OPEN ACCESS Freely available online

Journal of Tropical Diseases and Public Health

Review Article

Pasteurellosis Status in Ethiopia: A Comprehensive Review

Kula Jilo*, Tesfaye Belachew, Worku Birhanu, Dessalew Habte, Waktole Yadeta, Aden Giro

Addis Ababa University, Bishoftu, Ethiopia

ABSTRACT

Ethiopia has the largest national livestock populations in Africa. However, the productivity is one of the marginal due to a number of technical and non-technical factors. Infectious diseases like pasteurellosis are highly affecting livestock industry in the country. Pasteurellosis is a multifactorial disease caused by numerous etiologic agents. *Mannheimia haemolytica*, *Bibersteinia trehalosi* and *Pasteurella multocida* cause pasteurellosis in animals and humans. *Pasteurella* are commensal organisms of healthy animals which can be trigger with stress factors to cause fatal disease in farm animals. Infective agents acquired by inhalation of infected droplets or close contacts among susceptible animals. Pasteurellosis is responsible for huge mortality in feedlot animals worldwide. Haemorrhagic septicemia is an acute and characterized by sudden onset of fever, profuse salivation, severe dyspnea and death in about 24 hours whereas shipping fever causes severe broncho-pneumonia and pleurisy. The diagnosis of the disease is based on the clinical signs, gross pathological lesions, isolation of the pathogens and molecular characterization. Pasteurellosis is complex multifactorial disease difficult to control however, good management, chemotherapy, chemoprophylaxis and early immunization are control and preventive measures. In Ethiopia pasteurellosis is an endemic disease posing a serious threat to the animal productions. However, data on epidemiology, diagnosis, prevention and control is scarce. Therefore, a routine national wide survey encompassing multiple hosts and wider area should be undertaken to figure out prevalence and identify circulating serotypes in different agro ecology to design and implement appropriate interventions.

Keywords: Hemorrhagic septicemia; *Mannheimia haemolytica*; *Bibersteinia trehalosi*; *Pasteurella multocida*

INTRODUCTION

Ethiopia has the largest national livestock populations in Africa. However, the productivity is one of the marginal in the continent due to a number of technical and non-technical factors. Infectious diseases are among the technical factors affecting livestock productivity [1]. Among the infectious diseases affecting cattle industry, pneumonic pasteurellosis, is one of the common ones.

Pasteurellosis is a multifactorial disease caused by a numerous etiologic agent. *Mannheimia haemolytica*, *Bibersteinia trehalosi* and *Pasteurella multocida* are involve pasteurellosis in domestic animals including poultry [2]. *Pasteurella* are commensal organisms of the tonsils and nasopharynx of healthy animals; whereas stress factors can trigger the bacteria to move quickly invade the lungs and cause pasteurellosis in susceptible hosts. Transmission of agents of pneumonic pasteurellosis probably occurs by inhalation of infected droplet, coughed up or exhaled from infected animals which may be clinical case or recovered carriers in which the infection persists in the upper respiratory tract [3].

Hemorrhagic Septicemia is an acute and characterized by sudden onset of fever, profuse salivation, severe dyspnea and death in about 24 hours whereas shipping fever causes severe broncho-pneumonia and pleurisy [4]. Pneumonic pasteurellosis is responsible for huge mortality in feedlot animals accounting for approximately 30% of the total cattle deaths worldwide [5]. The diagnosis of the disease is based on the clinical signs, gross pathological lesions, isolation of the pathogens and molecular characterization [6].

Correspondence to: Kula Jilo, Addis Ababa University, Bishoftu, Ethiopia, E-mail: kula.jilo1@gmail.com

Received date: January 25, 2020; **Accepted date:** June 12, 2020; **Published date:** July 28, 2020

Citation: Jilo K, Belachew T, Birhanu W, Habte D, Yadete W, Giro A (2020) Pasteurellosis Status in Ethiopia: A Comprehensive Review. J Trop Dis 8:351. doi: 10.35248/2329-891X.20.8.351.

Pasteurellosis is complex multifactorial disease and difficult to control but good management, chemotherapy, chemoprophylaxis and early immunization are advisable control and preventive measures. In Ethiopia, a variety of serotypes of *Pasteurella* are endemic and posing a major threat of farm animal productions [7,8]. Attempts made towards documentation on the epidemiology, diagnosis, prevention and control pasteurellosis in Ethiopia is scant. Therefore, this review is aimed to made comprehensive manuscript on epidemiology, diagnosis, prevention and control measures of pasteurellosis in Ethiopia.

