




Research Article

Epidemiological and Seasonal Dynamicity Studies on Major Respiratory Diseases of Camel in Selected Districts of Borana Zone, Southern Oromia, Ethiopia

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Abstract

A crosswise analysis was carried out between December 2013 and March 2014 across two seasons to assess selected camel herds. The aim was to investigate how season affects disease occurrences through field surveys and collection of serum samples. A sum of 384 nasopharyngeal aspiration samples was gathered from camels. Primary biochemical tests were utilized to classify the isolates to the genus level. A multiple variable logistic regression analysis was employed to consider the relations among potential threats and immune response. The results showed a strong association between respiratory symptoms and the season, while no significant correlation was found with the districts, sex, or age ($p>0.05$). The most frequently identified Gram-positive bacteria were *Staphylococcus aureus*, *Bacillus* species, and *Micrococcus* species at rates of 19.0%, 11.1%, and 5.5%, respectively. The leading Gram-negative isolates included *E. coli* (15.9%), *Pasteurella multocida* (14.3%), and *Klebsiella pneumoniae* (12.7%). The study also identified a strong association between respiratory symptoms and the isolated bacteria, *Mannheimia hemolytica*. The study's findings suggest that various factors, such as the animals' nutritional and immune status, as well as environmental conditions, can transform the microbiota in the olfactory organ of healthy camel animals into pathogenic ones, leading to endogenous infections. The results of this study can inform the development of effective strategies for the prevention and control of camel respiratory diseases, ultimately improving their health and productivity highlighting the need for ongoing monitoring and management strategies for camel health.

Keywords

Bacteria, Camels, Respiratory Diseases, Nasal Swabs

1. Introduction

Llamas and camels are both categorized under the suborder Tylopoda within the order Artiodactyla [15, 65]. It is thought that camels evolved from *Protylopus*, a creature that roamed

North America between 40 and 45 million years ago [12, 55]. Based on previously established scientific knowledge [11, 47] the genus *Camelus* includes the Bactrian camel, known for its

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two humps (*Camelus bactrianus*) and the dromedary, which has a single hump (*Camelus dromedarius*). Single humped (*Camelus dromedarius*) are pronounced domestic animals that are particularly well adapted to hot, arid environments [15]. Their capacity to thrive in extreme weather conditions and endure shortages of water and feed makes them highly valued in Ethiopia [67]. Furthermore, they serve as a measure of wealth and social status [30, 57]. For pastoral communities in Eastern and Southern Ethiopia, camels are essential sources of milk, meat, draught power, and transportation [8, 9]. Approximately 13.71 million camels, representing over 87.1% of the global camel population, are located in Africa [20].

Camels are prone to respiratory infections, which can be classified as acute, or chronic [3]. Locals refer to the acute form with nasal discharge as "Furi" and the chronic form associated with coughing as "Dhuguda" or "kufa". The most prevalent and serious type of respiratory infection is acute, often occurring in outbreaks during the main rainy season (15.2% as opposed to 1.1% during dry periods) [7]. While previous studies in Ethiopia have identified the causes of camel respiratory diseases mainly succeeded referring animals that were slaughtered or through sero-epidemiological assessments, the primary risk factors include sudden temperature changes, poor management practices, exposure to various diseases, extensive travel, and insufficient nutrition [9, 62]. Nevertheless, a conclusive etiology for most camel respiratory diseases remains undetermined, as various viruses, fungi, bacteria, and parasites could potentially trigger respiratory outbreaks [33]. The health hazards related to camel farming are well recognized and have historically been associated with several classical illnesses, including trypanosomiasis, camelpox, gastrointestinal parasitism, contagious skin necrosis, pneumonia, tuberculosis, and mange mite infections [19, 32, 50]. However, camels seem to possess immunity against serious epidemic diseases like rinderpest, contagious pleuropneumonia, and foot-and-mouth disease, which pose threats to other livestock in the same area. Yet, in various countries, there have been reports of more recent cases exhibiting severe symptoms, high mortality rates, and challenges in obtaining precise diagnoses, particularly over the last decade [43, 48, 53]. Respiratory disorders pose a significant risk to the camel population and are among the many emerging health issues. These illnesses have recently become a critical concern for camel production in nu-

merous African countries. They adversely impact camel production by leading to increased treatment costs, reduced weight gain, lowered carcass value, impaired performance in sick animals, and economic losses from mortality [23, 62].

