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Review Article

Major respiratory diseases of goat and their epidemiology, prevention and control

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Abstract

Goats and sheep have the capacity to provide meat, milk, leather, and wool, making them valuable assets for the global livestock business, particularly in Southeast Asia, the Mediterranean region, and African nations. Respiratory diseases are the primary cause of death for these animals, accounting for about half of their deaths. Whatever their causes, goat and sheep infectious respiratory diseases account for 5.6% of all small ruminant diseases and disorders. Most of these have an infectious origin, particularly those that are bacterial, parasitic, fungal, or viral. PPR, caprine arthritis encephalitis, and bluetongue are the main viruses that cause respiratory diseases in goats. Through the use of a roadmap, the World Organization for Animal Health (WOAH) has established a global strategy for the eradication of PPR from the planet by 2030. Conversely, the two main bacterial causes of respiratory diseases are Pasteurella and Mycoplasma species, which can co-infect viral disorders or act as the primary cause. They can also exacerbate existing infections and lead to incorrect diagnoses. Numerous surveillances identified fungal infections, particularly Aspergillosis and Conidiobolomycosis, as well as parasite infections such as nasal myiasis and verminous pneumonia. In the review paper, we provide the most recent updated results on such diseases and their causative agents, taking into account elements such as distribution, transmission, spatiotemporal dynamics, possible risk factors, clinical signs and symptoms, treatment, avoidance, and control methods. Lastly, we offer some particular suggestions for addressing the respiratory conditions that affect goats.

Key words: Goat, Respiratory disease, Bluetongue, Pasteurellosis

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Introduction

Goats play an important role as providers of nutrition, food security and socio-economic status to their human owners in many low-income Asian countries, especially the landless small holder farmers in tropical countries (Liang *et al.*, 2019). In Bangladesh, the livestock sector has emerged as one of the key components of national as well as agricultural growth with

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an annual contribution of 1.85% of the national GDP and 16.52% share in the agricultural GDP (DLS, 2023). Goat is one of the major economically important livestock species in Bangladesh with a population of about 26.95 million representing 47.15% of Bangladesh's total ruminant population (DLS, 2023). The popularity of goat rearing is being increased in Bangladesh for fulfilling the growing demand of animal protein. But, hot and humid conditions in Bangladesh favour various diseases that impairs the productivity of animals and incurs veterinary costs (Rakib *et al.*, 2022; Rahman *et al.,* 2020; Munsi *et al.*, 2018). Respiratory diseases of goats and sheep are multifactorial (Lacasta *et al.*, 2008) and there are multiple etiological agents responsible for the respiratory disease complex. In small ruminants, respiratory infections are among the major causes of mortality and subsequent economic losses (Chakraborty *et al.*, 2014). In the USA, the respiratory disease-associated economic loss was estimated to be more than one billion dollars (Nicolas *et al.*, 2008). Interestingly, infectious respiratory disorders of sheep and goats are involved in 5.6% of the total small ruminant diseases and represent approximately 50% of the global death rate (Kumar *et al.*, 2014). Goats and sheep exhibit increased susceptibility to respiratory diseases, including bacteria, viruses, parasites, and fungi, primarily due to inadequate management practices that render these animals more vulnerable to infectious agents. Diseases of the respiratory tract can affect individuals or groups in sheep and goat flocks, resulting in low body weights and an increased death rate (Chakraborty *et al.*, 2014). The aforementioned phenomenon leads to significant economic losses for individuals engaged in shepherding and goat keeping, reflecting a decline in the production of meat, milk, and wool, as well as a decrease in the number of offspring. The presence of unfavourable weather conditions, hence inducing stress frequently contributes to the development and manifestation of multiple diseases. The unfavorable situation arises when both bacterial and viral infections coexist, especially in adverse environmental circumstances (Lacasta *et al.*, 2008). Furthermore, it has been observed that animals that are immunodeficient, being pregnant, lactating, or of old age are particularly susceptible to respiratory infections caused by various pathogens such as *Streptococcus pneumoniae, Mannheimia haemolytica, Bordetella parapertussis, Mycoplasma* species, *Arcanobacterium pyogenes,* and *Pasteurella* species (Brogden *et al.*, 1998). Infections of this type present a significant challenge in the context of the intensive rearing of sheep and goats. Diseases such as Peste des Petits Ruminants (PPR), ovine pulmonary adenomatosis, and bluetongue have a detrimental impact on global trade (Chakraborty *et al.*, 2014; Kumar *et al.*, 2014), consequently hindering economic growth.