LITERATURE RIVIEW

Etiology

Pasteurellaceae is a gram-negative bacterium with facultative anaerobe, non-motile, non-spore forming, coccobacilli, and grow well at 37 °C on 5% sheep blood [9,10]. *Mannheimia haemolytica*, *Bibersteinia trehalosi* and *Pasteurella multocida* are etiological agents of pasteurellosis in animals including poultry. Based on lipopolysaccharide and capsular antigens *P. multocida* have 5 serotype (A, B, D, E, F) and 16 somatic type [11]. Currently three subspecies of *P. multocida* are recognized; *P. multocida* subspecies *multocida P. multocida* subspecies *septica* and *P. multocida* subspecies *gallicida* [12]. *P. multocida* A causes fowl cholera in poultry and pneumonic pasteurellosis in cattle, sheep and swine [13]. *P. multocida* B: 2 or E: 2 cause haemorrhagic septicaemia in cattle and buffalo respectively. *M. haemolytica* formerly named *Pasteurella haemolytica* has two biotypes A and T depending on arabinose and trehalose fermentation. A biotype is further subdivided into 13 serotypes (A1, A2, A5, A6, A7, A8, A9, A11, A12, A13, A14, A16 and A17) causes pneumonic pasteurellosis (shiping fever) in cattle, sheep and goats [14]. *P. trehalosi* is later renamed in to *Biberstinia trehalosi* which subdivided in 4 serotypes (T3, T4, T10 and T15) *B. trehalosi* is a ubiquitous commensal organism that involves in BRD as secondary and an opportunistic bacterium disease in calf's respiratory disease [15].

Transmission

Pasteurella species are highly susceptible to environmental influences and a close contact is an important factor in the spread of the disease [16]. Particularly, when animals are closely confined in inadequately ventilated trains or held for long periods in holding pens and feed lots, the disease may spread very quickly and affect high proportion of the herd within short period [17]. It is acquired through inhalation of infected nasal secretions, droplet, coughed up or exhaled from infected animals or recovered carriers in which the infection persists in the upper respiratory tract [3]. *P. multocida* infection in humans is often transmitted by animal bites, scratches or licks from cats or dogs [18].

Clinical signs

Hemorrhagic septicemia is an acute septicemimc disease characterized by a sudden onset of fever (41°C-42°C), profuse salivation, sub mucosal petechiation, severe depression, death in about 24 hours, localization may occur in subcutaneous tissue, resulting in development of warm, painful swellings about the throat, dewlap, brisket or perineum, severe dyspnea occurs if respiration is obstructed in ruminants [19]. At necropsy generalized petechial hemorrhages particularly under the serosae, edema of lungs and lymph nodes and subcutaneous infiltration of gelatinous fluid [1].

Pneumonic pasteurellosis or shipping fever is the disease that develops within 10-14 days after stress or arrived in feedlot and animals found dead without any previous warning signs may be the first sign of an outbreak, when viewed from distance affected cattle are depressed and respirations are shallow and rapid, a weak protective cough becomes more pronounced and frequent when urged to walk [20,21]. Mucopurulent nasal and ocular discharge, crusty nose, dyspnea, fever of 40°C-41°C temperature [1,5,22]. Necropsy findings is manifested by red and grey consolidation in lungs, catarrhal bronchitis, fibrinous pleurisy, coagulation necrosis of lungs and accumulation of large amounts of effusions and residual lesions of bronchopneumonia in chronic case [23-25].

Atrophic rhinitis of pigs is manifested by excessive lacrimation, sneezing, epitaxis, shortened snout, lateral deviation of the snout and facial deformities [26]. Fowl Cholera is causes welling of wattles discharges nostril, mouth and ocular discharges, laboured breathing, lack of coordination and greeyish diarrhoea [27]. The most common manifestation of pasteurellosis in humans is a local wound infection, usually following an animal bite or scratch which can develop into a serious soft tissue infection that can be further complicated by abscesses, septic arthritis and osteomyelitis [28]. *Pasteurella* also cause meningitis, ocular infections, and respiratory infections, usually in patients with underlying pulmonary disease [29].