International organizations and local governments have largely overlooked camels in their initiatives to enhance their production and health, despite their various uses within pastoralist communities [8, 36, 66]. Pneumonia is one of the most significant and prevalent diseases affecting camels [26, 32, 58]. While mortality and morbidity rates are low, the prolonged recovery period negatively impacts overall productivity. [1, 46, 56, 64] identified pneumonia as the tenth most common disease, with peak incidence noted in the autumn, which aligns with our own observations. Several risk factors have been associated with pneumonia, including sudden weather changes and the strain of migrating northward during early rainfall. The shift from a warm, dry season to a rainy one has been associated with an increased occurrence of respiratory infections during the wet season [35, 38, 41]. Additional risk factors include wind, cold temperatures, rain, insufficient feeding, and animal movement, all of which can cause distress for the animals. Important predisposing factors have been identified as camels trekking long distances during the rainy season [1, 3, 18, 21, 24, 26, 32, 61] and keeping camels in open pens [16, 40, 42, 60, 66]. Despite microbiological examinations that have focused on isolating pathogens from unhealthy and ostensibly healthy animals, a comprehensive epidemiological study and analysis of the seasonal occurrence of respiratory diseases in Borana pastoral area remains lacking. There is currently no epidemiological study on camel respiratory disease in Borana pastoral areas; therefore, a prevalence of 50% assumed. Consequently, this study aims to evaluate the descriptive epidemiology and identify seasonal pattern of the disease plus other contributing risk factors.

2. Materials and Methods

Description of Research Sites: The research was conducted in four districts within the Borana pastoral zone, primarily populated by the Borana Oromo people. The zone has a sub-arid to arid climate, ranging from 4° to 6°N latitude and 36° to 42°E longitude, and features isolated mountains and valleys [17, 27, 29, 37].

