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Pasteurellosis in small ruminants and its epidemiology, prevention and control: A brief review

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Abstract

Small ruminant production contributes to the livelihood of small-scale farmers. However, the production is low due to several factors, including pneumonic pasteurellosis. The primary causes of infections are *Mannheimia haemolytica, Pasteurella multocida,* and *Biberstinia trehalosi.* It is of great importance at the national level. The disease is commonly transmitted through the air causing sporadic and epidemic pneumonia and septicaemia. Clinical signs include respiratory distress with high fever, coughing, difficulty breathing, and thick purulent nasal discharge. They typically occur in individuals with poor immunity. Weak management practices are often linked to stress. The disease incurs significant losses. The existence of many serotypes without cross-protection and the emergence of drug resistance have made its management more challenging. Furthermore, the causal agents are mostly organisms that reside in the upper respiratory tract but might lead to infection in those with reduced immune systems. Hence, it is crucial to prioritise appropriate selection of antimicrobials, reliable diagnosis, and the inclusion of relevant serotypes in developing vaccines to prevent and manage pneumonic pasteurellosis. (*Bang. vet.* 2023. Vol. 40, No. 1 – 2, 25 – 36)

Introduction

Globally, small ruminants are essential for the well-being of millions of people, particularly landless smallholders in Africa and Asia (Daphal *et al*., 2018). They need minimal inputs, including little starting capital, few resources, and low maintenance costs (Jibat *et al*., 2008). They contribute to the production of meat, milk, and wool and can proliferate quickly. Goats are referred as "the poor man's cow", highlighting their significance in developing nations (Chakraborty *et al*., 2014). Major sources of protein include meat and milk, while a substantial proportion of exports are skins, live animals, and carcasses (Chakraborty *et al*., 2014; Welay *et al*., 2018). In the economy of Bangladesh livestock contribute 1.6% of the total GDP, and 80% of rural people are directly or indirectly involved with livestock (Bangladesh Economic Review 2023).

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There are an estimated 24.8 million cattle, 1.6 million buffaloes, 26.9 million goats, and 3.8 million sheep in Bangladesh (DLS, 2022 - 23). Small ruminants constitute 53.8% of the ruminants in Bangladesh and the popularity of goat and sheep rearing is increasing for fulfilling the growing demand of animal protein (DLS, 2022-23). Hot and humid conditions in Bangladesh, however, favour various diseases (Rahman *et al.,* 2020). Production diseases and disorders in ewes and goats limit their profitability. Infectious diseases include *peste des petits ruminants*, goat and sheep pox, pasteurellosis, and brucellosis (Rassel *et al*., 2020; Islam *et al*., 2020; Rahman *et al*., 2023). Pneumonic pasteurellosis, an infectious disease of humans and many animal species, is economically important. Pneumonic pasteurellosis, (respiratory mannheimiosis) is the most prevalent respiratory tract infection in small ruminants, and leads to widespread financial losses because of death, reduced live weight, delayed marketing, and treatment costs (Hawari *et al*., 2008; Dereje *et al*. 2014; Rawat *et al*., 2019). Eradicating pasteurellosis would improve food security and livelihoods for millions of poor people around the world. In Bangladesh as well as globally there are insufficient efforts being made to document the epidemiology, diagnosis, prevention, and control of pneumonic pasteurellosis in small ruminants. This study provides a comprehensive overview of pneumonic pasteurellosis in small ruminants globally as well as in Bangladesh. This review is aimed to study epidemiology, diagnosis, prevention and control of pneumonic pasteurellosis globally.

