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Occurrence of Caprine Pasteurellosis, Bacterial Isolates and their Sensitivity Pattern to Antimicrobial Agents in Oyo State, Nigeria

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ABSTRACT

Background and Objective: Pneumonic pasteurellosis is one of the clinically important diseases of small ruminants with great socio-economic impacts. As common as this condition is in Nigeria, there is no adequate data on its occurrence among indigenous breeds, sex and ages of goats vis-à-vis the prevalent bacterial organisms and their antimicrobial susceptibility. This study, therefore, investigates the occurrences, prevalent bacterial pathogens, and their antimicrobial sensitivity patterns of pneumonic pasteurellosis in Nigerian breeds of goats in Ibadan, Nigeria. **Materials and Methods:** Nasal swabs were collected from 62 pneumonic goats at Akinyele sheep and goat market (June-December 2023), with signalments and body condition scores documented. Bacterial isolates were identified using growth patterns on blood and MacConkey agars, Gram staining, and biochemical tests; Gram-positive cocci were further tested on Mannitol Salt Agar and by the coagulase test. Five isolates of each organism underwent antibiotic susceptibility testing according to CLSI guidelines. **Results:** Out of the overall 40/62 (64.52%) positivity, we observed 100% in West African Dwarf, 68.42% in Red Sokoto, and 54.55% in Sahel goats. Age distribution of positivity revealed 72.22% in adults and 53.85% in young goats. Female goats had 80% positivity compared to males with 57.14%. *Pasteurella multocida* (38.71%) was the most prevalent isolate culpable for the disease among the sampled subjects. This was followed by *Staphylococcus aureus* (35.48%), and lastly by *Mannheimia haemolytica* (25.81%). Antimicrobial susceptibility testing demonstrated that *P. multocida* was highly sensitive to cip September 1, 2025 rofloxacin, clindamycin, ofloxacin, and enrofloxacin but resistant to oxytetracycline and tylosin. *Mannheimia haemolytica* was very sensitive to enrofloxacin and sulphadimidine and moderately sensitive to ciprofloxacin. *Staphylococcus aureus* showed high sensitivity to gentamicin and moderate sensitivity to enrofloxacin, ciprofloxacin, erythromycin, and clindamycin. **Conclusion:** Pneumonic pasteurellosis is more common in the West African Dwarf breed, females, and adults compared to the Red Sokoto, males, and young goats in Nigeria. The most prevalent organisms are *Pasteurella multocida*, *Staphylococcus aureus*, and *Mannheimia haemolytica*. Enrofloxacin and ciprofloxacin are the best drugs of choice recommended for the treatment of pasteurellosis in Nigerian breeds of goats.

KEYWORDS

Pneumonic pasteurellosis, goats, *Pasteurella multocida*, antimicrobial susceptibility, Nigeria, enrofloxacin

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INTRODUCTION

Nigeria ranks first in the number of small ruminant herds in Africa. An estimated 76 million goats and 42.1 million sheep make up the Nigerian herd population, most of which are indigenous breeds[1]. Small ruminant farming plays a very crucial role in the Nigerian agricultural sector and contributes significantly to the national economy. They are slaughtered and processed during festivals and parties for consumption as a source of protein in the diet and provide ready cash to most rural and urban dwellers who make their livelihoods from small ruminant rearing[2]. In 2016, the gross production value of goats in Nigeria was estimated to be $373.1 million[3]. Goats' production has been described as an integral part of people's lives and a means of livelihood for most rural communities in Oyo State[4]. Goat rearing is, however, confronted with a mirage of challenges from climate change, inadequate feeding, and diseases[5]. One of these common prevalent diseases is pneumonic pasteurellosis, with its associated economic losses and productivity issues related to mortality, reduced growth rate and decreased overall productivity.