Epidemiology

The geographical distribution of *Pasteurella* is worldwide. However, the microorganism is reported most frequently in Asia and Africa countries where sheep or goat breeding is widespread [30]. It is also common in USA and Canada where cattle breeding is also common [31]. In Europe, pasteurellosis widespread in many countries where sheep and cattle are present such as the Netherlands, Germany, Italy and France [13,32-34]. It has also a major impact on the livestock industry in countries of Southeast Asia especially in Bangladesh where a severe economic loss has been recorded and is ranked as one of the most important contagious disease of cattle and buffaloes [35].

Almost all species of animals including poultry are susceptible *Pasteurella* infection [36]. Host range susceptibility order includes buffaloes, cattle, pigs, sheep, goat, birds, rabbits, dogs, cats and humans [37]. All age groups can be infected but the most susceptible age group is 6 months up to 2 years of age [38]. Regarding temporal occurrence it is epidemic in poultry and exotic animals but pastreullosis is an endemic disease that occurs mostly in sporadic form [39,40]. Out breaks are associated with stressor factors include high temperature and humidity, concurrent infection (blood parasites or foot and mouth disease), poor nutrition, or work stress [10]. The

outbreaks of disease are common during the rainy season due to the multiple stressors present during this time and the moist conditions, which prolong the survival time of the organism in the environment [41].

Several studies have revealed that different serotypes of *Pasteurella* are widely spread in Ethiopia and posing a major threat to livestock production. *M. haemolytica* biotype A with serotype A1, A2 and A7 are most prevalent followed by A6 and A9 whereas A8, A12, A13, A14 are isolated in rare cases from Ethiopia [4,7,8,42]. However, serotype A16 and A17 are not reported yet from Ethiopia [5] Regarding *B. trehalosi* distribution; serotype T4 is commonly isolated followed by T15, T10 and T3 [8].

Economic importance of Pasteurellosis

Both morbidity and case-fatality rates vary between 50% and 100% respectively. Morbidity depends on the immune status of the herd, either acquired naturally or induced by vaccination. Outbreaks of the disease are often associated with wet humid weather during the rainy season and other stress factors. Pneumonic pasteurellosis is responsible for huge mortality in feedlot animals accounting for approximately 30% of the total cattle deaths worldwide [5]. In Ethiopia pneumonic pasteurellosis has been a topic of frustration to veterinary practitioners and a topic of liability to ruminant producers. It is a high-priority disease causing significant economic losses through mortality, morbidity, and the high cost of treatment [43].

Diagnosis of Pastuerellosis

Clinical signs: Pastuerellosis can be diagnosed with wide variety of clinical signs, ranging from occasional coughing to sudden death in sheep and cattle and nasal discharge, inappetence, weight loss and high temperature in the 40.4°C-42°C range with the history of stress like transportation [15].

Necropsy findings: Pneumonic pasteurellosis is manifested by marked consolidation involving the lungs, catarrhal bronchitis, bronchiolitis a fibrinous pleurisy the cut surface consists of several colors due to hemorrhage, necrosis and red and grey consolidation, coagulation necrosis of pneumonic lungs [44,45].

Isolation and identification: *Pasteurella* can be isolated by incubating lung or nasal swap pre-enriched in tryptose Soya broth specimen incubated for 24 hrs at 37°C. The collected culture is streaked on to blood agar base containing 5% sheep blood and incubated aerobically at 37°C for 24 hours. Then typical colonies subjected to gram's staining and cellular morphology under light microscope mixed and gram negative, coccobacilli bacteria will further sub cultured on both blood agar containing 5% sheep blood and MacConkey agar for isolation and characterization. Presence of haemolysis, the type of haemolysis, the general appearance of colonies will be analyzed and followed by biochemical and molecular tests for identification and characterization [43].

Serological techniques: Serotype differentiation is based on sugar composition of the capsule as well as the composition of LPS component of the cell membrane [6]. Indirect Hemagglutination test (IHA), Rapid slide/plate agglutination test and agar gel immunodiffusion test are common serological tests applied in diagnosis [46].

Molecular identification: Conventional Polymerase Chain Reaction (PCR) have been proved valuable to overcoming some limitations of the conventional biochemical and serological methods and better sensitivity and rapidity [23].

Prevention and control

Management: The most effective preventive method is good management and avoidance of stress and early diagnosis and antibiotic treatment are the key approaches of controlling disease within farm, especially during the first two to three weeks after arrival [31,44].