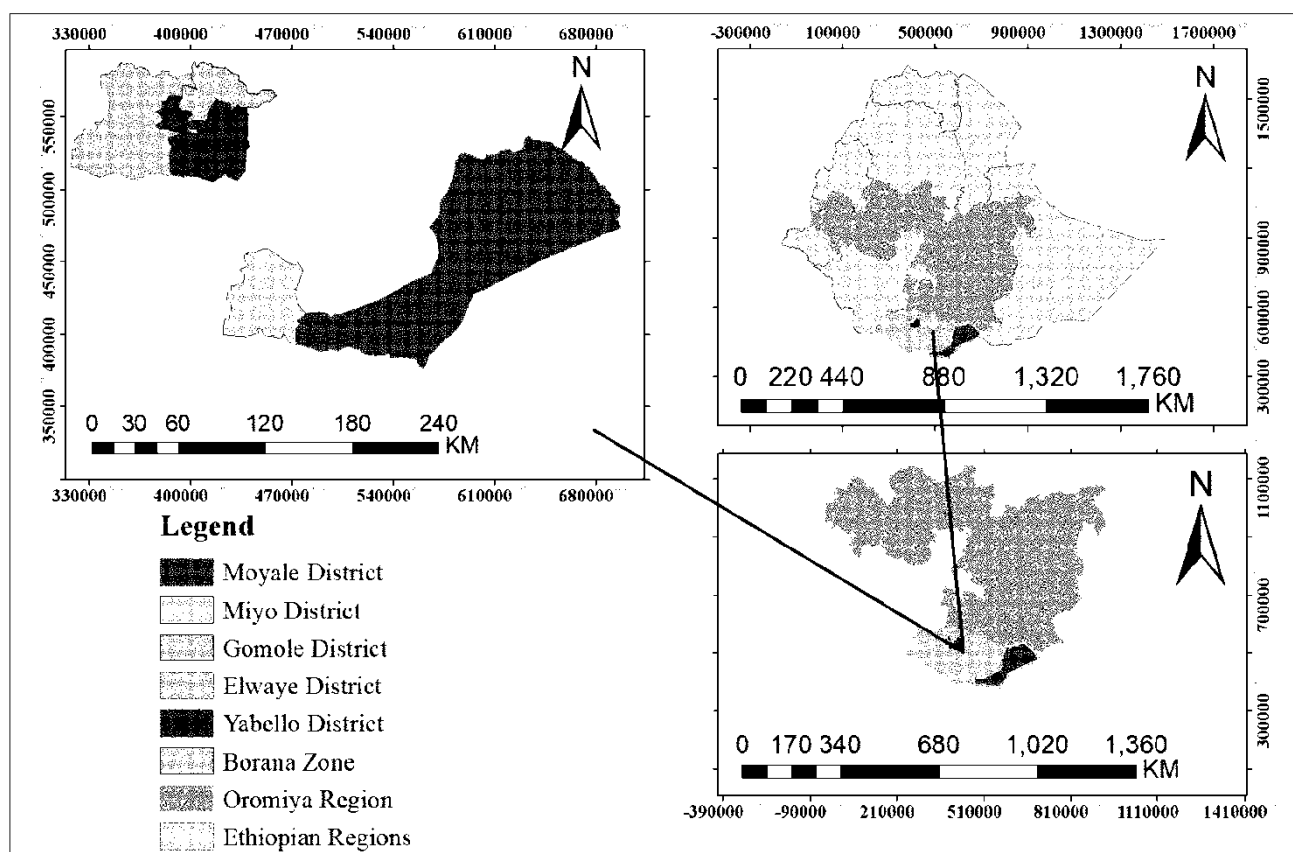


Figure 1. Study area.

Design and Samples: A cross-sectional study was conducted from December 2013 to March 2014 to assess camel herds and investigate the impact of season on disease occurrences. The study included both sexes of camels older than six months and collected serum samples. The sample size was determined using [59] formula for simple random sampling, with a 95% confidence level and 5% absolute precision. The expected prevalence of camel respiratory disease in Borana pastoral areas was assumed to be 50%, with a minimum sample size of 384 camels calculated.

$$n = \frac{1.96^2 P_{exp}(1-P_{exp})}{d^2} \quad (1)$$

Where n represents the required sample size, P_{exp} is the expected prevalence, and d signifies the desired (5%) absolute precision [39].

Laboratory Analysis: Camel nasal swab samples were taken from randomly selected herds as part of the study in order to assess respiratory symptoms and do laboratory analysis. Symptoms of diseased camels included nasal discharge, coughing, and dyspnea. Bacterial isolation was done on healthy camels. The swabs were placed in a tube with Stourts transport medium after being cleaned and placed within the nasal cavity [44]. It took four to six hours to get the samples to the Yabelo Regional Veterinary Laboratory. Bacteriological isolation and identification were conducted in accordance

with [49] standard protocols. After being inoculated into Brain Heart Infusion (BHI) broth and aerobically incubated for 24 hours at 37°C, the swab samples were streaked onto sheep blood agar enriched with 5%–7% sheep blood. The plates were checked every 18 to 24 hours for bacterial growth.

Data Analysis: Using Microsoft Excel files, data were captured and kept in distinct databases. Before the data was imported into the statistical program Stata version 13.0 (Stata Corp. 1985-2013), it was carefully examined for correct coding. To evaluate the connections between possible risk variables and sero-prevalence, logistic regression analyses were conducted. The magnitude of the Odds Ratio (OR) was used to measure the strength of the link for each risk factor [58].

3. Results

Case history and clinical observation: For the bacteriological study conducted over two seasons, a total of 384 nasal swabs were collected from camels. Among these, 92 were from Moyale, 77 from Elewoye, 86 from Gomole, 66 from Yabelo, and 63 from Miyo, representing different locations. Visual assessments indicated that 13% of the samples originated from camels showing one or more respiratory symptoms, such as coughing or nasal discharge, with some appearing weak and in poor physical health. A univariable logistic regression analysis was applied to evaluate camel respiratory

disease across five independent factors. As shown in Table 1, there was a strong association between respiratory symptoms

and the season, while no significant correlation was found with the districts, sex, or age ($p > 0.05$).

