Prevalence and Spatial Epidemiology of Goat's Respiratory System Disease and Its Association to Risk Factors in Darfur, Sudan, 2023: Short Communications

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Research Article	**ABSTRACT**
	Respiratory system (RS) diseases impact animal health. It causes severe disease in goats. Respiratory system disease (RSD) is a threat to man and animal health too. This survey was undertaken to examine goat's RSD in Darfur region during 2023. The objectives were to estimate RSD prevalence in goat, to determine risk factors and its association to RSD, to understand indigenous knowledge and to evaluate spatial epidemiology of it. The method used was RS examination by auscultation and measuring temperature, age and gender were studied .One herd (N=14) was selected from goat's herd in North Darfur and compared to other states in the region. 21.4% and 78.6% were male and female frequency. The age frequency was 42.9%, 21.4% and 35.7% for young; mid and old, respectively. The average body temperature was 39.15 ℃. The overall RSD prevalence was 35.71% (95% C.I 35.68%- 36%) during 2023. Fisher's exact test analyses revealed age and gender were not significantly associated with RS distress. Whereas multivariate analyses found that sex were not statistically significant and age was statistically significantly associated with RSD. Also, indigenous knowledge was estimated as 81.42% and goat's birth and death rate were estimated by 45% and 7% respectively in this report. Conclusion was RSD prevalence was 35.71% in this study, and age is risk factor for goat's RSD. Recommendation was further laboratory investigation is important to understand Goat's RSD and its epidemiology in Sudan.
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INTRODUCTION

Respiratory distress is one of the main causes of animal health and production system problem. Many viral infections are reported in goat RS in Sudan like parainfluenza virus (Saeed et al., 2016), pest des petits ruminant virus (PPR) (Ali et al., 2023), beside other bacterial organisms that cause Pneumonia in goat (Elsheikh and Hassan, 2012). These can prevail in animal populations. Goat's RSD is estimated to be 5.6%. As recently reported in COVID-19 pandemic in 2019 (WHO, 2020), whereat, livestock and wildlife are important in virus cycle. Also, it has a large socioeconomic impact on life and trade. Goat is a small ruminant and it is used in farming system for house-hold subsistence. Besides, revenues from goat were estimated as 45.41% in comparison with 45.29% in sheep, respectively. Goat population was estimated by 2,656,808 head, 2,756,688 head and 3,236,112 head in North Darfur, South Darfur and West Darfur respectively (El Dukheri et al., 2004). Also, the goat population was found to be increasing with 2.5%. It is regarded as source for hard currency earnings. It can survive in many agri-ecological zones (El Hag, 2020). It produces milk (Ali, 2010), meat and hides. Physiologically, temperature was significant for animal's RS. It affects evaporation and breathing rate (Hales, 1968). In remote areas, veterinary service is very limited (El Dirani, 2009). A lot of studies were performed to understand owner's knowledge on goat's RSD (Jones et al., 2020). Although, there was no specific laboratory testing to respiratory disease was done in this study. Thus, survey was carried out to investigate goat's individual risk factor and its association with RSD based on clinical exams and observation to understand it.

Objective

1. To estimate goat's respiratory disease prevalence in study area.
2. To understand indigenous knowledge to animal health and production.
3. To estimate spatial epidemiology of goat's RSD in the Darfur region.
4. To determine risk factors and its association with respiratory disease in goat.

The study question was what factors affecting goat respiratory disease epidemiology and its distribution were. We assumed that respiratory distress as dependent variable and individual risk factors as independent variables. Hence, this survey assumed that sample and population were equal in arithmetic mean given population was randomly distributed. What if they were differing. Then, we did accept type I error (α=0.5), wherein 100 samples , we are confident , 95% had an effect on population and only 5 sample had no effect on population (Cohen, 1992). Then we rejected the null hypothesis and accept alternative one which in fact is true.

MATERIAL and METHOD

Ethical Approval

The ethical approval for this research was obtained from the Central Veterinary Research Laboratory Center (CVRLC), Animal Resources Research Corporation, Ministry of Animal Resources and Fisheries, Republic of the Sudan, on 19 July 2021 (Approval No. 1/1).