Treatment: Chemophylasis are still the tools of choice for prevention and control of the infections as *Pasteurella* is generally susceptible to antibiotics like penicillin and tetracycline [47]. However, Antibiotic susceptibility tests are important, since the organism has been found resistant to a variety of antibiotics such as: Ciprofloxacin, Chlortetracycline, Cotrimoxazole, Furazolidone, Lincomycin, Ampicillin, Augmentin, Kanamycin, Apramycin and Cefatoxime [46].

Vaccination: Experimental study indicated that vaccine against *M. haemolytica* A1 provides little or no cross-protection against *M. haemolytica* A2. Vaccines for *M. haemolytica* A2 have been against both septicemic and pneumonic forms of pasteurellosis gamma-irradiated *M. haemolytica* vaccine showed better protective efficacy than the commonly used formalin killed vaccine in laboratory animals as well as in sheep and hence could be potential alternative method of vaccine production against ovine pasteurellosis [46,48]. Gamma irradiated vaccines appear to be more effective than formalin killed vaccines against disease, and has the added advantage of a longer storage life than "live" vaccines [38]. In Ethiopia, recent studies indicated that most cases of ruminant pasteurellosis are caused by *M. haemolytica* and a monovalent vaccine inactivated *P. multocida* biotype B in bovine and inactivated *P. multocida* biotype A in ovine is being used for vaccination against pasteurellosis which cannot match to the actual causative agent [4,49,50].

CONCLUSIONS AND RECOMMENDATIONS

Pasteurellosis is a complex multifactorial disease caused by a combination of numerous etiologic agents worldwide. The disease primarily results from interaction of stress, immunity and the causative bacteria commensally resident in the respiratory tract of susceptible animals. Pneumonic pasteurellosis is transmitted with aerosol and close contact and responsible for huge mortality in feedlot animals accounting for approximately 30% of the total animal death and very difficult to control. Good management, chemotherapy, chemoprophylaxis and early immunization are advisable control and preventive measures. In Ethiopia, a variety of serotypes of *Pasteurella* are endemic and posing a major threat of farm animal productions. However, data on epidemiology, diagnosis, prevention and control is scarce. Therefore, a routine national wide survey encompassing multiple hosts and wider area should

be undertaken to figure out prevalence and identify circulating serotypes in different agro ecology to design and implement appropriate interventions.