Table 1. Results from the univariable analysis identifying risk factors and the observed distribution of disease in the study locations.

Variable	Category	n=384	+ve (%)	OR	95% CI	p value
Districts	Moyale	92	27 (29.3)	Ref	Ref	Ref
	Elewoye	77	27 (35.0)	0.76	0.40 - 1.47	0.428
	Gomole	86	35 (40.7)	0.59	0.31 - 1.10	0.101
	Yabelo	66	18 (27.3)	1.10	0.54 - 2.23	0.776
	Miyo	63	19 (30.2)	0.96	0.47 - 1.93	0.914
Age	Adult	210	74 (35.2)	Ref	Ref	Ref
	Young	174	52 (30.2)	1.28	0.83 - 1.97	0.253
Sex	Female	310	100 (32.2)	Ref	Ref	Ref
	Male	74	26 (35.1)	0.88	0.51 - 1.5	0.649
Season	Rainy	197	74 (37.5)	Ref	Ref	Ref
	Dry	187	52 (27.8)	1.50	1.00 - 2.38	0.046
Clinical status	Sick	50	35 (70.0)	Ref	Ref	Ref
	Healthy	334	91 (27.2)	6.20	3.23 - 11.89	0.000

Notes: +ve = number of camels infected from total considered; OR= odds ratio; CI=confident interval.

The application of a multivariate analysis revealed that among the predictor variables analyzed (refer to Table 2), the season and clinical symptoms were linked to camel respiratory

diseases ($p < 0.05$). The findings indicated that the odds of respiratory disease were 1.6 times greater inside the wet time compared to the dry period.

Table 2. Findings from the multivariable logistic regression analysis of camel respiratory disease in the study areas (n=384).

Variable	Category	n	+ve (%)	OR	95% CI	p value
Clinical status	Sick	50	35 (70.0)	Ref	Ref	Ref
	Healthy	334	91 (27.2)	6.20	3.23 - 11.89	0.000
Seasons	Rainy	197	74 (37.5)	Ref	Ref	Ref
	Dry	187	52 (27.8)	1.6	1.07 - 2.67	0.024

Notes: +ve = number of camels infected from total considered; OR= odds ratio; CI=confident interval.

Isolated and identified bacteria: Isolated and identified bacteria. An in-depth investigation was undertaken to identify the bacterial composition present in the upper airway of both healthful and unhealthy animals. Based on the case history and visual evaluations, it was found that 13.0% of the samples were from sick camels, while the remaining 86.9% were classified as coming from healthy camels. From the 384 nasal swab samples, 126 (32.8%) produced not less than one kind

of pathogens. With regard to 334 samples taken from camels deemed to be healthy, 91 (27.2%) showed signs of bacterial growth. Conversely, out of the 50 samples collected from clinically sick camels, 35 (70.0%) tested positive for bacterial growth. The current investigation revealed a significant correlation between respiratory symptoms and the isolated bacteria, *Staphylococcus aureus* and *Mannheimia hemolytica* (see Table 3).

Table 3. Pathogenic isolates recognized from animals with (n=50 camels) and without (n=76 camels) respiratory issues.

BA	RS	I (%)	OR	95% CI	p value
Staphylococcus aureus	Sick	12 (24)	Ref	Ref	Ref
	Healthy	12 (3.5)	8.47	3.55 - 20.18	0.000
E. coli	Healthy	15 (4.5)	Ref	Ref	Ref
	Sick	5 (10)	0.42	0.14 - 1.21	0.110
Pasteurella maltocida	Healthy	13 (3.8)	Ref	Ref	Ref
	Sick	5 (10)	0.50	0.15 - 1.58	0.241
Micrococcus spp	Healthy	7 (2.0)	Ref	Ref	Ref
	Sick	0 (0)	1		
Mannhemia hemolytica	Sick	6 (12)	Ref	Ref	Ref
	Healthy	5 (1.5)	8.97	2.62- 30.63	0.000
S. pneumonia	Healthy	3 (0.9)	Ref	Ref	Ref
	Sick	1 (2)	0.44	0.04 - 4.34	0.484
Klebsilla pneumoniae	Healthy	15 (4.5)	Ref		
	Sick	1 (2)	2.29	0.29 - 17.77	0.426
Streptococcus spp	Healthy	3 (0.9)	Ref	Ref	Ref
	Sick	0 (0)	1		
Pasteurella spp	Healthy	3 (0.9)	Ref	Ref	Ref
	Sick	1 (2)	0.44	0.04 - 4.34	0.484
Bacillus spp	Healthy	10 (2.9)	Ref	Ref	Ref
	Sick	4 (8)	0.35	0.10 - 1.17	0.090
S. pyogen	Healthy	4 (1.1)	Ref	Ref	Ref
	Sick	0 (0)	1		