Pneumonic pasteurellosis has a mix of aetiological agents. Some of the specific causative agents are *Mannheimia haemolytica*, *Pasteurella multocida*, and *Bibersteinia trehalosi*[6]. These organisms are usually a part of the normal microflora of the tonsils and nasopharynx of healthy sheep and goats. However, when animals are exposed to stressors such as overcrowding, poor ventilation, inconvenient transportation, and harsh weather conditions, they become immunosuppressed, and this predisposes them to the manifestation of pasteurellosis[7]. The disease is characterised by clear clinical signs in affected sheep and goats, which range from sudden death to depression, 40 to 41°C fever, reduced appetite, coughing, thick muco-purulent nasal discharge, anorexia, and occasional foam in the mouth[8]. As reported by most Nigerian animal disease investigation centres, *P. haemolytica* has been identified as one of the most prevalent organisms at slaughter. And this is responsible for about 35% to 59% of small ruminants' diseases during postmortem[9].

Incidentally, the global issue of antimicrobial resistance and residue in food animals is becoming prominent in Nigerian public places. And this has been linked to abuse and misuse of antimicrobial agents, especially in food animals. Indiscriminate use of these antimicrobial agents and the development of defence mechanisms in the pathogens may be a major contribution to the precipitation of this disease. It is more challenging to manage this disease, as there may be other organisms beyond Pasteurella and Mannheimia species, especially since these bacteria are part of the normal microbiota in the upper respiratory tract, making the prevention of the disease very difficult[10,11]. It has therefore become more imperative to investigate the occurrence of pneumonic pasteurellosis vis-à-vis the prevalent bacteria and their sensitivity pattern to commonly used antimicrobial agents in Nigerian breeds of goats in Ibadan, Oyo State. The study highlights age, sex, and breed predispositions to the disease within the studied population. It also demonstrates the varied susceptibility patterns of the isolated bacterial agents involved in the disease to commonly used veterinary antimicrobial agents.

MATERIALS AND METHODS

Study area: Samples were collected from the Akinyele sheep and goats' market, which is located in the Akinyele Local Government Area (LGA) of Ibadan, Oyo State, Nigeria, with a latitude and longitude of 7°23'47"N and 3°55'0"E, respectively according to Efenakpo *et al.*[12]. The area has an estimated thriving population of 211,359 people and an annual growth rate of approximately 4.14%. It covers an area of 222 km^2. Akinyele shares borders with Lagelu LGA to the East, Afijio LGA to the North, Ido LGA to the West, and Ibadan North LGA to the South as described by Azeez *et al.*[13]. The local government area is a very mixed region, with inhabitants being indigenes, other Nigerian tribes, and foreign nationals. The area notably houses a central abattoir that serves as a meat-supplying centre for Southwestern Nigerian States, producing an estimated 1,000 metric tonnes of meat daily: A significant contributor to the GDP of Oyo State and Nigeria in general.

Studied animals: The studied animal subjects included three common Nigerian breeds of goats, namely Red Sokoto, Sahel, and West African Dwarf. Breed and sex were morphologically categorised based on their specific features and sexual organs, respectively, as reported by Olaogun and Esan[14]. Age was broadly classified into young (0 to 2½ years) and adult (>2½ years) goats using dentition according to Dubie *et al*.[15]. The body condition score was classified into good, medium and poor body condition scores according to Belina *et al*.[16]. A total of 62 goats exhibiting clinical respiratory signs of pneumonic pasteurellosis were randomly sampled from June 2023 to December 2023. These were all animals that had undergone the stress of transportation from the Northern parts of Nigeria to be sold at the Akinyele sheep and goats' market in Ibadan, Oyo State, Nigeria.

Sample collection: Nasal swabs (n = 62) were collected aseptically from goats showing clinical signs that are indicative of pneumonic pasteurellosis. These clinical signs included open-mouth breathing, fever (40-41°C), mucopurulent nasal discharge, coughing, anorexia, fast and shallow breathing, and depression. Before sampling the goats, the external nares were disinfected with 70% alcohol. A sterile cotton-tipped applicator stick was inserted into the nostril and rotated against the nasal cavity wall to collect the nasal samples. These samples were labelled appropriately with information about the goat's breed, age, sex, and severity of the condition. The swab was put in a sterile test tube appropriately labelled. It was then stored in an icebox until it was taken to the Bacteriological Laboratory of the Department of Veterinary Medicine at the University of Ibadan for instant bacteriological analysis, adopting the standard procedures for culturing as established by Quinn *et al*.[17].