However, there is a limited amount of research available on respiratory disorders in goats, and there is a shortage of comprehensive information regarding the present prevalence and distribution of these diseases across a greater geographical area. This work presents a comprehensive overview of various important respiratory diseases affecting goats, with particular emphasis on the context of global as well as Bangladesh. Our effort in this subject has been focused on reviving the study of disease dynamics, covering epidemiology, pathophysiology, present situation, and future possibilities, with a particular emphasis on diagnostics, treatments, and prophylactics, as well as forthcoming problems or threats. This study reviewed and summarized goat respiratory diseases literature to identify gaps and make recommendations for sustainable goat production in Bangladesh and abroad.

Methodology

The review of various studies holds significant importance in the development of control and preventative strategies. The authors carefully reviewed the currently available knowledge on these important respiratory diseases which were collected and downloaded from various sources. Then provided an in-depth discussion regarding the present prevalence and distribution of these diseases, present situation, particular emphasis on diagnostics, treatments, and prophylactics measures of their implications within the global and Bangladeshi scenario.

Respiratory Diseases of Goat

The classification of infectious respiratory diseases in goats and sheep depending on the involvement of the etiological agents (Kumar *et al.*, 2014; Bell, 2008):

- Bacterial diseases: Pasteurellosis, Mycoplasmosis, Ovine progressive pneumonia, Enzootic pneumonia, and Caseous lymphadenitis
- Viral diseases: PPR, Bluetongue, Caprine arthritis encephalitis (CAE) virus, and Parainfluenza
- Parasitic diseases: Nasal myiasis and Verminous pneumonia
- Fungal diseases: Fungal pneumonia (Conidiobolomycosis, Aspergillosis)

Frequently, the existence of environmental stress, immunosuppression, and inadequate management procedures can lead to a greater susceptibility of sick individuals to secondary pathogens. Additionally, the occurrence of mixed infections involving many causes is a frequently observed phenomenon (Chakraborty *et al.*, 2014; Scott, 2011). These diseases mostly affect the respiratory tract, with lesions localized either in the upper or lower respiratory tract of the animals (Chakraborty *et al.*, 2014; Daniel *et al.*, 2006). Therefore, these diseases can be divided into the following categories: (Bell, 2008)

Diseases of the upper respiratory tract, namely, nasal myiasis and enzootic nasal tumors, mainly remain confined to sinus, nostrils, and nasal cavity. Various tumors like nasal polyps (adenopapillomas), squamous cell carcinomas, adenocarcinomas, lymphosarcomas, and adenomas are common in upper respiratory tracts of sheep and goats. However, the incidence rate is very low and only sporadic cases are reported.

Diseases of the lower respiratory tract, namely, PPR, parainfluenza, Pasteurellosis, Ovine progressive pneumonia, mycoplasmosis, caprine arthritis encephalitis virus, caseous lymphadenitis, verminous pneumonia, and many others which involve lungs and lesions, are observed in alveoli and bronchioles.

The morbidity and mortality rates in animals of all age groups can vary depending on the severity of the infections and the physical condition of the infected animals. These diseases, either alone or together with other related conditions, may appear as either acute or chronic in nature, and they pose a substantial threat to the livestock industry, resulting in major economic losses (Chakraborty *et al.*, 2014). Therefore, respiratory diseases can also be categorized based on the disease onset and duration, as shown below (Bell, 2008):

(1). Acute: PPR, Pasteurellosis, Bluetongue, and Parainfluenza,
(2). Chronic: Mycoplasmosis, Verminous pneumonia, Nasal myiasis, and Enzootic nasal tumors,
(3). Progressive: Ovine progressive pneumonia, Caprine arthritis encephalitis virus, Caseous lymphadenitis, and Pulmonary adenomatosis.

Important Viral Respiratory Diseases

Peste des petits ruminants (PPR)

Peste des petits ruminants (PPR) are a highly contagious viral disease akin to rinderpest, afflicting goats, sheep, and certain wild ruminants, with camels among the carriers (Kinne *et al.,* 2010). PPR is marked by high morbidity and mortality and it can reach up to 5–90% and 50–80%, respectively (Chowdhury *et al.*, 2014).

The major clinical signs of PPR affected goats are high fever, depression, mucopurulent discharges from the eye and nose and mouth; acute diarrhea; enteritis; bronchial pneumonia; and erosive stomatitis (Rahman *et al.*, 2020; Chowdhury *et al.*, 2014). A higher frequency of PPR infection is reported during the summer season than other seasons (Rahman *et al.*, 2020). Crucially, it doesn't affect humans. It affects 30 million animals across 70 nations, causing annual economic losses of up to USD 1.2 to 1.7 billion, endangering the livelihoods, food security, and employment of 300 million families, while impeding national and regional development (FAO-OIE, 2015).