Notes: BA = Bacterial agents, RS = Respiratory Symptom, I= Isolates, OR= odds ratio.

In this study, g^{+ve} and g^{-ve} bacterial taxa were classified from the 384 nasal swabs obtained at the research location, with 126 (32.8%) demonstrating bacterial growth in culture and identification. The most frequently identified Gram-positive bacte-

ria were Staphylococcus aureus, Bacillus species, and Micrococcus species, at rates of 19.0%, 11.1%, and 5.5%, respectively (Figure 2). The leading Gram-negative isolates included E. coli (15.9%), Pasteurella multocida (14.3%), and Klebsiella pneumoniae (12.7%).

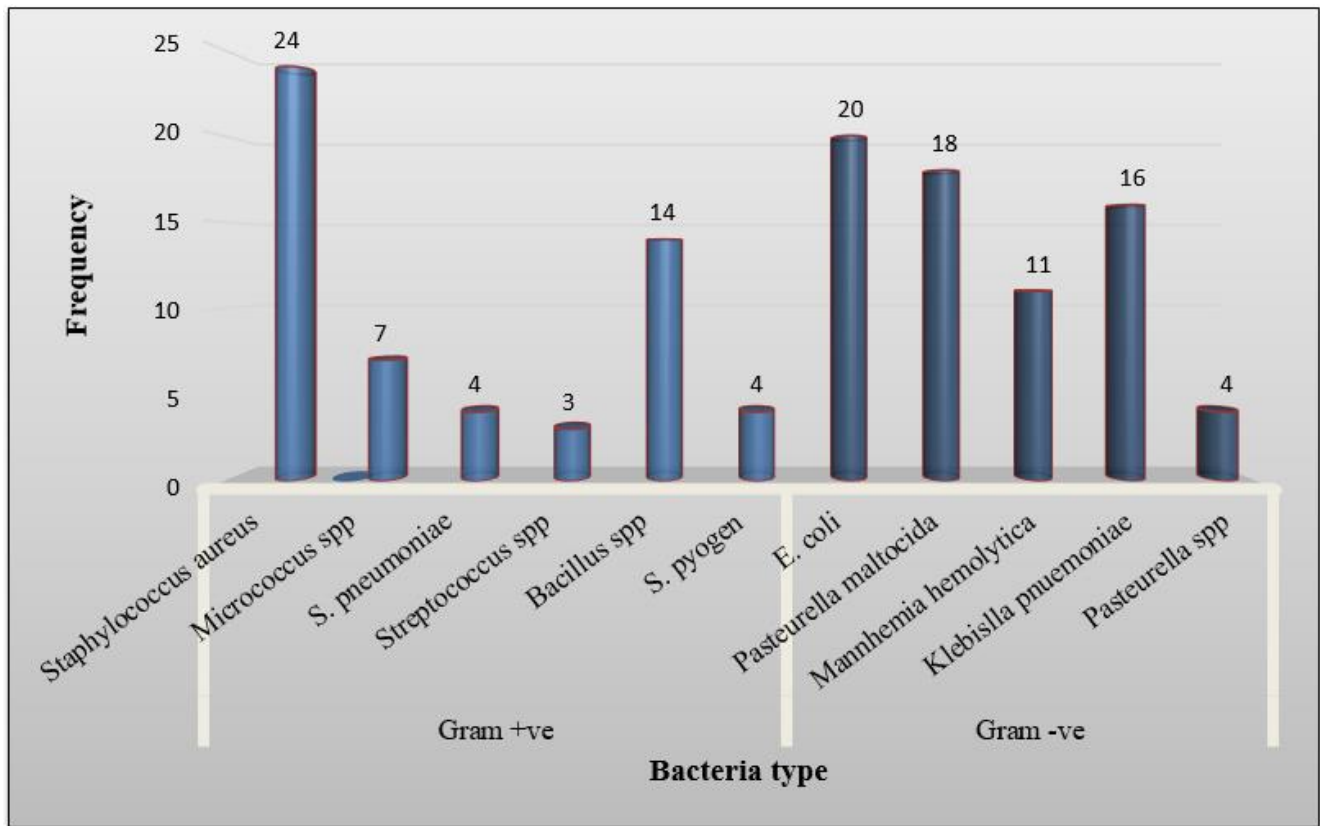


Figure 2. Bacterial isolates from camel nasal swab collected from study site.

4. Discussion

This study provides a comprehensive analysis of the bacteriological landscape associated with respiratory diseases in camels across different locations and seasons. The collection of 384 nasal swabs revealed significant insights into the relationship between respiratory symptoms and bacterial presence, particularly highlighting the impact of seasonal variations on camel health. The observation that 13% of samples originated from camels exhibiting respiratory symptoms aligns with previous studies that have reported similar prevalence rates in livestock populations. Notably, the strong association observed between respiratory symptoms and the rainy season is corroborated by existing literature [21, 24, 28, 32, 45, 52, 61, 69] suggesting that environmental conditions, such as increased humidity and temperature fluctuations, can exacerbate respiratory illnesses in animals. This finding indicates a critical need for heightened surveillance and management strategies during the rainy season to mitigate the risk of disease outbreaks. The univariable logistic regression analysis indicated no significant correlation between respiratory disease and factors such as district, sex, or age ($p > 0.05$). This contrasts with some earlier studies that have identified demographic factors as potential risk contributors to respiratory diseases in camels and other livestock [31]. The lack of significant findings may suggest that the geographical locations sampled share similar

environmental and management practices that neutralize the influence of these demographic variables. Further research could explore whether specific management practices, such as housing conditions or herd density, contribute to this observation.