Bacterial isolation and identification: Bacterial isolates were identified and characterised using standard methods as described by Ugboma and Otamiri[18]. The nasal swabs were each removed from the bottle and streaked over blood agar plates containing 5% sheep blood. Inoculating loops were further used in spreading the streaks so that the colonies are more easily identifiable after they form. Each plate was labelled and incubated aerobically at 37°C for 24 hrs. The gram-negative bacteria were further subcultured on blood agar plates containing 5% sheep blood and incubated at 37°C aerobically for another 24 hrs. The MacConkey agars were also incubated under the same conditions to differentiate the Gram-negative bacteria based on lactose fermentation as previously described by[19-21].

Initial identification of *Pasteurella multocida* was based on the physical observation of spherical, smooth (mucoid), and non-haemolytic colonies on blood agar that did not grow on MacConkey agar. *Mannheimia haemolytica* was suspected based on its ability to grow on MacConkey agar and produce clear zones of beta-haemolysis on blood agar according to Girma *et al*.[22]. Gram staining was performed on the colonies to confirm Gram-negative characteristics and observe their morphology as small, pleomorphic coccobacilli often exhibiting bipolar staining as described by Amin[23]. Further identification was achieved through biochemical tests, including catalase, oxidase and indole tests according to Abdelrahman *et al*.[24]. The Gram-positive cocci isolates were further subjected to Mannitol Salt Agar and coagulase tests following standard protocols. *Pasteurella multocida* isolates tested positive for catalase, oxidase, and indole production and were able to ferment glucose and sucrose. They, however, were unable to ferment lactose. *M. haemolytica* was identified by its ability to grow on MacConkey agar, produce beta-haemolysis on blood agar, and ferment lactose, maltose and L-arabinose. It also reacted negatively to indole production as described by Alemu *et al*.[25].

Antibiotic susceptibility tests: Aseptically kept antibiotic discs containing eleven antibiotics, which include amoxicillin (25 µg), gentamicin (25 µg), oxytetracycline (30 µg), sulphadimidine (10 µg), enrofloxacin (5 µg), ciprofloxacin (5 µg), erythromycin (10 µg), tylosin (30 µg), penicillin-streptomycin (10 µg), ofloxacin (10 µg), and clindamycin (10 µg), were prepared using 1 mL of the drugs to 1 mL of distilled water. Mueller-hinton agar (MHA) was prepared and used as a growth medium for the test. The

colony of bacteria was put inside a new swab stick with normal saline and mixed until it was free from cloudiness and spread throughout the surface of the prepared Mueller-Hinton agar plate. The antibiotic sensitivity discs were impregnated on the surface of the Mueller-Hinton agar, and the plates were then incubated at 37 for 16-24 hrs. The zones of growth inhibition around the antibiotic discs were measured to the nearest millimetre. The zone diameter of each drug was interpreted using the criteria chart provided to measure the inhibition zone diameters[26]. Based on disc diffusion diameters, results were qualitatively interpreted as susceptible, intermediate, and resistant.

Statistical analysis: Applied descriptive statistics to summarise the collected data, establish frequencies and percentages, and present them in tables. Descriptive statistics were conducted using the Statistical Package for Social Sciences (SPSS) version 26 (SPSS Inc., Chicago).

Ethical consideration: Sampling and laboratory analyses were conducted following the University of Ibadan's Research Ethics Committee (ACUREC) guidelines in Ibadan, Nigeria. Informed consent was duly obtained from the goats' owners before sampling, and there are no procedures in the study that are against animals/animal welfare.

RESULTS

Distribution of goats sampled based on breed, sex, and age in Oyo State: Out of the 62 goats sampled, 38 (61.29%) were of the Red Sokoto breed, 22 (35.48%) were of the Sahel breed, and 2 (3.22%) were West African Dwarf goats. 42 (67.74%) were male (Buck), while 20 (32.25%) were female (Doe). The 36 (58.06%) were adult goats, while 26 (41.93%) were young goats (Table 1).

