tibbo [8, 24] have also reported MV in Awasssi sheep at Debre Berhan and Amed Guya breeding ranches.

MV is a chronic disease of sheep produced by ovine lentivirus (OvLV), a member of a family of Retroviridae [5]. Maedi-visna comprises two Icelandic words describing the clinical presentation of two apparently different syndromes Maedi or labour breathing; a fatal progressive pneumonia of mature sheep, Visna or wasting which is a meningoencephalitis, which causes progressive paralysis and death [25].

The seroprevalence of MVV infected sheep that developed overt clinical disease increased as the age increased. This could be due to chronic nature of the disease. Because of the chronic nature of the virus, MVV infections are characterized by a long incubation period and life-long viral persistence and clinical signs are rarely seen in sheep less than 3 years old. And the main route of transmission of the MVV from infected to healthy animals could be via ingestion of colostrum and milk from their mothers and contact with infected sheep [26].

In the past, the only control approach that has been attempted is by complete destruction of all sheep in the area and subsequent restocking. However, it is possible to reduce the prevalence of the disease either by segregated rearing or test and cull [5].

**Sheep Pulmonary Adenomatosis:** Ovine pulmonary adenocarcinoma (OPA) is a contagious lung cancer of sheep which is caused by a beta retrovirus also called jaagsiekte sheep retrovirus (JSRV), which induces oncogenic transformation of alveolar and bronchiolar secretory epithelial cells. In addition to aerosol transmission it can also transmitted via colostrum and milk. A pathognomonic sign of OPA is the production of copious amounts of fluid in the lung that is frothy, clear, milky or at times pinkish and drains from the sheep's nostrils when it lowers its head. Up to 400 ml per day may be collected from such animals by lifting the rear end (the 'wheelbarrow' test). Though 10 - 40 ml per day is more common [27]. Once the clinical signs are seen the sheep usually lives for only a few more days and may die abruptly following exercise or exposure to cold. Despite the unique clinical signs in some affected animals, in many cases no lung fluid is seen. A definitive diagnosis of OPA in an individual animal therefore always requires the identification of the characteristic gross and histopathological findings by post-mortem examination. OPA occurs in domestic and wild sheep species and affects no other livestock except goats, in which natural cases have been described only in sub clinically affected animals [28].

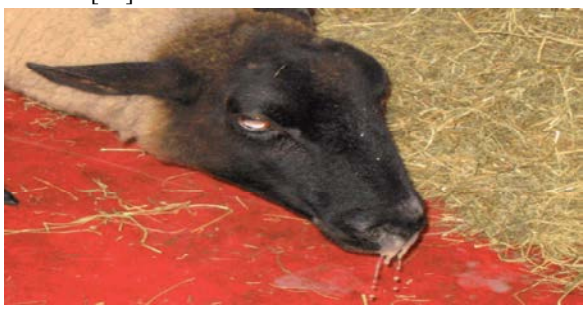

Fig. 1: Profuse quantities fluid draining from the nose in ovine pulmonary adenocarcinoma infected sheep. Source: ([21].

**Parainfluenza-3 Virus:** Parainfluenz-3 (PI3) virus, which is a member of the paramyxovirus family, is an RNA virus. The one serotype of PI3 that infects sheep is related to but distinct from the PI3 that infects cattle and human beings. Most infections are inapparent, but outbreaks have been reported with high rates of morbidity. Although, other respiratory viruses and bacteria may predispose to pneumonic pasteurellosis, PI3 appears to be more important [22].

Clinical signs include frequent coughing, serous nasal discharge and occasional ocular discharge. Body temperature is usually not elevated. PI3 infection causes a mild, undifferentiated interstitial pneumonia. It is more common in lambs younger than one year. Protection against experimental and natural cases of pneumonic pasteurellosis by use of a live intranasal PI3 vaccine has been demonstrated [29].

**Lungworm Infections:** Lungworm infection in sheep is caused by nematode species such as *Dictyacaulusfilaria, Muellerius capillaries* and *Protostrongylusrufescens*. These nematode parasites belong to two super families, Trichostrongyloidea (*D filaria*) and Metastrongyloidea (*P. rufescens*and *M. capillaries*). *Protostrongylus* and

*Muellerius* species occur in the alveoli, bronchioles and parenchyma of the lungs of various species of mammals. Dictyocaulidae species are located in respiratory passages of the lungs [30].