Data Collection

Data was collected randomly from goat herd in North Darfur state. It was managed and prepared for analyses. Goat herd was comprised from fourteen animals (N=14). Male and female frequency was 21.4% and 78.6%, respectively, Figure 1.
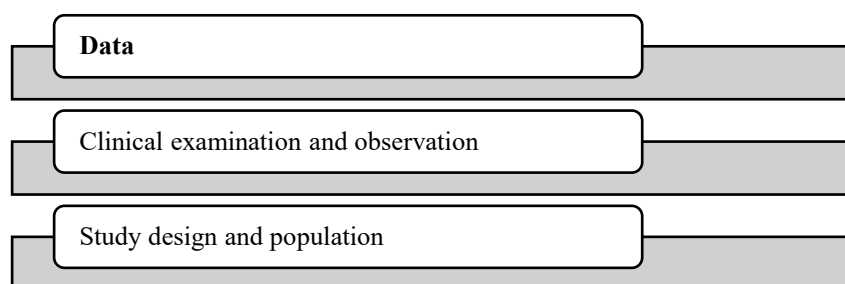

Figure 1. Data collection about RSD in goat

Study Area

This survey was carried out in North Darfur state (NDs) in goat species. It is one of five wilayat or/and states in Darfur region. It is located in an area of 296,420 km^2 and estimated population of 2,304,950 in 2018. Alfashir city is state capital. Other significant towns are Ailliet, Kebkabiya, Kutum, Mellit, Tawilah and Umm keddada. ND occupies most of Darfur region including part of Marrah Mountains. The northern part is entirely desert and south is slightly rainfall with eastern side is plain with low sandy hills, while volcanic Marrah Mountains occupy most of western side of the south. In southern part most important crops are millet, maize and peanuts. NDs is bounded on the northwest by Libya, on the north by Northern state on the east by Northern state and North Kordofan state on the Southeast by South Kordofan state on the south by South Darfur and in the west by West Darfur and Republic of Chad.

Study Population

The target population was an indigenous goat breed in NDs. Sudan has significant smallruminant population, estimated in 2006 at 50.1 million sheep and 42.1 million

goats. Arab market is the main market for Sudanese livestock, therein it accounts for about 70% of cattle, 31% of sheep, 49% of goats, and 25% of camels. Livestock populations are concentrated in Northern and Southern Kordofan and Darfur States, accounting for 36% cattle, 40% sheep, 36% goats, and 33% camel in Sudan (Figure 2, Figure 3).
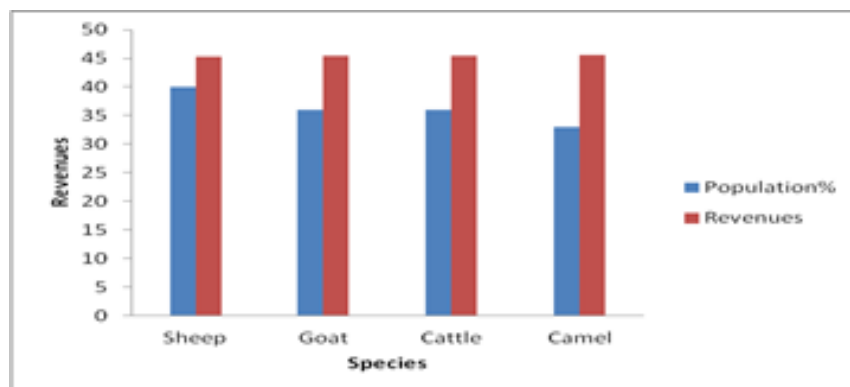

Figure 2. Animal's population and revenues

Figure 3. Goat population and age in Darfur region (Postgis-project, 2013)

Sample Size and Study Design

Sample size determination

Sample size was determined by using the following formula (Thrusfield, 2007).