Number of samples positive based on breed, sex, age, and level of severity of infection among goats with clinical Pasteurellosis in Oyo State: The overall total number of positive samples was 40/62 (64.52%). The breeds' distribution indicates the following: The highest positivity of 2/2 (100%) was observed in West African Dwarf, followed by 26/38 (68.42%) in Red Sokoto, and the least positivity was observed in Sahel goats, 12/22 (54.55%). The highest positivity was observed in adult goats, with 26/36 (72.22%), while the young goats had the lowest positivity of 14/26 (53.85%). There were more positive samples in Doe 16/20 (80%) compared to Buck with 24/42 (57.14%). More goats were positive in the severe infection category, 30/44 (68.18), followed by the moderate infection group, 8/14 (57.14), and the least positivity in the mild infection group, 2/4 (50%) (Table 2).

Distribution of bacterial organisms isolated based on breed, age, sex, and level of severity in goats with pneumonic pasteurellosis in Oyo State: Out of the overall 40 samples. *Pasteurella multocida* was the most common, with a frequency and percentage of 17 (42.50%), followed by *Staphylococcus aureus* with 13 (32.50%) and *Mannheimia haemolytica* with 10 (25.00%). Out of 26 positives Red Sokoto goats, *Pasteurella multocida* was the most isolated, with 11 (42.31%), followed by *Mannheimia haemolytica* with 9 (34.62%) and *Staphylococcus aureus* with 6 (23.08%). Of the 12 positive Sahel goats, *Staphylococcus aureus* 7 (58.34%) was the most prevalent, followed by *Pasteurella multocida* with 4 (33.33%) and *Mannheimia haemolytica* with 1 (8.33%). Only 2 positive WAD goats were positive only for *Pasteurella multocida* 2 (100). Age group distribution reveals the lowest positive samples of 14 in young goats, with *Pasteurella multocida* and *Staphylococcus aureus* being the most isolated organisms, with 5 (35.71%) each, while *Mannheimia haemolytica*, with 4 (28.57%), is the least isolated organism. Adult goats had the highest positivity of 26, with a higher occurrence of *Pasteurella multocida* 12 (46.15). While *Mannheimia haemolytica* with 6 (23.08) is the least. More female goats (24) were found positive for pasteurellosis compared to male goats (16). The distribution of the organisms in female goats was revealed as follows: *Mannheimia hemolytica* with 7 (29.17%), *Staphylococcus aureus* with 8 (33.33%), and *Pasteurella multocida* with 9 (37.50%), being the highest. The distribution of the organisms in male goats was as follows:

Table 1: Distribution of goats sampled based on breeds, sexes and ages in Oyo State

Risk factors	Frequency (n = 62)	Percentage (%)
Location	62	100
Breed		
West Africa dwarfs (WAD)	2	3.22
Red Sokoto	38	61.29
Sahel	22	35.48
Sex		
Male	42	67.74
Female	20	32.25
Age		
Young	26	41.93
Adult	36	58.06

Table 2: Percentage positivity based on breed, sex, age and level of severity of infection among goats with clinical Pasteurellosis in Oyo State

Risk factors	Total sampled (62)	Number positive (40)	Positive (%) (64.52)
Breed			
Red Sokoto	38	26	68.42
Sahel	22	12	54.55
West Africa dwarf	2	2	100
Age			
Young	26	14	53.85
Adult	36	26	72.22
Sex			
Male	42	24	57.14
Female	20	16	80
Level of severity			
Severe	44	30	68.18
Moderate	14	8	57.14
Mild	4	2	50

Positive sample: Any sample with at least one or more of the 3 organisms isolated.