The pathogenic effect of lungworms depends on their location within the respiratory tract, the number of infective larvae ingested and the immune system of the animals. Those parasites can suppress the immunity of the respiratory tract and causes death, poor weight gain or loss of body weight as well as greatly affects the potential productivity of sheep industry in the areas where it is prevalent [31].

*Dictyacaulus filaria* has a direct life cycle whereas *M. capillaries* and *P. rufescens* have indirect life cycles. *Dictyacaulus filarial* infection is acquired by ingestion of infective larvae with herbages but *M. capillaries* and *P. rufescens* are transmitted when Molluscan intermediate hosts are accidentally ingested by grazing animals. *Dictyacaulusfilaria* is the most important lungworm of sheep and goats and commonly associated with a chronic syndrome of coughing and unthriftiness, which usually affects lambs and kids. *Muelleriuscapillaris*and *P. rufescens*are common but less pathogenic when compared to *D. filaria* [5].

Coprological and postmortem examinations have shown that *Dictyocaulusfilaria*as the commonest parasite followed by*Muellerius capillaris*and *Protostrongylus rufescens*, respectively. This difference in the prevalence of the different species of lungworms is assumed to be associated with differences in their life cycles. *Dictyocaulusfilaria* which has a direct life cycle; takes less time to reach the infective stage and the larvae appear in the faeces within five weeks after ingestion but others require longer time to be detected on fecal samples [32]. *Dictyocaulus*, *Protostrongylus* and *Muellerius* worms are all responsive to benzimidazole, levamisole and avermectin anthelmintics. Treatment with levamisole may need to be repeated after two weeks as this drug has a limited efficacy against the larval stages of worms [21].

Fig. 2: Severe adult *Dictyocaulus filarial* infection in the trachea and bronchi of a lamb.
Source: [16].

**Epidemiology of Respiratory Disease Complex**

**Prevalence and Incidence of the Disease:** According to an investigation carried out by [8], the monthly incidence of RDC was shown to be varied from 2.8% to 4% and the prevalence was as high as 17%. The case fatality rate of the disease was also about 18%, despite the culled sick sheep. Greater than 76% of morbidity occurred in adults followed by19% among weaners. Generally, it accounts about 54% of the overall mortality of sheep in the central highlands of Ethiopia [4].

According to the report of Nigusu and Fentie [33], in indigenous Gumuz sheep in Metema District, the overall prevalence of respiratory infections was 40.6%. Infection rate of 15.1% for lungworms, 27.6% for pasteurellosis and 26.3% for PPR was reported. Concurrent infection rate was 13.8% for lung worm and pasteurella species, 9.4% for lung worm species and PPR, 14.1% for pasteurella species and PPR and 8.9% for lung worm, pasteurella and PPR infections.

The seroprevalence of MV in sheep has been determined at different parts of Ethiopia. The overall apparent seroprevalence of MV in eastern Amhara region was 15.6%. The individual-level prevalence was 6.6% in smallholder farms and 30% in breeding sheep at ranches. The MV prevalence distribution had varied among the districts [34].

In Ethiopia, PPR in goats was described and confirmed by the laboratory. However, there was always a question if other species of animals (camel, cattle and sheep) could be infected in the absence of detectable clinical signs. Abraham and Birhan [7] reported a seroprevalence of 10% in camel, 16% in cattle, 22% in goat and 23% in sheep. This showed that the virus can circulate in sheep and other domestic animals without showing apparent clinical signs. [35], also reported seroprevalence of 92% and 63.5% for *M. agalactiae*and *M. ovipneumoniae* respectively.

**Distribution of the Disease:** Ovine pasteurellosis, the dominant disease problem in ovine respiratory disease complex, occurs in sheep of all age groups and is more prevalent in the late spring and early summer [5]. Pneumonia due to multiple agents occurs, in all breeds in every country of the world. This is because of the ubiquitous nature of the agents. The disease occurs more commonly in intensively reared lambs that live in areas with poor ventilation and in assembled groups of lambs in feedlots and it commonly develops as level of maternal antibody declines.