Nationwide intensive risk factors and space-time cluster analysis of PPR in Bangladesh found that 27.6% of cases occurred during the monsoon season, with varying proportions by division (Chowdhury *et al.*, 2014). Five space-time clusters and nine hotspots were identified, and PPR incidence remained high in certain regions.

The worldwide eradication of PPR by 2030 is a realistic and cost-effective endeavor. PPR is easily diagnosed, and a single vaccine dose confers lifelong immunity, while the virus has a short survival period outside a host, making it a prime target for eradication efforts (WOAH, 2016). International consensus, political support, technical feasibility, and the successful partnership between FAO and OIE, notably in eradicating rinderpest, all enhance the prospects for success in the global PPR eradication program. The program consists of 04 (four) stages, starting from epidemiological assessment (stage 1) and culminating in OIE-recognized freedom from PPR (stage 4) (Figure 1). Countries are categorized as "below stage 1" when no epidemiological data is available or "beyond stage 4" when OIE recognition is attained (FAO-OIE, 2015). Bangladesh is actively participating in the PPR Global Eradication Program (2015–2030) and has assessed its progress using the PPR Global Control and Eradication Strategy (GCES), placing it at Stage 2. The country aims to achieve PPR-free status by 2025 (Samad *et al.,* 2019). Despite various control efforts, Bangladesh has experienced recurring PPR outbreaks, causing substantial economic losses predicted US$25 million for small-scale livestock farmers (Begum *et al.,* 2018).

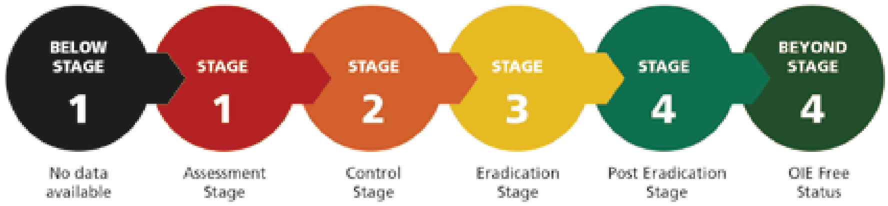

Figure 1. The phases of the worldwide PPR eradication initiative, as outlined by the World Organization for Animal Health (WOAH), leading to a country's official recognition as free from PPR

To effectively combat the disease, it's crucial to understand the virus's pathobiology and molecular evolution. Molecular analysis, particularly of the N gene sequence, has revealed the presence of lineage IV PPRV strains in Bangladesh closely linked to isolates from neighboring countries like Nepal, China, India, Bhutan, and Tibet indicating potential transboundary animal movement (Nooruzzaman *et al.*, 2021; Rahman *et al.,* 2018). PPRV has a single serotype but is divided into four genetic lineages (Banyard *et al.*, 2010). Lineages I and II are in western and central Africa, lineage III is in eastern Africa and the Arabian Peninsula, and lineage IV spans South Asia, the Middle East, and recent parts of Africa (Clarke *et al.*, 2018). Lineage IV reached South Asia, starting in 1987 in southern India and subsequently spreading to Bangladesh in 1993 (Islam *et al.*, 2001), Pakistan in 1994 (Amjad *et al.*, 1996), and Nepal in 1995 (Dhar *et al.*, 2002). These lineages offer insights into the distribution of PPRV strains. Bangladeshi PPRVs, analyzed through phylogenetics, belong to lineage IV and are closely related to strains in China, Tibet (2007-2008), and India (2014-2018) (Nooruzzaman *et al.*, 2021). Predictive analysis identified sixteen epitopes in N, M, F, and hemagglutinin (H) proteins. Notably, N and M protein epitopes match existing vaccines, suggesting Bangladeshi strains could serve as local vaccine options (Nooruzzaman *et al.*, 2021; Rahman *et al.*, 2018).

Vaccination is crucial for Peste des petits ruminants (PPR) prevention. Live attenuated vaccines, such as Nigeria 75/1 (used in Africa and the Middle East) and India's lineage IV strains like Sungri 96, have been effective (Diallo *et al.*, 1989). Bangladesh has its own Titu strain, developed by the Bangladesh Livestock Research Institute, successfully used for PPR control for 20 years (Rahman *et al.*, 2011). There is no particular remedy for PPR, but addressing bacterial and parasitic complications can reduce mortality rates in impacted groups of animals. Additionally, providing supportive care, such as administering fluids, antibiotics, and PPR-specific hyperimmune serum, can lower the mortality rate in goats infected with PPR (Begum *et al.*, 2018). The global challenge of Peste des Petits Ruminants (PPR) in goat farming needs a comprehensive and integrated approach involving the development of suitable diagnostic methods, immunization strategies, and therapeutic protocols for effective mitigation and control.