Table 3: Distribution of bacterial organisms isolated based on breed, age, sex and level of severity in goats with Pneumonic Pasteurellosis in Oyo State

Risk factors	Total/% positive (40/100)	N/% positive for *Pasturella multocida* (17/42.50)	N/% positive for *Manheimia haemolytica* (10/25.00)	N/% positive for *Staphylococcus aureus* (13/32.50)
Breed				
Red Sokoto	26/100	11 (42.31)	9 (34.62)	6 (23.08)
Sahel	12/100	4 (33.33)	1 (8.33)	7 (58.34)
West Africa dwarf	2/100	2 (100.00)	0 (00.00)	0 (00.00)
Age				
Young	14/100	5 (35.71)	4 (28.57.00)	5 (35.71)
Adults	26/100	12 (46.15)	6 (23.08)	8 (30.77)
Sex				
Female	24/100	9 (37.50)	7 (29.17)	8 (33.33)
Male	16/100	8 (50.00)	3 (18.75)	5 (31.25)
Level of severity				
Severe	30/100	12 (40.00)	8 (26.67)	10 (33.33)
Moderate	8/100	3 (37.50)	2 (25.00)	3 (37.50)
Mild	2/100	2 (100)	0 (00.00)	0 (00.00)

Pasteurella multocida was the highest with 8 (50.00%), followed by *Staphylococcus aureus* with 5 (31.25%), and the least isolated organism was *Mannheimia haemolytica* with 3 (18.75%). The distribution of the organisms based on the severity of the disease is indicated as follows: Out of 30 positive samples, under the severe category. *Pasteurella multocida* was the most isolated organism, with 12 (40.00), followed by *Staphylococcus aureus* with 10 (33.33), and the least isolated organism was *Mannheimia haemo*lytica, with 8 (26.67). While the least positivity was recorded in the mild category with two samples, the two organisms were *Pasteurella multocida* with 2 (100%) (Table 3).

Table 4: Susceptibility pattern of *Pasturella multocida* to commonly used veterinary antimicrobial agents and number of isolates n = 5

Antimicrobial class	Antimicrobial agent	Disk potency (µg)	Sensitive (n = %)	Intermediate (n = %)	Resistance (n = %)
Beta lactam	Amoxicillin (500 mg/mL)	25	0 (00)	5 (100)	0 (00)
Fluoroquinolone group	Enrofloxacin (300 mg/mL)	5	1 (20)	4 (80)	0 (00)
Fluoroquinolone group	Ofloxacin (200 mg/mL)	10	1 (20)	4 (80)	0 (00)
Aminoglycosides	Gentamycin (100 mg/mL)	10	0 (00)	5 (100)	0 (00)
Beta lactam	Penicillin streptomycin (200 mg/mL)	10	0 (00)	5 (100)	0 (00)
Fluoroquinolone group	Ciprofloxacin (200 mg/mL)	5	2 (40)	3 (60)	0 (00)
Sulfonamides	Sulphadimidine (333 mg/mL)	10	0 (00)	5 (100)	0 (00)
Macrolides	Erythromycin (500 mg/mL)	10	0 (00)	5 (100)	0 (00)
Macrolides	Tylosin (200 mg/mL)	30	0 (00)	1 (20)	4 (80)
Lincosamide	Clindamycin (300 mg/mL)	10	1 (20)	4 (80)	0 (0)
Tetracycline	Oxytetracycline (200 mg/mL)	30	0 (00)	0 (00)	5 (100)

Table 5: Frequency susceptibility of *Mannheimia haemolytica* to commonly used veterinary antimicrobial agents and number of isolates = 5

Antimicrobial class	Antimicrobial agent	Disk potency (µg)	Sensitive (n = %)	Intermediate (n = %)	Resistance (n = %)
Beta lactam	Amoxicillin (500 mg/mL)	25	0 (00)	4 (80)	1 (20)
Fluoroquinolone group	Enrofloxacin (300 mg/mL)	5	4 (80)	1 (20)	0 (00)
Fluoroquinolone group	Ofloxacin (200 mg/mL)	10	1 (20)	4 (80)	0 (00)
Aminoglycosides	Gentamycin (100 mg/mL)	10	0 (00)	4 (80)	1 (20)
Beta lactam	Penicillin strept (200 mg/mL)	10	0 (00)	4 (80)	2 (20)
Fluoroquinolone group	Ciprofloxacin (200 mg/mL)	5	2 (40)	3 (60)	0 (00)
Sulfonamides	Sulphadimidine (333 mg/mL)	10	4 (80)	1 (20)	0 (00)
Macrolides	Erythromycin (500 mg/mL)	10	1 (20)	4 (80)	0 (00)
Macrolides	Tylosin (200 mg/mL)	30	0 (00)	3 (60)	2 (40)
Lincosamide	Clindamycin (300 mg/mL)	10	2 (40)	3 (60)	0 (00)
Tetracycline	Oxytetracycline (200 mg/mL)	30	0 (00)	0 (00)	5 (100)