Aetiology

Respiratory diseases in small ruminants can be caused by bacterial, viral, or parasitic agents in addition to other stressors (Chakraborty *et al*., 2014). Because of their diverse clinical presentations, the severity of the illnesses, and the resurgence of strains resistant to chemotherapeutic agents, bacterial agents have garnered significant attention (Nejiban and Al-Amery, 2018). The Pasteurellaceae contain the majority of respiratory pathogens in sheep and goats. When the body's defence mechanisms are compromised, infection is more likely (Mohamed and Abdelsalam, 2008; Daphal *et al*., 2018). *Mannheimia haemolytica, Biberstinia trehalosi*, and *Pasteurella multocida* are the primary causes of clinical infections in small ruminants (Quinn *et al*., 2002; Belege *et al*., 2017; Legesse *et al*., 2018). *M. haemolytica, B. trehalosi,* and *P. multocida* are frequently found in the tonsils and nasopharynx of healthy sheep and goats. These organisms are pleomorphic, tiny (0.2 x 1 - 2 µm), non-motile, non-sporing, fermentative, Gram-negative rods and coccobacilli, and are responsible for bronchopneumonia in goats of all ages (Dousse *et al*., 2008; Abdullah *et al.,* 2015; Legesse *et al*., 2018). The majority are catalase-positive, and oxidase-positive (Alemneh *et al*., 2016) and exhibit excellent growth in media supplemented with blood or serum although they can grow in media that is not enriched (Quinn *et al*., 2002; Brown *et al*., 2008). Previously, they were categorised as Pasteurella, but *Pasteurella haemolytica*, biotype A is now *Mannheimia* (Ahmed *et al*., 2017). *P. multocida* has 16 somatic types and 5 serotypes (A, B, D, E, and F) and three subspecies. Subspecies of *P. multocida septica* and of *P. multocida gallicida* have been identified (Jilo *et al*., 2020; Assefa *et al*., 2018). In poultry, *P. multocida* A causes fowl cholera, while in cattle, sheep, goats and swine pneumonic pasteurellosis is associated with serotype D and *P. multocida* B: 2 or E: 2 cause haemorrhagic septicaemia in cattle and buffalo respectively (Niemann *et al*., 2019; Daphal *et al*. 2018). *Mannheimia haemolytica* (formerly *Pasteurella haemolytica*) has two biotypes, A and T. Biotype A is split into 13 serotypes (A1, A2, A5, A6, A7, A8, A9, A11, A12, A13, A14, A16 and A17): These cause pneumonic pasteurellosis (shipping fever) in cattle, sheep and goats (Berhe *et al*., 2017). *P. trehalosi* (now called *Biberstinia treh*alosi) is subdivided into 4 serotypes (T3, T4, T10 and T15): all are responsible for pneumonic pasteurellosis in small ruminants (Legesse *et al*., 2018; Mitku *et al*., 2017). *B. trehalosi* is a ubiquitous commensal organism involved as a secondary and opportunistic bacterium in calf respiratory disease (Radostits *et al*., 2007). Pneumonic pasteurellosis in small ruminants is primarily caused by *P. multocida* and *M. haemolytica* in Bangladesh, *P. multocida* serotypes A, B and D being the most common serotypes (Rahman *et al*., 2023; Akther *et al*., 2023; Sarker *et al*., 2018).

Epidemiology

Pneumonic pasteurellosis is widely distributed in temperate and tropical regions of the world in small ruminants (Nicholas *et al*., 2008). The disease is more prevalent in hot, humid lowland regions, with high rates of morbidity and mortality (Belege *et al*., 2017). Pneumonic pasteurellosis is prevalent in the USA and Canada (Catry *et al*., 2005). In Europe, pasteurellosis is widespread in Netherlands, Germany, Italy, and France (Niemann *et al*., 2019; Holman *et al*., 2015; Pangallo *et al*., 2017; Weber *et al*., 2016). It is one of the most significant infectious diseases affecting cattle and buffaloes, and has a significant economic effect on the livestock industry in Southeast Asia, particularly in Bangladesh (Ievy *et al*., 2013).

Infection with Pasteurella can occur in almost all species of animal. Cattle are most susceptible, followed by pigs, sheep, goats, dogs, cats, birds, rabbits, and humans (Abera *et al*., 2023; Niemann *et al*., *2019*). Many species of the Pasteurellaceae family live on the mucous membranes of genital, respiratory, and alimentary tracts as commensal organisms (Dousse *et al*., 2008). *P. multocida* can infect a wide variety of hosts, whereas *M. haemolytica* is mainly limited to ruminants and *B. trehalosi* to sheep (Quinn *et al*., 2002; Berhe *et al*., 2017). The most vulnerable age range is six months to two years old, though all age groups can get the infection (Syaifudin *et al*., 2011). Pasteurellosis manifests as sporadic episodes in poultry and exotic animals (Sarangi *et al*., 2016).

Transmission

Pasteurella species are extremely sensitive to environment. When conditions are appropriate, the disease can spread quickly and infect a large percentage of the flock in a matter of hours, especially when animals are closely confined with insufficient ventilation (Radostits *et al*., 2007; Legesse *et al*., 2018). Small ruminants are particularly susceptible because their groups live close together (Chakraborty *et al*., 2014). Pasteurellosis is spread by inhaling droplets from infected animals, which can be carriers or clinical cases (Belege *et al*., 2017). Aerosols can transmit pneumonic pasteurellosis in small ruminants (Quinn *et al*., 2002). They may invade immunocompromised animals (Dousse *et al*., 2008).

Risk factors

Pneumonic pasteurellosis is exacerbated by stress triggered by environmental factors, such as bad weather, inadequate management, crowded living quarters, transportation, or prior infection with viruses, mycoplasma, or other organisms (Belege *et al*., 2017). Disease outbreaks are frequent during the rainy season because the moist conditions promote an organism's survival (Jilo *et al*., 2020). Endogenous factors, such as endotoxin, leukotoxin, fimbriae, and cell capsule, can enhance the pathogenicity of the organism and facilitate rapid invasion and destruction of the susceptible host's tissues (Belege *et al*., 2017).