Bluetongue (BT)

Bluetongue (BT), caused by the Bluetongue virus (BTV), affects goats and sheep and spreads through *Culicoides spp.* primarily (Qin *et al.*, 2018). Infected ruminants, including domestic and wild species, are susceptible. While cattle and goats might carry BTV without symptoms, sheep and deer often show clinical signs, sometimes leading to high fatality rates (Constable *et al.*, 2017). Goats infected with BTV-8 exhibit fever and mild symptoms like lameness and diarrhea. Trade restrictions and production losses, including mortality and reduced milk/meat output, result in significant economic impacts (Rushton and Lyons, 2015).

Bluetongue virus (BTV), comprising 27 serotypes and diverse strains, exhibits considerable genetic variability affecting its epidemiology. Classified as a "notifiable" disease by the WOAH, BTV impacts both animal health and the economy globally (WOAH, 2021). Present on all continents except Antarctica, the virus perpetuates in enzootic regions, maintaining transmission cycles among vectors and vertebrate hosts. Factors shaping BTV dynamics encompass host, vector, and virus genetics alongside environmental conditions. In goat flocks, morbidity averages 2.7%, mortality 1.2%, and a 45% case fatality rate, notably higher than in sheep (Allepuz *et al.*, 2010). Bangladesh, bordering BTV-endemic India, faces susceptibility due to livestock and Culicoides midge movements. Local factors like species, density, climate, and management practices significantly influence BTV transmission dynamics (Courtejoie *et al.*, 2018; Ali *et al.*, 2020). Temperature thresholds regulate outbreaks, while vector dispersal and host migrations facilitate disease transmission between herds.

Bluetongue virus (BTV) affects goats globally, with diverse seroprevalence rates reported across countries. BTV misdiagnosis is common due to clinical similarities with diseases like peste des petits ruminants (PPR), foot rot, foot and mouth disease, pox, and contagious ecthyma (Rahman *et al.*, 2018). Diagnosis involves molecular methods like ELISA, PCR, serum neutralization tests (SNT), and real-time PCR, aiding in early detection and serotype-specific identification, albeit with varied sensitivities, costs, and time requirements (Mars *et al.*, 2010). These diagnostic tools are vital for monitoring and controlling BTV in livestock populations. Effective bluetongue control involves prevention, supportive care, and vaccination movement restrictions around infected farms helped manage outbreaks (Ensoy *et al.*, 2013). An inactivated vaccine from an Italian bluetongue virus isolate demonstrated success in vaccinated animals (Emidio *et al.,* 2004). Treatment for affected animals focuses on rest, soft food, and managing secondary infections during the healing phase.

Caprine Arthritis and Encephalitis (CAE)

Caprine arthritis-encephalitis is a fatal, widespread multisystemic inflammatory viral disease which is responsible for major production loss in goats (Olech *et al.*, 2020). The causative agent of the disease, caprine arthritis-encephalitis virus (CAEV), is a lentivirus within the group of small ruminant lentivirus (SRLV) belonging to the retroviridae family and subfamily Orthoretrovirinae (Jesse *et al.*, 2018; Thomann *et al.*, 2017). Lentivirus infections cause progressing and fetal infections in different target organs includes carpal joints, mammary glands, lungs and central nervous system (Thomann *et al.,* 2017; Didugu *et al.*, 2016). This might have made a detrimental impact on the amount of milk produced and raised the possibility of developing mastitis (Leitner *et al.*, 2010). In kids, the disease presents as encephalitis, whereas adult goats may experience severe indurative mastitis, arthritis, and occasionally interstitial pneumonia (Rahman *et al.*, 2023; Jesse *et al.*, 2018). Other clinical manifestations of CAEV infections encompass enlargement of the joint resulting in lameness, synovitis, and decreased growth rate have further been mentioned (Jesse *et al.*, 2018). The arthritic form exhibits a greater occurrence rate in goats, resulting in lameness and an enlargement of joint area (Souza *et al.*, 2015). The economic losses associated with the disease can be attributed to factors such as mortality resulting from clinical ailments, the reduced value of culled animals, the adverse effects of subclinical disease on productivity, and a reduction in the economic lifespan (Norouzi *et al.*, 2015).