Table 6: Frequency susceptibility of *Staphylococcus aureus* to commonly used veterinary antimicrobial agents and number of isolates = 5

Antimicrobial class	Antimicrobial agent	Disk potency (µg)	Sensitive (n = %)	Intermediate (n = %)	Resistance (n = %)
Beta lactam	Amoxicillin (500 mg/mL)	25	0 (00)	0 (00)	5 (100)
Fluoroquinolone group	Enrofloxacin (300 mg/mL)	5	2 (40)	3 (60)	0 (00)
Fluoroquinolone group	Ofloxacin (200 mg/mL)	10	0 (00)	0 (00)	5 (100)
Aminoglycosides	Gentamycin (100 mg/mL)	10	5 (100)	0 (00)	0 (000
Beta lactam	Penicillin streptomycin (200 mg/mL)	10	1 (20)	4 (80)	0 (00)
Fluoroquinolone group	Ciprofloxacin (200 mg/mL)	5	2 (40)	3 (60)	0 (00)
Sulfonamides	Sulphadimidine (333 mg/mL)	10	1 (20)	4 (80)	0 (00)
Macrolides	Erythromycin (500 mg/mL)	10	2 (40)	3 (60)	0 (00)
Macrolides	Tylosin (200 mg/mL)	30	1 (20)	4 (80)	0 (00)
Lincosamide	Clindamycin (300 mg/mL)	10	2 (40)	3 (60)	0 (00)
Tetracycline	Oxytetracycline (200 mg/mL)	30	0 (00)	0 (00)	5 (100)

Susceptibility pattern of *Pasturella multocida* to commonly used veterinary antimicrobial agents: About 40% of the organisms were very sensitive to ciprofloxacin, while 20% were sensitive to clindamycin, ofloxacin, and enrofloxacin. All five isolates were 100% intermediately sensitive to amoxicillin, gentamycin, penicillin, streptomycin, sulphadimidine, and erythromycin. 80% of the organisms were intermediately sensitive to Oflaxacin, Enrofloxacin, and Clindamycin, while 60% were intermediately sensitive to Ciprofloxacin and 20% were intermediately sensitive to Tylosin (Table 4).

Susceptibility pattern of *Mannheimia haemolytica* to commonly used veterinary antimicrobial agents: The 80% of the organisms were very sensitive to enrofloxacin and sulphadimidine, 40% were very sensitive to ciprofloxacin and clindamycin, and 20% were sensitive to erythromycin and ofloxacin. The 80% were intermediately sensitive to amoxicillin, ofloxacin, gentamicin, penicillin, streptomycin, and

erythromycin. The 60% were intermediately sensitive to ciprofloxacin, tylosin, and clindamycin, and 20% were intermediately sensitive to enrofloxacin and sulphadimidine. 100% of the organisms were very resistant to oxytetracycline, 40% were resistant to tylosin, and 20% were resistant to amoxicillin, gentamicin, and penicillin streptomycin (Table 5).

Susceptibility pattern of *Staphylococcus aureus* to commonly used veterinary antimicrobial agents: The 100% of the organisms were sensitive to Gentamycin, and 40% of the organisms were sensitive to Enrofloxacin, Ciprofloxacin, Erythromycin, and Clindamycin. 20% were sensitive to penicillin, streptomycin, sulphadimidine, and tylosin. 80% were intermediately sensitive to penicillin, streptomycin, sulphadimidine, and tylosin. The 60% were intermediately sensitive to ciprofloxacin, enrofloxacin, erythromycin, and clindamycin. The 100% of the organisms were very resistant to amoxicillin, ofloxacin, and oxytetracycline (Table 6).