The primary respiratory symptoms observed in camels included coughing, sneezing, dyspnea, either single handed or conjoined nasal discharge, and an increased respiratory rate ranging from 18 to 20 within 60 second interval. In reference to anamnesis, it is demarcated that the illness presented in both active and persistent arrangements. The active type, referred to the area as "Furi," can exhibit moderate to acute signs. The moderate variant is manifested by sternutation and pressing rhinorrhea, while the severe variant is noticeable with choking and mucopurulent rhinorrhea. Long-term symptoms observed in the chronic form, locally known as "Dhukuda," included weight loss, reduced feed intake, and prolonged coughing. Previous studies have reported similar clinical signs [7, 34, 45] utilized the terms "Furri" and "Dhukuda" to classify respiratory diseases in Borana camels.

A significant correlation was found between the respiratory diseases and the seasons, with camels being more affected inside wet period than arid term. Consistent with our findings [1] noted pneumonia as the tenth most common disease, with peak incidence during autumn. Pneumonia has been associated with several risk factors, including sudden weather changes and the migration strain from south to north during

early rainfall. The shift from a warm, dry season to a rainy one is connected to a higher occurrence of respiratory infections during the wet season. Additional risk factors identified include wind, cold, rain, poor nutrition, and animal movement, all of which can negatively impact the animals' well-being. According to various studies [13, 32, 68] the long distances camels travel during the wet season and their habitation in open areas may contribute to these issues.

In assessing the bacterial isolates, the study found a striking difference in bacterial growth between healthy and sick camels, with 70% of samples from clinically sick camels testing positive for bacterial pathogens compared to 27.2% from healthy camels. This discrepancy underscores the role of bacterial infections in exacerbating respiratory symptoms and highlights the importance of routine health assessments in camel populations and found in line with previous studies made [2, 13, 25, 51]. The identification of *Staphylococcus aureus* and *Mannheimia hemolytica* as predominant pathogens is consistent with previous findings in various animal species, emphasizing their relevance in respiratory disease etiology. The bacterial composition revealed in this study, including both Gram-positive and Gram-negative taxa, contributes to our understanding of the microbial landscape in camel respiratory infections. The isolation of *E. coli*, *Pasteurella multocida*, and *Klebsiella pneumoniae* as the leading Gram-negative bacteria aligns with established knowledge regarding pathogens commonly associated with respiratory diseases in livestock [4, 10, 14, 54, 63]. The predominance of *Staphylococcus aureus* among Gram-positive isolates further supports its recognized role as an opportunistic pathogen in cases of respiratory distress.