Typically, the infection caused by the CAE virus has been observed to spread by both vertical and horizontal transmission routes (Jesse *et al.*, 2018; Thomann *et al.*, 2017). It has been observed that the CAE virus normally spreads both vertically and horizontally. Horizontal transmission arises through direct contact with infected animals, bodily fluids, and excretions; vertical transmission arises by consumption of contaminated milk or colostrums (Jesse e*t al.*, 2018; Thomann *et al.*, 2017). However, the mechanism of CAEV's sexual transmission remains unclear, in contrast to other lentiviruses (Al Ahmad *et al.*, 2008). CAEV cause disease mainly in goats. Once the virus enters the body, the host becomes permanently infected. In mixed populations, there have also been reports of natural cross-species transmission from sheep to goats and from goats to sheep (Gjerset *et al.*, 2009). There is no proof that the caprine arthritis-encephalitis virus (or any SRLV) may infect people. Following its first discovery in 1974 in goats, reports of CAE virus infection have been made in various countries globally (Cork *et al.*, 1974). The prevalence of infection in endemic regions can vary widely, ranging from < 5% to more than 60% and has been recorded from Thailand 5.52% (Nyi Lin *et al.*, 2011), Turkey 7.5% (Azkur *et al.*, 2011), Mexico 3.6% (Torres-Acosta *et al.*, 2003), Italy 40% (Gufler and Baumgartner, 2007), Malaysia 8.8% (Jesse *et al.*, 2018), Jordan 18. 5% (Hailat *et al*., 2022), Brazil 8.2% (Bandeira *et al.*, 2009), Iraq 8.69% (Hamzah and Mosa, 2020), India 4.5% (Didugu *et al.*, 2016), America 31% (De Groot *et al.*, 1993), Norway 42% (Nord and Ådnøy, 1997) and also in Bangladesh 4.26% (Rahman *et al.*, 2023).

The disease diagnosis incorporates a blend of clinical manifestations, postmortem results and histopathological observations (Jesse *et al.*, 2018). Serological testing is the primary tool used to detect the MV/CAEV virus because it takes into account the longevity of circulating antibodies against the virus. For serological diagnosing of CAEV, these procedures consist of indirect immunofluorescence, enzyme-linked immunosorbent assay (ELISA), and agar gel immuno diffusion (AGID) (Norouzi *et al.*, 2015). In practical applications, the most common serological test used to diagnose CAEV infection is the enzyme-linked immunosorbent assay (ELISA). Since ELISA is more sensitive than AGID, it is the preferred method (Jesse *et al.*, 2018).

There is currently no effective treatment or vaccination for this disease, but improvements in the quality and efficacy of diagnostic tests may be able to eradicate it (Norouzi *et al.*, 2015). Hence, there is neither a vaccination nor a treatment for CAE, so preventative measures are crucial. These include (i) separating kid from their seropositive dams as soon as they are born,

(ii) using heat-treated or SRLV-negative colostrum, (iii) increasing the culling rate, and (iv) conducting routine serological surveillance and separating seropositive goats right away (Cirone *et al.*, 2019). Antibiotics may be prescribed for secondary bacterial infections in cases of mastitis or pneumonitis (www.cfsph.iastate.edu). Therefore, the rapid diagnosis of the disease via a serological test remains an essential technique for controlling, preventing, and eliminating CAEV infection (Brinkhof e*t al.*, 2010).