Sample size (n)$=\frac{1.96^{\wedge}(2)*Pexp\,(1-Pexp)}{d2}=$ (1)

Where;

n = required sample size

Pexp = expected prevalence

d = desired absolute precision

This study assumed 50% expected prevalence of goat's RSD in 384.16 samples in North Darfur states given population was randomly distributed. Herd sampled was 14 animals per herd selected in this study. Therefore, prevalence was calculated. A cross sectional study design was used from January to February 2023 in this survey. Sampling method used was simple random sampling. Bias and confounding due to random selection were considered; state was selected, then herd within state was selected randomly and then individual animal within herd was randomly chosen.

Indigenous knowledge

Respondent's indigenous knowledge was examined by personal interview and telephone call. It was assessed qualitatively. It examines animal disease information, animal production system, animal housing system, animal management system and animal husbandry.

Clinical Examination

RS was examined by auscultation on goat chest whether it is normal or abnormal. Also, Age, gender, and body temperature were checked clinically by dentition, observation and thermometer, respectively.

Spatial Epidemiology

Geographical data were collected to analyze goat's RSD distribution in Darfur by using Qgis software version 3.16, Hannover (Postgis-project, 2013).

Statistical Analyses

Descriptive statistics, univariate and multivariate analyses were done by using Jamovi software, version 2.3 (The Jamovi Project, 2022) , statistical analyses software PSPP, version 1.4 (GNU, 2020) and Microsoft window (MS) excel spreadsheet, version 7 using analyses tool pack (Sokal and Rohlf 1995).

RESULTS and DISCUSSION

On herd was examined (N=14), male and female frequency was 21.40% and 78.60% respectively. The age frequency was 42.90%, 21.40% and 35.70% for young, medium and old respectively. Body temperature was considered. 0.21, 0.93 and 0.64 were arithmetic means to gender, age and RS examination in goat in this study, respectively, Table 2, Table 1, Figure 3.

Frequencies

Table 1. Frequency table for gender,age and Clinical examination

Variable		Frequency	Percent
Gender	Female	11	78.60%
	Male	3	21.40%
Age	Young	6	42.90%
	Medium	3	21.40%
	Old	5	35.70%
RS exam	Abnormal	5	35.70%
	Normal	9	64.30%

Goat's Body Temperature

Average body temperature was 39.15 ^{0} C. The lowest temperature was estimated as 38.18 ^{0} C and the highest temperature estimated was 39.88 ^{0} C in this survey, Figure 4.
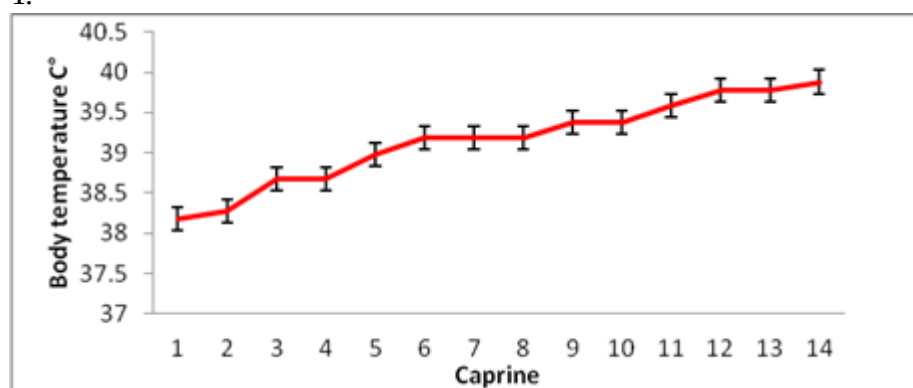

Figure 4. Goat's body temperature

Descriptive Statistics

Table 2. Descriptive statistics of goat individual-characteristics

Variable	N	Mean±SD	Minimum	Maximum
Gender	14	0.21±0.43	0	1
Age	14	0.93±0.92	0	2
Clinical examination	14	0.64±0.5	0	1