PPR has been reported in virtually all parts of the African continent, except for the southern tip; the Middle East and the entire Indian subcontinent. In the last two decades, the virus has rapidly expanded within Africa and to large parts of Central Asia, South Asia and East Asia [36].

The geographical distribution of PI3, sheep pulmonary adenomatosis and Maedi-visna is worldwide in all sheep raising countries but Australia and New Zealand are free from MVV [16].

**Pathogen-Host-Environment Interplay for the Initiation and Progress of RDC:** The development of any disease in an animal is determined by the three basic factors: the host, the pathogen and the environment, usually represented in the form of a triangle. It is the balance between these three components that decides the initiation and progress of disease. A pathogenic agent can certainly gain entry into the animal body and initiate disease development process but the immune system of host can phagocytise the pathogen (e.g., by secreting chemical factors) and thus check the disease progress [37]. Environmental variables have conventionally been accepted as the major determinant factors for disease development. As it is difficult to assess the prevalence, duration and amount of exposure, the precise risk each environment factor poses is hard to define [38].

Bacterial infections in a sheep farm are common clinical and subclinical findings. Some of the common respiratory commensal bacteria include Pasteurellaspp [39], Staphylococcus *spp,* Streptococcus pneumonia [30]. *Mycoplasma spp, P. multocida*, *M. haemolytic* and Chlamydia spp are associated with either primary or secondary bronchopneumonia in sheep. Not all factors predisposing to respiratory disease are known, but viral infections in susceptible animal can alter the protective mechanism of the respiratory tract so that the opportunistic bacteria can invade the lung tissue [36].

Combined effects of ammonia and bacterial endotoxins predispose the animals to respiratory infections with viruses and bacteria, both primary pathogenic as well as opportunistic species. Viruses are believed to predispose to bacterial infections in two distinct ways. The first, viral agent can cause direct damage to the respiratory clearance mechanism and translocation of bacteria from the upper respiratory tract. The second way, viral infection can interfere with the immune system's ability to respond to bacterial infections. The viruses can affect the leukocytes causing impairment of their function which result in increased susceptibility to infection of *Mannheimia haemolytica* [41].

As the management practices become more intensive the level and risk of pneumonia become much greater. Overcrowding or close contact allows for rapid spread of infectious organisms from one lamb to the next. Intensive management also leads to a buildup of pathogens in the environment. Manure in sheds also leads to the production of ammonia which irritates and damages the respiratory mucosa and reduces the sheep's ability to fight the infection. In shed or semi-confinement operations the disease will peak towards the end of the lambing season. Extreme weather, drought, shipping/ transportation, may contributes for the outbreak of the disease by initiating and increasing the amount of "Barn cough", a term used to describe a non-productive hacking cough in growing and finishing lambs. Lung worm larvae migrating through the alveoli and bronchioles produce an inflammatory exudate, which may block small bronchi and bronchioles. Secondary bacterial pneumonia and concurrent viral infections are often complications of lung worm infections [42].

**Integrated Management Strategies for the Control of Respiratory Disease Complex:** The identification of predisposing factors and confirmation of the causal pathogens are key steps in designing a control programme for the successful treatment and management of respiratory disease in sheep, particularly when dealing with an outbreak. The causes of respiratory diseases in sheep of any age have been broadly described as adverse physical and physiological stresses, combined with viral, bacterial or parasitic infections. The prevention and control of respiratory diseases in sheep is therefore based on minimizing these factors, combined with strategic prophylactic treatments or vaccinations to reduce the impact of the causal respiratory pathogens [21].

**Chemoprophylaxis:** One injection of long-acting oxytetracycline (20 mg/kg of a 200 mg/ml solution intramuscularly) is usually effective in very early cases or for prophylactic treatment and provides four days of cover. Some cases will need retreating after three to four days. Tilmicosin and penicillin-based antimicrobials can also be effective, although not all *Mannheimia/ Pasteurella* strains are sensitive to penicillin. In severely affected cases, the use of a non-steroidal anti-inflammatory drug (NSAID) together with an antimicrobial can increase treatment success [43, 44].

Mycoplasmas are sensitive to macrolide and newer fluoroquinolone antibiotics and are potentially less sensitive to penicillin. However, evidence of macrolide antibiotic resistance has been demonstrated in some

isolates. Recent studies to investigate the efficacy of fluoroquinolone antibiotics (difloxacin and dano-floxacin) against various respiratory pathogens in sheep, including *M. ovipneumoniae*, have produced promising results [45], although these products are not licensed for use in this species. As it is known no effective antibiotic treatment for viral agents discovered yet.