Important Bacterial Respiratory Diseases

Pneumonic Pasteurellosis

Pneumonic pasteurellosis, commonly known as respiratory mannheimiosis, is a widespread and acute respiratory tract infection in ruminant animals, leading to significant financial losses due to death, reduced weight gain, delayed marketing, treatment costs, and reduced overall health among survivors (Dereje *et al.*, 2014). It is caused by bacteria from the Pasteurellaceae family, including *Mannheimia haemolytica, Biberstinia trehalosi,* and *Pasteurella multocida,* which become problematic when the host's defense mechanisms are compromised. These bacteria are typically commensals in the tonsils and nasopharyngeal microflora of healthy goats (Legesse *et al.*, 2018; Belege *et al.*, 2017). Pneumonic pasteurellosis is prevalent in both temperate and tropical regions worldwide, affecting goats in hot, humid lowland areas as well as highlands, leading to high morbidity and mortality rates (Belege *et al.*, 2017). While *M. haemolytica* is mostly limited to ruminants, *P. multocida* has a broader host range (Quinn *et al.*, 2002). Many species within the Pasteurellaceae family colonize the mucous membranes of the genital, respiratory, and alimentary tracts in various mammals, birds, and reptiles. Controlling and preventing pneumonic pasteurellosis is essential for preserving the health and productivity of ruminant livestock (Dousse *et al.*, 2008). Pasteurellosis, or pneumonic pasteurellosis, spreads through inhalation of infected droplets coughed up or exhaled by infected animals, affecting both carriers and clinical cases. *Mannheimia haemolytica* and *Pasteurella multocida,* typically upper respiratory commensals, can become opportunistic pathogens when animals are immunocompromised (Belege *et al.*, 2017). Aerosols serve as a means of exogenous transmission (Quinn *et al.*, 2002). These bacteria are highly sensitive to environmental factors, making conditions crucial in disease spread. Goats, with their group-rearing and huddle-prone behavior, are particularly susceptible to contagious diseases (Chakraborty *et al.*, 2014). Pneumonic pasteurellosis in goat manifests with a wide range of clinical symptoms, including intermittent coughing, sudden death, or acute respiratory distress (Afata, 2018). Clinical signs usually appear within 10-14 days of stress exposure, although earlier onset is common. In acute outbreaks, the clinical course is relatively brief, lasting 2-3 days, resulting in death, recovery, or treatment-related outcomes. Infected goats exhibit dullness, reduced appetite, depression, high fever, coughing, nasal discharge, and anorexia, with productive coughs developing later in most cases (Legesse *et al.*, 2018; Mohamed and Abdelsalam, 2008). Dyspnea with an expiratory grunt can be observed in advanced stages. Pneumonic pasteurellosis may cause severe bronchopneumonia, pleurisy, septicemia, and acute febrile courses. Young goats are more susceptible, and severe infections can lead to sudden death (Mohamed and Abdelsalam, 2008). The disease primarily arises from physical or physiological stress due to unfavorable environmental and climatic factors, such as extreme weather, poor management, crowded living conditions, inadequate transportation, or prior infections with respiratory viruses or mycoplasma (Belege *et al.*, 2017; Dereje *et al.*, 2014). Pneumonic pasteurellosis mainly affects animals with compromised lung defenses and can lead to morbidity rates of up to 35% and case fatality rates ranging from 5% to 10% in small ruminants (Belege *et al.*, 2017). The prevalence of pneumonic pasteurellosis varies in different countries, with rates reported from 22.8% to 58.13% in India (Makwana *et al.*, 2022), 4% for *Pasteurella multocida* and 2.6% for *Mannheimia haemolytica* in Iraq (Ahmed *et al.*, 2022), and rates ranging from 21.9% to 44% in Ethiopia (Assefa *et al.*, 2018). In Bangladesh, various studies have reported the presence of Pasteurella spp. and *P. multocida* and *Mannheimia haemolytica* in pneumonic goats, with prevalence rates of 16.67% (Ahmed *et al.*, 2019), 20% (Sen *et al.*, 2018), 15% (Rashid *et al.*, 2013), 20% (Momin *et al.*, 2011), and 48.57 % (Rahman *et al.*, 2023) in different regions.

Pneumonic pasteurellosis is a significant concern affecting goat populations in many countries, leading to economic losses and necessitating proper management and control measures. These bacteria are typically part of the upper respiratory tract's microbiota and often coexist with other pathogens. Antibiotic resistance is a growing concern, making sensitivity testing critical (Kehrenberg *et al.*, 2001). Gentamicin and Ceftriaxone group were comparatively more sensitive group of antibiotics and some symptomatic treatments should be given (Rahman *et al.*, 2023). Effective control strategies include stress reduction, early diagnosis, antibiotic treatment, vaccination, and biosecurity measures (Afata, 2018). Vaccination is a practical and cost-effective approach, particularly in developing countries, although challenges exist due to multiple serotypes of Pasteurella and Mannheimia without cross-protection. Integrating these techniques is essential for effective pneumonic pasteurellosis control in goats and sheep (Belege *et al.*, 2017).

Contagious caprine pleuropneumonia (CCPP)