Morbidity and Mortality

Pneumonic pasteurellosis primarily affects animals with compromised lung defences. Sheep and goats subjected to physical stress or unfavourable environments are more likely to develop the disease (Mohamed and Abdelsalam, 2008). In small ruminants, the morbidity can reach 35%, and the case fatality rate can vary from 5 to 10% (Belege *et al*., 2017).

Clinical signs

Pneumonic pasteurellosis in small ruminants can lead to a wide range of clinical signs, from intermittent coughing to sudden death (Afata, 2018). In adult animals, the clinical signs of acute respiratory distress typically appear 10 – 14 days after exposure to stress. According to Mohammed and Abdelsalam, (2008), the disease is brief (two to three days), ending in death or recovery. Infected animals exhibit extreme dullness, reduced appetite, high fever (42°C - 43°C), coughing, dyspnoea, muco-purulent nasal discharge, and anorexia (Legesse *et al*., 2018). In most infected animals, a productive cough usually develops later, accentuated by physical effort. When the disease is more advanced, marked dyspnoea with an expiratory grunt may be seen (Mohamed and Abdelsalam, 2008). Pneumonic pasteurellosis can cause severe fibrinous or fibrinopurulent bronchopneumonia, fibrinous pleurisy, and septicaemia. Those who survive a severe attack may develop a persistent infection (Beyene *et al*., 2017). Young animals are more vulnerable than mature ones, and they experience more severe infections that can cause sudden death (Mohamed and Abdelsalam, 2008). Fibrinous pleural and pericardial effusions, as well as ventral consolidation in the lungs' cranial lobes, are among the postmortem findings (Quinn *et al*., 2002). Generalized petechial haemorrhages particularly under the serosae, oedema of lungs and lymph nodes and subcutaneous infiltration of gelatinous fluid are common features (Kabeta *et al*., 2015).

Prevalence rate

In Ethiopia overall *Pasteurella* species were found in 25%, *Mannheimia haemolytica* in 87.5% and *Pasteurella multocida* in 12.5% of apparently healthy sheep (Marru *et al.*, 2013): pasteurellosis was found in 32.7% of goats (Girma *et al.*, 2023). In India *Mannheimia haemolytica* was found in 55.3%, and *Pasteurella multocida* in 7.9% of affected lungs of sheep (Sahay *et al.*, 2020), and in 22.8% (Puvarajan *et al.*, 2020) and 58.1% (Makwana *et al.*, 2022) *Pasteurella* spp. of affected lungs from goat. In Iraq, *Pasteurella multocida* was found in 4% and *Mannheimia haemolytica in* 2.6% (Ahmed *et al.*, 2023), 31.4% (Assefa *et al.*, 2018), 21.9% (Alemneh *et al.*, 2016), 36.5% of goats and in 56% of sheep (Rasha *et al.*, 2014). Pneumonic pasteurellosis has been reported in Bangladesh by many investigators where Pasteurella spp. were found in 48.6% of 51 pneumonic goats, but *Pasteurella multocida* was found in 29.4% and *Mannheimia haemolytica in* 70.6% (Rahman *et al.*, 2023). *Pasteurella multocida* was found in 8.6% and *Mannheimia haemolytica in* 30% of pneumonic sheep (Akhter *et al.*, 2023). *P. multocida* has been isolated from 16.7% of goats in Savar (Ahmed *et al.*, 2019), 20% of goats in Chittagong (Sen *et al.*, 2018), 3.3% of goats in Chittagong (Nath *et al.*, 2014), 15% of goat lungs in Mymensingh (Rashid *et al.*, 2013) and 20% of Black Bengal Goats (Momin *et al.*, 2011).

Economic significance

Small ruminants play a major role in livestock economy Bangladesh because of their ability to adapt to harsh conditions: they constitute 53.8% of the total ruminants (DLS, 2022 - 23). They make money through the export of live animals, meat, and skin. Significant financial losses are caused by diseases such as respiratory diseases (Islam *et al.*, 2020). Pasteurellosis is one of the most common disease of ruminants that causes high mortality and morbidity, treatment costs, reduced weight gain, delayed marketing and unthriftiness (Kumar *et al.*, 2015). Pneumonic pasteurellosis causing respiratory problems in small ruminants has a significant economic effect on the livestock industry in Bangladesh and worldwide (Ievy *et al.*, 2013).

Diagnostic Methods

Losses can be reduced by reliable diagnosis (Chakraborty *et al.*, 2014). A physical examination, clinical signs, a history of exposure to stress, and the identification of the aetiological agent, are helpful (Kumar *et al.*, 2015; Mekibib *et al.*, 2019).