Goat's RSD Prevalence

Overall prevalence in goat herd was estimated as 35.71%, (95% C.I 35.68%- 36%) for goat's RSD in North Darfur state during 2023, Figure 5.
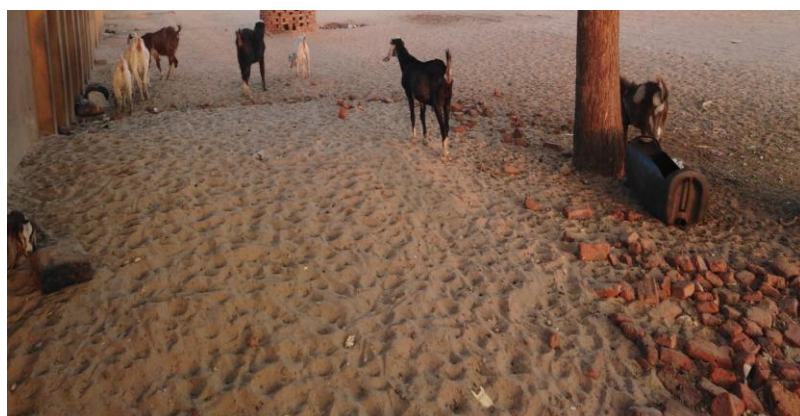
Figure 5. Herd grazing in neighborhood

Individual Risk Factors Univariate Analyses

Univariate risk factors of sex and age was calculated to be not significantly associated with respiratory status, (P-value >0.05), respectively in this study, Table 3.

Table 3. Fisher's exact test for goat's individual risk factors and RS disease

Variable		Clinical examination		Fisher's exact test	df	Fisher's exact sig
		Abnormal	Normal			
Gender	Female	4(36.40%)	7(63.60%)	1	1	0.05
	Male	1(33.30%)	2(66.70%)			
Age	Small	1(16.70%)	5(83.30%)	0.37	2	0.07
	Medium	0(0.00%)	3(100%)			
	Old	4(80.00%)	1(20.00%)			

Significant level,*=P<0.05, **=P<0.01 and P<0.001

Multivariate Analyses for Individual Risk Factor

Multivariate regression analysis found age was highly significantly related with RSD, (P<0.05), while sex was not, (P>0.05). Also, regression line was obtained as formulation of co-efficient, (y= 0.56 sexes- 2.99 age), Table 4.

Table 4. Multivariate analyses for goat's individual risk factors and its correlation with RS

	Unstandardized Coefficients		Standardized Coefficients	t	Exp(B)	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta				Lower	Upper
RSD	0.92	0.18	0	5.05		0	0.52	1.32
Gender	0.06	0.29	0.05	0.2	-2.99	0.84	-0.58	0.7
Age	-0.31	0.13	-0.57	-2.29	0.56	0.04*	-0.6	-0.01

Significant level,*=P<0.05, **=P<0.01 and P<0.001

Spatial Epidemiology of Goat's Respiratory Disease

This study showed goat's respiratory disease prevalence was 35.71%, 49.96% and 44.22% in North Darfur, South Darfur and West Darfur respectively, Figure 5.
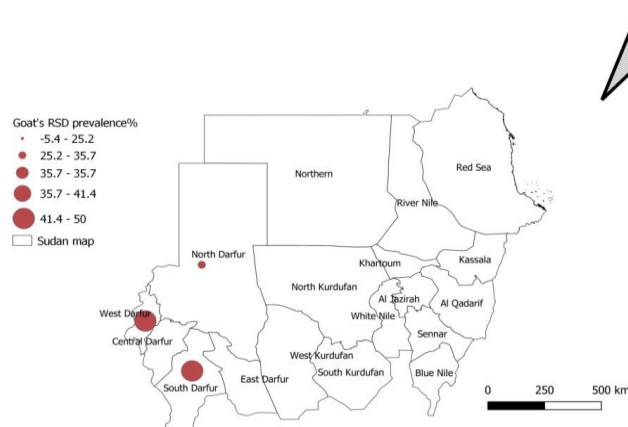

Figure 5. Spatial pattern of goat's RS disease in Darfur (Post-Project, 2013)

Indigenous Knowledge

Conditional formatting was used to estimate respondent indigenous knowledge in this survey. The indigenous knowledge evaluated as 81.42%. The respondent knowledge about goat health, breeding, husbandry, production, management and housing was excellent, excellent, excellent, very good and good respectively, Table 5.