Contagious caprine pleuropneumonia (CCPP) is a highly transmissible and fast-spreading mycoplasmal respiratory disease affecting goat populations and causing significant financial damage in many parts of the world, especially in Africa and Asia (Yatoo *et al.*, 2019). The disease is caused by *Mycoplasma capricolum subsp. capripneumoniae,* formerly strain F38, a member of the Mycoplasma mycoides cluster (Ahaduzzaman, 2021). It is the smallest fastidious bacteria size is only 300nm which has a triple layer membrane but lacks cell wall (Wazir *et al.*, 2016). CCPP induced catastrophic harm through direct production losses like high infection rates, death of animals and reduced productivity or indirect losses such as treatment costs, monitoring, disease diagnosis, restrictions on trade and minimal animal price (Solangi *et al.*, 2023; Yatoo *et al.*, 2019). CCPP resulting from Mccp contributes to 100% morbidity in goat herds and 60–80% of mortality occurs (Solangi *et al.*, 2023). The disease is listed by the World Organisation for Animal Health (WOAH, 2020; Ahaduzzaman, 2021) as one of the diseases that must be reported. An estimated US$ 507 million is spent annually on CCPP worldwide (Yatoo *et al.*, 2019). Acute infection is clinically characterised by a high fever (40.5–41.5°C), anorexia, depression, dyspnea, difficulty breathing, coughing, grunting, and, within five days, the death of unrecovered animals (Teshome *et al.*, 2019; Yatoo *et al.*, 2019). Chronic and per-acute types are less frequent. When an infection is per-acute, animals can pass away from it in 1 to 3 days with no or few clinical symptoms; when it is chronic, symptoms are less apparent and include just minor nasal discharge and coughing that occurs after physical activity (Ahaduzzaman, 2021). Only domestic and wild ruminants are susceptible to CCPP and domestic goats are the primary CCPP hosts (Ahaduzzaman, 2021; Yatoo *et al.*, 2019). However, Teshome *et al.* (2019) have recorded cases of CCPP in sheep that are kept in close vicinity to goats. All ages and sexes of animals may be affected (Bölske *et al.*, 1996). Close contact with infected animals may transmit the highly contagious CCPP virus quickly through oculo-nasal discharge, bruising production, bare joints, feces, urine, and inhaling droplets that are contaminated (Ahaduzzaman, 2021; Yatoo *et al.*, 2019). In the acute stage of the disease, profuse mucopurulent to fibrinopurulent exudate develops in fibrinous pleuropneumonia, indicating that CCPP's pathogenicity is strictly restricted to the lungs and pleura (Wesonga *et al.*, 2004). No zoonotic importance exists for CCPP (Ahaduzzaman, 2021).

In CCPP, different methods are used for diagnosis. Pleural fluid, which has a high concentration of the pathogenic organism, and a portion of the infected lung at the interface between the affected and healthy tissues are the preferable samples for the diagnosis of CCPP (Ahaduzzaman, 2021). Appropriate diagnostic tests are then used to detect the antigen or antibody. Clinical samples from the nose, throat, pleural fluid, and lung tissue are subjected to the fast and effective polymerase chain reaction (PCR) method (Bölske *et al.*, 1996). Complement fixation test (CFT), counter-immunoelectrophoresis, enzyme-linked immunosorbent assay (ELISA), indirect hemagglutination (IH), and latex agglutination test (LAT) are further diagnostic tests for CCPP. Although culturing bacteria is challenging, the isolation of bacteria is regarded as confirmation of the causal agent. There is currently little epidemiological research on the frequency of CCPP. CCPP is a significant transboundary disease, and reports of the occurrence and prevalence of CCPP vary widely. The prevalence of CCPP was recorded from Somalia 49% (Abdi *et al.*, 2020), Ethiopia 7.1% (Gelagay *et al.*, 2007), Oman 28% (Hussain *et al.*, 2021), India 8.11% (Jain *et al.*, 2015), Nepal 3.37% (Adhikari *et al.*, 2022), Kenya 48.6% (Kipronoh *et al.*, 2016) and Tajikistan 10.1% (Amirbekov *et al.*, 2010). Because certain regions are endemic and some are neglected, prevalence estimations are frequently affected by the local epidemiological factors as well as the specificity and sensitivity of the diagnostic tests applied (Ahmed *et al.*, 2020). Different authors have reported on a variety of therapeutic studies using antibiotics with varying degrees of success, such as oxytetracycline and streptomycin, fluoroquinolones (e.g., danofloxacin), and the macrolide family (Dereje and Teshale, 2021; Yatoo *et al.*, 2019). But for treating local and systemic Mycoplasma infections in sheep, goats, cattle, and swine, macrolides, particularly tylosin are thought to be the most effective drug against Mccp (Yatoo *et al.*, 2019). Additionally, it was found that danofloxacin was very useful in treating clinical CCPP in goats (Ozdemir *et al.*, 2006). The primary methods used for CCPP prevention and control are vaccination, quarantine, limitations on movement, slaughtering exposed and sick animals, and complete cleaning and disinfection of the premises (Dereje and Teshale, 2021; Yatoo *et al.*, 2019). However, in most of these countries vaccines are not available currently. Worldwide efforts are needed to develop suitable diagnostic, preventive, and therapeutic strategies for the prevention and control of CCPP in order to combat this new and serious danger to goat husbandry internationally.