The similarity in isolation rates between healthy camels and those showing clinical signs points to the potential involvement of agents linked to airway disorder. Moreover, isolates identified from unhealthy individual animals bore similarities to the one found in seemingly healthy camels. This may indicate that various factors, such as the animals' nutritional and immune status as well as environmental conditions, can transform microbiota of the nose, pharynx and larynx of vigorous camels into pathogenic ones. Thus, during periods of stress, microorganisms in healthy animals may become opportunistic pathogens, leading to endogenous infections [5, 6] noted that opportunistic bacteria can transition to potential pathogens when host defenses are compromised, which can lead to a wide range of diseases. Our current findings align with earlier bacterial isolation rates, who observed isolation rates of 88% from camels with respiratory issues and 28.88% from healthy ones reported by [42]. However, [22] reported a lower isolation rate, with 70.7% from healthy camels and 98.3% from clinically diseased camels. Among the isolates obtained from nasal swab samples, *Staphylococcus aureus* (19.0%), *Pasteurella maltocida* (14.3%), *Klebsiella pneumoniae* (12.7%), and *E. coli* (15.9%) were the most prevalent species. Additionally, *Mannheimia hemolytica*, *Micrococcus* spp., *Streptococcus* spp., *S. pyogenes*, and *Pasteurella* spp. were isolated

less frequently. Similar bacterial species have been identified in the nasal passages of camels in previous research [6].

5. Conclusions

In conclusion, this bacteriological study, conducted over two seasons, revealed a significant correlation between respiratory symptoms and the season, with camels being more affected during the rainy season. The odds of respiratory disease were greater (OR=1.6) inside wet period than arid term. The study also identified a strong association between respiratory symptoms and the isolated bacteria, *Staphylococcus aureus* and *Mannheimia hemolytica*. A total of 126 (32.8%) nasopharyngeal aspiration samples displayed no less than single kind of microbes, with the most frequently identified Gram-positive bacteria being *Staphylococcus aureus*, *Bacillus* species, and *Micrococcus* species, and the leading Gram-negative isolates being *E. coli*, *Pasteurella multocida*, and *Klebsiella pneumoniae*. An anamnesis and organoleptic evaluations revealed that 13.0% of the nasopharyngeal aspiration samples drawn from sick individual animals, while the remaining 86.9% were classified as coming from healthy camels. The study's findings suggest that various factors, such as the camels' nutritional and immune status, as well as environmental conditions, can transform the microbiota in the nose, pharynx and larynx of vigorous camels into pathogenic ones, leading to endogenous infections. Overall, this study provides valuable insights into the bacteriological composition of the upper respiratory tracts of camels and highlights the importance of considering the season and clinical symptoms in the diagnosis and management of camel respiratory diseases. The results of this study can inform the development of effective strategies for the prevention and control of respiratory diseases in camels, ultimately improving their health and productivity.

Abbreviations

BA	Bacterial Agents
BHI	Brain Heart Infusion
CI	Confident Interval
OR	Odds Ratio
RS	Respiratory Symptom
YRVL	Yabelo Regional Veterinary Laboratory

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Author Contributions

Bantayehu Muluneh: Conceptualization, Data curation,

Formal analysis, Methodology, Visualization, Writing – original draft

Dereje Teshome: Formal analysis, Investigation, Methodology, Writing – review & editing

Tamirat Tessema: Data curation, Validation, Resources, Writing – review & editing

Adem Kumbe: Investigation, Methodology, Supervision

Sisay Kumsa: Data curation, Validation, Visualization

Gayo Ginbe: Project administration, Resources, Supervision

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Conflicts of Interest

The authors declare that they have no competing interests.

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