Table 5. Qualitative assessment for farmer indigenous knowledge

Parameter	Score			
	Poor (20-49)	Good (50-59)	Very good (60-79)	Excellent (80-100)
Animal disease information	0	0	0	90
Animal production system	0	0	79.5	0
Animal management system	0	0	79.5	0
Animal housing system	0	59.5	0	0
Animal breeding system	0	0	0	90
Animal husbandry	0	0	0	90
Average grade(level)	44.5	59.5	79.5	90

The current study discussed total goat population in Sudan was estimated by 41,485,000 heads, its annual growth rate was 2.5% and its off-take rate was 37% (SAR Network, 2024). Eighteen percent of tropical livestock units (TLUs) are from Darfur region. Goat is considered one of small ruminants like sheep. It can survive in harsh environment. Although, there are many constraints e.g. diseases that impact goats. For example, study done had revealed that seroprevalence of Para-influenza virus was estimated as 47.8% in goat in Nayala, Darfur during 2010-2013 (Saeed et al., 2016). Also, RSD may cause systematic infection in goat as Caprine arthritis encephalitis virus, (Li et al., 2013) ; and Blue tongue (BT) virus infection (Chakraborty et al., 2014).Fisher's exact test found no significant association between gender and age with respiratory distress in goat, However, multivariate analyses found that age was significantly related with RSD. This finding had found to be in alignment with study done by (Callan and Garry, 2002 and (Chakraborty et al., 2014). Also, study done by (Smith, 2000) showed that young animals were most affected by respiratory infection in cattle. On other hand, chronic wasting diseases like goat and sheep tuberculosis were reported at slaughter house in Darfur (Aljameel et al., 2017) and also it could be a good carrier for infection to a man. However, this required further investigation. Similar research done by (El Khalfaoui et al., 2024) about sheep caseous lymphadenitis was observed to be higher in adult than young sheep in Morocco. The birth rate was 45% and 5 kids were born for about 11 does in this survey. This means, 2.2 kids for one doe per year. This had an agreement with study done by (Wilson, 1976). Death rate was estimated by 7% in this study. Environment is a major risk that impact goat RS, however, limited information was available to understand it. For example, mixed parasitic infestation was detected in goat shedding in this survey; hence this may reduce goat productivity. But its relation to respiratory disease in goat was not understood. Also, goat sera were screened serologically for rift valley fever that causes influenza like symptoms in human, and it was negative. Also, Blue tongue virus infection was reported in Darfur in cattle (Khair et al., 2014). Therefore, cross-infection and differential diagnosis are essential to identify risk about respiratory infection in goat. Livestock production

system is mainly conventional in Darfur. It is dependent on grazing of animal in natural grazing lands. It is, therefore, animals are exposed to contracting RSD in such a condition. Although, no evidence for camel and goat to be as a carrier for MERS-CoV to human (Farag et al., 2019); SARS-COV-2 had been reported in children and it was not infectious (Silva et al., 2023). Goats are kept with camel as trekking animal for livelihood. This often consists hazard for people at risk. Further, host specificity is another variables affecting goat health. For instance, PPR virus was found to be serologically prevailing in goat rather than sheep (Ali et al., 2023). This has important role to play in epidemiology of respiratory diseases in animal. Generally, veterinary services are very limited to livestock export from Darfur region; for example, fed-lots, fattening and watering points and slaughter houses required to be further developed. Also, this survey had scored respondent's knowledge about goat health and productivity qualitatively; nonetheless, quantitative data is essential to have insight about goat's RSD. Goat has socioeconomic value in our community. It had fulfilled gender equality as one of millennium development goals (MDGs) that empowering woman who are widow and responsible for family in rural community; and it gives them chance to increase their income and live sustainable life (Kids for Kids Organization, 2023).

CONCLUSION

This study concluded that overall goat's RSD prevalence was estimated as 35.71% and age was highly significantly associated with RSD. It is recommended that laboratory testing is emphasized to determine the cause of RSD in goat and understand its epidemiology in Sudan.

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Conflict of Interest

There is no conflict of interest in this paper.

Author Contribution

Mohammed EAM had contributed by collecting and managing survey data and writing of the manuscript in this work.

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