DISCUSSION

This study establishes pneumonic pasteurellosis in Nigerian goats with variation in susceptibility across different breeds, sex, age, and levels of severity. As we highlight and discuss the findings of this study. The distribution of goats sampled based on clinical symptoms in this study is similar to the earlier reports of Habibur Rahman *et al*.[27], who also reported a higher prevalence of pneumonia in Red Sokoto, and adult goats in Gwagwalada, Abuja abattoir, Nigeria. The sampling of a relatively high number of Red Sokoto breeds compared to the other two breeds reflects the actual higher population of Red Sokoto goats in the study location. It has been established that Red Sokoto goats is the most essential breed that is generally spread in Northern part of Nigeria and is estimated to be half of the total population of goats in Nigeria as observed by Muhammad *et al*.[28]. And incidentally 95% of traders selling livestock in this market are from the Northern Nigeria and the animals are predominantly from the Northern part of Nigeria. Also, more adult goats are expected to be brought to the market for sale, and this may be the reason why we sampled more adult goats compared to young goats. Higher positivity of the West African Dwarf breed to pneumonic pasteurellosis compared to other breeds may be due to the small number of WAD sampled in the study location. This observation contradicts the findings of Habibur Rahman *et al*.[27], who reported a higher occurrence in Red Sokoto breeds compared to the other two breeds of goats at Abuja abattoir. This variation may be associated with differences in location and method of diagnosis of the studies. The earlier study adopted clinical signs, postmortem findings, and histopathological findings, whereas the present study adopted clinical findings and bacteriological confirmation. The observation of higher occurrence in adult goats compared to young goats agrees with the observation of Muhammad *et al*.[28], who reported higher prevalence in adult goats as well. This might be due to immunosuppression associated with old age and other stress factors, which often make them more susceptible to bacterial infections and other etiological factors. This is also in tandem with the works of Lawal *et al*.[29].

This showed that pneumonia was more common in goats between the ages of 6 months to 2 years. This, however, disagrees with the observation of Abdulkadir *et al*.[30], who reported a higher prevalence among young goats compared to adult goats in Ethiopia. This difference in observation may be a result of variations in the study location, sampling procedures, sample size, and the period (season) of sampling. Moreover, pneumonic Pasteurellosis affects all ages of goats, with kids and dams more vulnerable during their first few weeks post kidding and at kidding, respectively.

The higher positivity among female goats compared to male goats as observed in this study may be attributed to small sample size of female goats. Farmers prefer to keep female animals for reproductive purposes and will ordinarily not sell, like they will have willing to sell male animals. This could also be attributed to factors such as stress associated with transportation, hormonal influences, geographical location or differences in immune competences. Another explanation could be that there is a higher number of bucks than does at the goat market.

This agrees with the findings of Shimelis *et al.*[31], who reported a higher incidence in does than in bucks. Conversely, this result contradicts the work of Emikpe and Akpavie[32], which stated that male goats were more prone to respiratory infections than female goats, possibly due to the sniffing of the females during estrus, which often exposes them to frequent infection. This finding also contradicts the observation of Abdulkadir *et al.*[30]; who reported a higher prevalence of pneumonic pasteurellosis in bucks (70%), than in does (30%). The observation of more adult goats being positive for pneumonic pasteurellosis compared to young goats in this study may be due to low immunity in adults, and increased stress that may be associated with frequent mating, parturition, ageing and prolonged exposure to environmental toxicants. This agrees with the earlier observation of Olaogun *et al.*[21], who also reported higher susceptibility of adult sheep to foot rot compared to young sheep in Ibadan, Nigeria.