REFERENCES

1. Kabeta T, Fikadu T, Zenebe T, Kebede G. Review on the pneumonic pasteurellosis of cattle. Acad J Anim Dis. 2015;4:177-184.
2. Abdelsalam E. A review on pneumonic pasteurellosis (respiratory mannheimiosis) with emphasis on pathogenesis, virulence mechanisms and predisposing factors. Bulg J Vet Med. 2008;11:139-160.
3. Tadesse B, Alamirew K, Ketema A, Kiflie W, Endashaw M. Ruminant pneumonic pasteurellosis: Review on epidemiology, pathogenesis and virulence mechanism. Acad J Anim Dis. 2017;6:30-39.
4. Yami B. Isolation, identification and antimicrobial susceptibility of Pasteurella multocida from cattle with hemorrhagic septicemia in Assosa and Bambasi districts, Benishangul Gumuz Regional state, Ethiopia. Int J Ani Res. 2017;9:2301.
5. Weiser GC, DeLong WJ, Paz JL, Shafii B, Price WJ. Characterization of Pasteurella multocida associated with pneumonia in bighorn sheep. J Wildl Dis. 2003;39:536-544.
6. Seleim RS. Major pathogenic components of Pasteurella multocida and Mannheimia (Pasteurella) haemolytica isolated from animal origin. 2005.
7. Abebe W. Isolation and identification of mannheimia haemolytica, bibersteinia trehalosi and pasteurella multocida from cattle and sheep from selected areas of Ethiopia. Vet World. 2018;11:636-641.
8. Deressa A, Asfaw Y, Lubke B, Kyule MW, Tefera G, Zessin KH. Molecular detection of Pasteurella multocida and Mannheimia haemolytica in sheep respiratory infections in Ethiopia. Int J Appl Res Vet Med. 2010;8:101-108.
9. Bisgaard M. Taxonomy of the family Pasteurellaceae Pohl 1981. Haemop Actinob Pasteurella Springer. 1995:1-7.
10. Bowles RE, Pahoff JL, Smith BN, Blackall PJ. Ribotype diversity of porcine Pasteurella multocida from Australia. Aust Vet J. 2000;78:630-635.
11. Hines ME, Kreeger JM, Herron AJ. Special topic overview mycobacterial infections of animals: pathology and pathogenesis. Lab Ani Sci. 1995;45:334-351.
12. Fegan N, Blackall PJ, Pahoff JL. Phenotypic characterisation of Pasteurella multocida isolates from Australian poultry. Vet Microbiol. 1995;47:281-286.
13. Niemann L, Feudi C, Eichhorn I, Hanke D, Müller P, Brauns J, et al. Plasmid-located dfrA14 gene in Pasteurella multocida isolates from three different pig-producing farms in Germany. Vet Microbiol. 2019;230:235-240.
14. Davies RL. Genetic diversity among Pasteurella multocida strains of avian, bovine, ovine and porcine origin from England and Wales by comparative sequence analysis of the 16S rRNA gene. Microbiol. 2004;150:4199-4210
15. Radostitis OM, Gay CC, Blood DC, Hinchcliff KW. Veterinary medicine, a text of the diseases of cattle, horses, sheep, pigs, and goats. Elsevier. 2007.
16. Wilkie IW, Harper M, Boyce JD, Adler B. Pasteurella multocida: diseases and pathogenesis, in: Pasteurella Multocida. Springer. 2012:1-22.
17. Legesse A, Abayneh T, Mamo G, Gelaye E, Tesfaw L, Yami M, et al. Molecular characterization of Mannheimia haemolytica isolates associated with pneumonic cases of sheep in selected areas of Central Ethiopia. BMC Microbiol. 2018;18:1-10.
18. Elane PI, Elane MPO. Pasteurellosis, 2019. Online Library.
19. Beyene TJ, Eshetu A, Abdu A, Wondimu E, Beyi AF, Tufa TB, et al. Assisting differential clinical diagnosis of cattle diseases using smartphone-based technology in low resource settings: A pilot study. BMC Vet Res. 2017;13:1-11.
20. Gemeda B, Desta H, Roesel K, Okoth E, Secchini F, Liljander A, et al. Interventions and tools to improve small ruminant health in Ethiopia. CGIAR. 2016;25:1-4.
21. Haji H, Abunna F. Epidemiology of Ovine Pasteurollosis in Lume District, East Shewa Zone of Oromiya Region, Ethiopia. Int Know Share Plat. 2016;6:12-20.
22. Berhe K, Weldeselassie G, Bettridge J, Christley RM, Abdi RD. Small ruminant pasteurellosis in Tigray region, Ethiopia: Marked serotype diversity may affect vaccine efficacy. Epidemiol Infect. 2017;145:1326-1338.
23. Kumar J, Dixit SK, Kumar R. Rapid detection of Mannheimia haemolytica in lung tissues of sheep and from bacterial culture. Vet World. 2015;8:1073.
24. Smith DF. Haemorrhagic septicaemia. Indian Vet J. 1947;24:132.
25. Tewodros A, Annania T. Sheep and goats pasteurellosis: Isolation, identification, biochemical characterization and prevalence determination in Fogera Woreda, Ethiopia. J Cell Anim Biol. 2016;10:22-29.
26. Garcia GJM, Bailie N, Martins DA, Kimbell JS. Atrophic rhinitis: a CFD study of air conditioning in the nasal cavity. J Appl Physiol. 2007;103:1082-1092.
27. Ali MZ, Sultana S. Determination of humoral immune response in chickens against formalin-inactivated alum-precipitated fowl cholera vaccine. Int J Anim Biol. 2015;1:114-117.
28. Abreu F, Rodríguez-Lucas C, Rodicio MR, Vela AI, Fernández-Garayzábal JF, Leiva PS, et al. Human Pasteurella multocida infection with likely zoonotic transmission from a pet dog, Spain. Emerg Infect Dis. 2018;24:1145.
29. Bardou M, Honnorat E, Dubourg G, Couderc C, Fournier PE, Seng P, et al. Meningitis caused by Pasteurella multocida in a dog owner without a dog bite: clonal lineage identification by MALDI-TOF mass spectrometry. BMC Res Notes. 2015;8:626.
30. Nicholas RAJ, Ayling RD, Loria GR. Ovine mycoplasmal infections. Small Rumin Res. 2008;76:92-98.
31. Catry B, Haesebrouck F, Vliegher S, De-Feyen B, Vanrobaeys M, Opsomer G, et al. Variability in acquired resistance of Pasteurella and Mannheimia isolates from the nasopharynx of calves, with particular reference to different herd types. Microb Drug Resist. 2005;11:387-394.
32. Holman DB, Timsit E, Alexander TW. The nasopharyngeal microbiota of feedlot cattle. Sci Rep. 2015;5:155-157.
33. Pangallo G, Bonilauri P, Gherpelli Y, Dottori M, Lorenzi G. Antimicrobial resistance in Actinobacillus pleuropneumoniae and Pasteurella multocida strains isolated during the period 2002-2016 in Italian pigs. Societá Italiana di Patologia ed Allevamento dei Suini (SIPAS). 2017:209-217
34. Weber DJ, Rutala WA, Kaplan SL, Calderwood SB, Edwards MS, Baron EL. Pasteurella infections. 2016.
35. Ievy S, Khan MFR, Islam MA, Rahman MB. Isolation and identification of Pasteurella multocida from chicken for the preparation of oil adjuvanted vaccine. Microbes Heal. 2013;2:1-4.
36. Fegan N, Blackall PJ, Pahoff JL. Phenotypic characterisation of Pasteurella multocida isolates from Australian poultry. Vet Microbiol. 1995;47:281-286.