Important Parasitic Respiratory Disease

Verminous Pneumonia

Lungworm infection, known as verminous bronchitis or pneumonia, affects the lower respiratory tract due to various nematodes like *Dictyocaulus filarial, Protostrongylus rufescens,* and *Muellerius capillaris* (Zafari *et al.*, 2022). Clinical signs include coughing, dyspnea, and weight loss, varying based on infection severity, age, and immune status (Asmare *et al.*, 2018). Its prevalence in tropical regions averages 19-22%, with limited studies in Bangladesh. Pakistan and Turkey reported infection rates of 31% in sheep, 11% in goats (Ahmed, 2020), and 62.5% in post-mortem sheep exams, 45.1% in faecal investigations (McCarthy *et al.,* 2022). Diagnosis involves Baermann technique and ELISA tests, although interpretation complexities exist (Zafari *et al.,* 2022; Asmare *et al.,* 2018). Anthelmintic drugs and oral vaccinations are primary management methods, emphasizing preventive measures via grazing management to curb reinfection through larvae surviving on pasture or intermediate hosts like snails and slugs (McCarthy *et al.,* 2022).

Important Fungal Respiratory Disease

Aspergillosis

Pneumonia caused by *Aspergillus* spp. has been documented in goats, particularly in young individuals, resulting in symptoms such as lethargy, loss of appetite, coughing, difficulty breathing, and discharge from the nose. The fungi discussed in this study are responsible for producing many diseases, such as sinonasal and sino-orbital aspergillosis, diarrhoea, pneumonia, mastitis, and abortion in ruminant animals (Carmo *et al.*, 2014). The aetiology and epidemiology of a given phenomenon are of paramount importance in academic research and analysis. Understanding the underlying causes and factors contributing to the development and occurrence of a Fungi belonging to the taxonomic genus Aspergillus (order Eurotiales, family Trichocomaceae) are saprophytic organisms that have a broad distribution across several natural habitats. The transmission of spread takes place by the dispersion of spores in the form of aerosols, which can be found in soil, decomposing plant matter, and, on occasion, animal tissues. Aspergillosis, a disorder observed in goats, can manifest as a nasal form, leading to a decline in physical well-being due to necrosis of the nasal mucosa and nasal turbinate bones. This pathological process can ultimately result in significant respiratory distress (Elad and Segal, 2018). Cutaneous nodules, typically ranging from 0.3 to 3 cm in diameter, occasionally exhibiting ulceration, can be detected in the dorsal nasal region and ears. Prolonged utilisation of antimicrobials, concurrent presence of chronic ailments, and consumption of feed contaminated with mould have been identified as contributing factors in the development of pulmonary aspergillosis in ruminant animals. Mastitis caused by *Aspergillus* spp. has also been documented in goats. The hyphae of *Aspergillus* species exhibit a slender morphology, measuring between 3 to 12 um in width. They are characterised by their distinct separation, dichotomous branching pattern, and parallel margins. The staining of these entities can be achieved using the Periodic Acid-Schiff (PAS) and Gomori Methenamine Silver (GMS) techniques, as well as visualized in sections stained with Hematoxylin and Eosin (H&E) (Baker and Bennett, 2007).

Conclusion and Recommendations

Goats with respiratory diseases perform poorly in production and mortality, which costs farmers a lot of economic loss. Animal welfare is also significantly impacted by the diseases. In goats and sheep, respiratory disorders are frequently caused by unfavorable weather, physiological stress, bacterial, viral and parasitic infections. For the common respiratory diseases that afflict goat, it is crucial to evaluate clinical diagnostic techniques, treatment choices, and preventative measures critically. This paper reviewed the overall scenario of important respiratory diseases of goats in global and Bangladesh perspective. However, we can share specific recommendations for the prevention and control of respiratory diseases of goats are as follows:

- Keep the herd dry, clean and follow the good farm practice.
- Advances in early diagnosis of respiratory diseases of small ruminants lead to identification of affected animals and isolation from the herd.
- Control of the route of transmission of pathogens through proper farm biosecurity guidelines and herd management plan.
- Follow the proper quarantine guidelines during incorporating new animals to the herd.
- Strengthen and easy access to veterinary services of the farmers.
- Surveillance: regular surveillance of diseases and monitoring of disease trends is significant for correct policy decisions to prevent the respiratory diseases.
- Vaccination: regular vaccination against endemic diseases with a proper vaccination plan is quite important.

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