This observation is, however not in tandem with the findings of Abera and Mossie[7] and Shimelis *et al.*[31], who both reported higher susceptibility among young animals compared to adults. This difference may be associated with differences in breeds and diagnostic approaches adopted by the two studies. The earlier study adopted antemortem, postmortem and bacteriological examination and was conducted on caprine slaughtered at Hashim's Ethiopian Livestock and Meat Export (HELIMEX) abattoir, whereas the present study adopted clinical signs, history and bacteriological examination and was conducted at the livestock market in Ibadan, Nigeria. The predominance of *P. multocida* aligns with previous reports, identifying it as a primary agent responsible for the disease in goats in various regions Lukeye *et al.*[33]. However, it is worthy of note that the presence of *Staphylococcus aureus* suggests that it also plays an active role as a primary aetiological agent. This finding is consistent with the findings reported by McMullen *et al.*[34]. The presence of *M. haemolytica* further confirms that caprine pneumonia is a very polymicrobial condition. This is in line with the findings of Habibur Rahman *et al.*[35]. Antimicrobial susceptibility testing in this study revealed distinct patterns for *Pasteurella multocida*, *Mannheimia haemolytica* and *Staphylococcus aureus* which are major culprits of caprine pneumonic pasteurellosis as observed in this study. *Pasteurella multocida* showed sensitivity to amoxicillin, gentamicin, penicillin-streptomycin, sulphadimidine, ciprofloxacin, clindamycin, and erythromycin, but exhibited 100% resistance to oxytetracycline in this study. This high resistance to oxytetracycline is likely due to its overuse in treating respiratory infections and the presence of specific genes such as tet (R) and tet (H) in the bacteria that encode proteins that can change the antibiotic's structure, thereby diminishing its effects. This observation aligns with the findings of Kim *et al.*[36] and Oh *et al.*[37], who also recorded significantly high resistance of *P. multocida* to oxytetracycline.

Mannheimia haemolytica demonstrated a high susceptibility (80%) to amoxicillin, enrofloxacin, ofloxacin, gentamicin, sulphadimidine, penicillin-streptomycin, and erythromycin. It was, however, found to be 100% resistant to oxytetracycline also. Conversely, *Mannheimia haemolytica* showed the highest sensitivity (100%) to gentamicin in this study. This high sensitivity to gentamicin aligns with the findings of Bahr *et al.*[38] and Abate and Kassa[39], who recommended gentamicin as the most effective drug for treating pneumonic pasteurellosis involving *M. haemolytica*. In contrast, Marru *et al.*[40] reported a contrarian view, stating that gentamicin is the most ineffective drug with 100% resistance according to their study. This contradiction could be due to differences in the geographic distribution of bacterial strains as different strains could exhibit varied sensitivity levels to different antibiotics.

Streptococcus aureus was most sensitive to gentamicin (100%) and showed moderate sensitivity to enrofloxacin, erythromycin, ciprofloxacin, and clindamycin. It was, however, highly resistant (100%) to amoxicillin, ofloxacin, and oxytetracycline. The high resistance shown in this study to amoxicillin and oxytetracycline is consistent with the findings of Nazmul Hoque *et al.*[41], who reported a significant 92.7% and 80.7% resistance of *Streptococcus aureus* to amoxicillin and oxytetracycline, respectively.

CONCLUSION

Pneumonic pasteurellosis poses a significant health challenge in Nigerian goat breeds, with the highest occurrence in West African Dwarf goats, females, and adults. *Pasteurella multocida* was identified as the predominant pathogen, followed by *Staphylococcus aureus* and *Mannheimia haemolytica*. Antimicrobial profiling revealed enrofloxacin and ciprofloxacin as the most effective treatment options. These findings provide valuable insights for targeted control and therapeutic strategies against pneumonic pasteurellosis in small ruminants in Nigeria.

SIGNIFICANCE STATEMENT

Pneumonic pasteurellosis was more prevalent in the Red Sokoto breed, male and adult' goats, compared to other breeds, female and young goats, respectively. Notably, all three bacteria isolated were highly resistant to oxytetracycline, which should be of serious concern to livestock stakeholders and the general populace. Based on the findings of this study, gentamicin appeared to be the best antimicrobial agent, and oxytetracycline should not be used in the treatment of pneumonia pasteurellosis in Nigerian breeds of goats.

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