**Immonoprophylaxis:** Because *Mannheimia haemolytica*is the most common bacteria involved in cases of acute pneumonia as a primary or secondary infection, prevention and treatment focusing on this organism will often reduce losses due to respiratory disease syndrome. Booster vaccination of ewes four to six weeks before lambing allows lambs to acquire antibody protection from colostrum for the first three to four weeks of life. Lambs may need booster vaccinations at times of peak risk (e.g., at weaning). The primary vaccination course consists of two injections four to six weeks apart, with protective antibody levels achieved two weeks after the second injection [21].

Commericial vaccinations are available for, PPR and pasteurellosis/mannheimiasis, but no vaccines specifically designed for use in sheep for Mycoplasmal, SPA and Maedi-visna infections [16]. Hence, improved management reduces the problem. The vaccines should be given strategically, especially prior to peak disease season and before transportation.

**Strategic Deworming:** A strategic deworming approach involves more than administering a dewormer annually. It is about knowing when parasites could be compromising the health of the animal. Timing is critical for strategic deworming. *Dictyocaulus filaria* infections most commonly occur from ingestion of overwintered larvae in May and development to L3 occurs only in between spring and autumn [42]. Thus a strategic deworming program should aim to interrupt the lifecycle of the parasite within this time interval. To do that, Farmers should deworm their herd twice a year, once just before the rainy season and again after the rainy season [46].

Several drugs are useful to treat lungworms. The benzimidazoles (fenbendazole, oxfendazole and albendazole) and macrocyclic lactones (ivermectin, doramectin, eprinomectin and moxidectin) are frequently used in sheep and other animals. They are effective against all stages of Dictyocaulus species. Levamisole is used in cattle, sheep and goats, but treatment by this drug may need to be repeated 2 weeks later because it is less effective against larvae during the early stages [36].

Good Husbandry Practice: Measures such as, improving management practices by providing optimal sanitation and air quality in housing, minimizing transportation stress, providing good quality hay and water and supplement as appropriate should be taken into account to reduce the prevalence respiratory disease [13].

To have a healthy sheep herd, a large number of husbandry/management practices is required in any sheep farming system. The consequences of not performing certain husbandry procedures may result in far more pain and distress to the animal than the procedure itself. All reasonable precautions should be taken to minimize the effects of weather that produce either cold stress or heat stress in sheep. Freshly shorn sheep and newborn lambs are particularly susceptible. Windbreaks to reduce the effects of cold may be provided in the form of scrub or planted trees, long grass or artificial shelter [47].

## CONCLUSION

In this review, respiratory diseases complex appeared as a significant disease problem in sheep in Ethiopia, especially in the highland region of the country. The etiopathogenesis is very complex that involved many bacterial, viral and parasitic agents along with environmental and managemental stressors. Sheep management and husbandry practices have a great role in the initiation and progress of respiratory disease. Distribution of respiratory disease is related to the harsh environments, host immunity and available pathogens and management practices. Since several of the pathogens do not appear to cause respiratory disease individually, many of these diseases can be prevented by good management of the herd, which includes improved hygiene, nutritional management and vaccination against some diseases.

Due to involvement of multiple agents, confirmatory diagnosis of respiratory disease complex is difficult and economically not justifiable. Thus it seems very important to understand the exposure-host-environment interaction in order to take appropriate intervention. Based on the above conclusion the following general recommendations are forwarded:

- Poorly ventilated or draughty barns should be avoided.
- Farmers should be advised to deworm their herds prior to rainy season by using suitable prophylactic and curative anthelmenthics and grazing areas should be rotated.

- There should be regular vaccination programme against Mannheimaia, Pasteurella and PPR.
- The vaccine for *Mannheimi ahemolytica* should contain the most prevalent serotype.
- Wet and windy sites that induce stress and encourage overcrowding should be avoided.
- Priority should be given for lambs, pregnant and intensively managed animals which are supposed to be at a relatively higher risk for the disease.
- Newly introduced sheep with unknown health status should be isolated from the existing herd and existing groups of animals should be housed according to their age, size and origin.

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