Clinical signs

Inappetence, weight loss, nasal discharge, coughing, and sudden death, with a history of stress such as transportation, can be used to diagnose pasteurellosis (Radostits *et al.*, 2007).

Necropsy

Pneumonic pasteurellosis is characterised by a fibrinous pleurisy, catarrhal bronchitis, bronchiolitis, and a marked consolidation in the lungs. The cut surface of pneumonic lungs can show bleeding, necrosis, red and grey consolidation, and coagulation necrosis (Kabeta *et al*., 2015; Quinn *et al*., 2002).

Isolation and identification of bacteria

A lung or nasal swab specimen that has been pre-enriched in tryptone Soya broth can be incubated for 24 hours at 37°C in order to isolate Pasteurella. After being streaked onto blood agar with 5% sheep blood, the culture is incubated aerobically for 24 hours at 37°C (Marru *et al*., 2013). Following a light microscope examination of the morphology and Gram's staining, bacteria will be sub-cultured on MacConkey agar and blood agar containing 5% sheep blood (Alemneh and Tewodros, 2016; Afata, 2018). *P. multocida* colonies are round, greyish, shiny and non-haemolytic on blood agar. Colonies of some pathogenic strains are mucoid due to the production of thick capsules of hyaluronic acid. The colonies have a characteristic sweetish odour. All *P. multocida* are gram-negative, coccobacillary and do not grow on MacConkey agar. *M. haemolytica* and *P. trehalosi* colonies are haemolytic and grow on MacConkey agar and are odourless (Quinn *et al*., 2002; Alemneh and Tewodros 2016).

Serology

The composition of the LPS component of the cell membrane and the sugar content of the capsule are the bases for serotype differentiation. Diagnostic tests include the agar gel immunodiffusion, rapid slide/plate agglutination, and indirect hemagglutination (Munir *et al*., 2007).

Molecular identification

Polymerase Chain Reaction (PCR) is useful in overcoming limitations of the traditional biochemical and serological techniques and improving sensitivity and rapidity (Kumar *et al*., 2015; Daphal *et al*., 2018). Various nucleic acid-based techniques have been widely considered for molecular diagnosis and phylogenetic relationships within the Pasteurellaceae family. These tests are also used at the subspecies level. (Fulton and Confer, 2012). The multiplex PCR test can identify multiple bacteria in a single test. (Fulton and Confer 2012). Species-specific primers are performed to detect *Pasteurella* species. *P. multocida* can be identified through the detection of the KMT1 gene target. Similarly, *M. haemolytica* can be identified through the detection of the PHSSA and Rpt2 genes, while *B. trehalosi* can be identified through the detection of the LktA gene (Kumar *et al*., 2015).

Prevention and Control

Control of pneumonic pasteurellosis requires integration of multiple techniques (Disassa *et al*., 2013). *Pasteurella* and *Mannheimia* infections are challenging to treat for two reasons: first, the pathogens are typically not the only ones causing the infection, and second, the pathogens are evolving resistance to antibiotics. The antimicrobial sensitivity of the *Pasteurella* and *Mannheimia* isolates should be tested, and an appropriate antibiotic selected (Kehrenberg *et al*., 2001). Gentamicin and Ceftriaxone group were more effective than other antibiotics (Rahman *et al*., 2023). It is challenging to prevent the disease because these bacteria are commensals in the upper respiratory tract (Kehrenberg *et al*., 2001; Catry, 2005).

The key strategies for disease control include stress-reduction with good management, early diagnosis and antibiotic treatment, vaccination of healthy goats, and a biosecurity plan (Afata, 2018). The most effective way to control the disease is through vaccination (Abdullah *et al*., 2015; Disassa *et al*., 2013; Mitku *et al*. (2017). A challenge to developing a globally effective vaccine is the existence of multiple serotypes of both *B. trehalosi* and *M. haemolytica* without cross-protection (Belege *et al*., 2017).

Conclusions

Small ruminants are important in the economy of many countries. Pneumonic pasteurellosis is a complex disease caused by a multiple aetiologic agents. The disease results from interaction of stress, immunity and the bacteria that exist in the respiratory tract of vulnerable animals. Aerosol and close contact are the two main ways that pneumonic pasteurellosis is spread, and it causes a high mortality rate in housed animals and leads to huge losses and poses serious hazards in small ruminant farming. Control and prevention are therefore essential. Immunization, antibiotic therapy, and appropriate management are crucial in minimizing its effects. Accurate diagnosis is necessary for appropriate antimicrobial therapy to prevent the emergence of drug resistance, and vaccine development should take into account the circulating serotypes of the disease agent in Bangladesh and across the world.

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