37. Félix M, Tallón P, Salavert M, Navarro V, Bretón JR, Pérez-Bellés C, et al. Bacteriemia por Pasteurella spp.: una entidad infrecuente durante los últimos 8 años en nuestro centro. Enferm Infecc Microbiol Clin. 2003;21:334-339.
38. Syaifudin M, Tetriana D, Darlina D, Nurhayati S. The feasibility of gamma irradiation for developing malaria vaccine. Atom Indones. 2011;37:91-101.
39. Sarangi LN, Thomas P, Gupta SK, Kumar S, Viswas KN, Singh VP. Molecular epidemiology of Pasteurella multocida circulating in India by Multilocus sequence typing. Transbound Emerg Dis. 2016;63:286-292.
40. Wilkie IW, Harper M, Boyce JD, Adler B. Pasteurella multocida: diseases and pathogenesis, in: Pasteurella Multocida. Springer. 201:21-22.
41. Baker RB, Wilkins PA, Ames TR, Smith JA. Diseases of the respiratory system, in: Proceedings of the North Carolina Healthy Hogs Seminar. Clinton. 2005:1-19.
42. Awol N, Ayelet G, Jenberie S, Gelaye E, Sisay T, Nigussie H. Bacteriological studies on pulmonary lesions of camel (Camelus dromedarius) slaughtered at Addis Ababa abattoir, Ethiopia. African J Microbiol Res. 2011;5:522-527.
43. Marru HD, Anijajo TT, Hassen AA. A study on Ovine pneumonic pasteurellosis: Isolation and Identification of Pasteurellae and their antibiogram susceptibility pattern in Haramaya District, Eastern Hararghe, Ethiopia. BMC Vet Res. 2013;9:1-8.
44. Filion LG, Willson PJ, Bielefeldt-Ohmann H, Babiuk LA, Thomson RG. The possible role of stress in the induction of pneumonic pasteurellosis. Can J Comp Med. 1984;48:268.
45. Odugbo MO, Odama LE, Umoh JU, Lamorde AG. Pasteurella multocida pneumonic infection in sheep: Prevalence, clinical and pathological studies. Small Rumin Res. 2006;66:273-277.
46. Munir R, Shahwar D, Farooq U, Nawaz I, Shahzad I, Khanum A. Outer membrane protein profiling of Pasteurella multocida. Pak Vet J. 2007;27:1-7.
47. Kehrenberg C, Schulze-Tanzil G, Martel JL, Chaslus-Dancla E, Schwarz S. Antimicrobial resistance in Pasteurella and Mannheimia: Epidemiology and genetic basis. Vet Res. 2001;32:323-339.
48. Ahmed WA, Mohammed RJ, Khalaf IA. Molecular and phenotypical characterization of mannheimia haemolytica isolated from goats in Baghdad province. Adv Microbiol. 2017;7:304.
49. Berhe K, Weldeselassie G, Bettridge J, Christley RM, Abdi RD. Small ruminant pasteurellosis in Tigray region, Ethiopia: Marked serotype diversity may affect vaccine efficacy. Epidemiol Infect. 2017;145:1326-1338.
50. Davies RL. Genetic diversity among Pasteurella multocida strains of avian, bovine, ovine and porcine origin from England and Wales by comparative sequence analysis of the 16S rRNA gene. Microbiol. 2004;150:4199-4210.