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Research Reports

Seroprevalence and Geographical Distribution of Rift Valley Fever in Livestock in Sudan

Seroprevalensi dan Distribusi Geografis *Rift Valley Fever* pada Ternak di Sudan

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ABSTRACT

Background: Rift Valley Fever (RVF) is zoonotic and Transboundary Snimal Disease (TAD) that has public health and trade implications for livestock and livestock products. It occurs following heavy rains and is characterized by miscarriages in small ruminants, such as sheep and goats, and illness in humans. The mosquito is the main vector for the disease. It can be transmitted by direct contact with tissues, aerosol, and blood of the infected individual and by ingestion of raw and/or uncooked milk. **Purpose:** This study aims to estimate the seroprevalence of RVF in Sudan and to determine the geographical distribution of RVF to understand the pattern of its occurrence in Sudan. **Methods:** This study was conducted in Central Sudan. This study was a retrospective study in which the data were collected mainly from archives and records of the laboratory and were used to estimate the seropositivity. The target population in this study was concentrated on livestock, especially ruminants. **Results:** In this study, the overall seroprevalence of RVF was estimated to be 16%. The highest seroprevalence was recorded at 66% in cattle in River Nile (95% CI [60.37171, 73.44393]), whereas the lowest seroprevalence was recorded at 0.8% in cattle in Blue Nile (95% CI [0.73293, 0.96704]). **Conclusion:** This study concluded that herd immunity is a significant factor in understanding the epidemiology of RVF in Sudan. In addition, the retrospective data provided a roadmap for managing and controlling transboundary diseases that have had an impact on human health.

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ABSTRAK

Latar Belakang: *Rift Valley Fever* (RVF) adalah penyakit hewan zoonosis dan lintas batas yang mempunyai implikasi kesehatan masyarakat dan perdagangan terhadap ternak dan produk ternak. Penyakit ini terjadi setelah hujan lebat dan ditandai dengan keguguran pada hewan ruminansia kecil, seperti domba dan kambing, dan penyakit pada manusia. Nyamuk merupakan vektor utama penyakit ini. Penyakit ini dapat ditularkan melalui kontak langsung dengan jaringan tubuh, aerosol, dan darah orang yang terinfeksi, serta melalui konsumsi susu mentah dan/atau susu mentah. **Tujuan:** Penelitian ini bertujuan untuk memperkirakan seroprevalensi RVF di Sudan dan menentukan sebaran geografis RVF untuk memahami pola kejadiannya di Sudan. **Metode:** Penelitian ini dilakukan di Sudan Tengah. Penelitian ini merupakan penelitian retrospektif dimana data dikumpulkan terutama dari arsip dan catatan laboratorium dan digunakan untuk memperkirakan seropositif. Populasi sasaran dalam penelitian ini terkonsentrasi pada hewan ternak khususnya ruminansia. **Hasil:** Dalam penelitian ini, seroprevalensi RVF secara keseluruhan diperkirakan sebesar 16%. Seroprevalensi tertinggi tercatat sebesar 66% pada sapi di Sungai Nil (95% CI [60,37171; 73,44393]), sedangkan seroprevalensi terendah tercatat sebesar 0,8% pada sapi di Blue Nile (95% CI [0,73293; 0,96704]). **Kesimpulan:** Penelitian ini menyimpulkan bahwa kekebalan kelompok merupakan faktor penting dalam memahami epidemiologi RVF di Sudan. Selain itu, data retrospektif memberikan peta jalan untuk mengelola dan mengendalikan penyakit lintas batas yang berdampak pada kesehatan manusia.

Kata kunci: Ruminansia; Rift Valley Fever; Seroprevalesi; Zoonosis

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INTRODUCTION

Rift Valley fever (RVF) is viral disease transmitted by arthropods. It belongs to the Bunyviridae family, *Phlebovirus spp.* genus (Calisher and Karabatsos, 1989). It affects small ruminants, such as sheep and goats, as well as cattle, camels, and humans. In general, RVF is asymptomatic, but it can be characterized by neonatal death and miscarriage in pregnant females following heavy rains, which predispose the climatic conditions for the multiplication of mosquitoes such as Aedes spp. as the primary vector for RVF (Gerdes, 2004).

In humans, RVF is asymptomatic, but it is generally a flu-like disease. In some cases, RVF can cause retinitis and eye diseases. Severe cases may involve encephalitis and hepatic and hemorrhagic diseases (Madani *et al.*, 2003). RVF is considered as one of the transboundary animal diseases that have impacts and dire consequences in the international trade of livestock and livestock products. It also has public health implications that has caused socioeconomic losses due to its high rate of mortality and morbidity in humans and animals (Meegan *et al.*, 1989). Genetically, the RVF virus is stable and can survive in the environment inside infected mosquito eggs in dambos or land depressions. Unfortunately, there is no vaccine available for humans, which increases the risk of RVF (OIE, 2014). Furthermore, RVF has been reported in many countries in Africa and Madagascar and recently in Saudi Arabia and Yemen in the Arabian Peninsula (Shoemaker *et al.*, 2000). This has eventually affected the livestock industry in East African countries, Ethiopia, Sudan, Somalia, Kenya, and Djibouti because most of the livestock commodities and imports for the Gulf countries are related to the exports from the East African community.

Risk assessment and risk analysis are important tools for improving the livestock health in case of suspicion of RVF. RVF can be transmitted by direct contact with infected animal tissues and ingestion of undercooked and/or raw milk. Mosquitoes play a significant role in the epidemiology of RVF, whereas the susceptible host is exposed to infected mosquitoes through the sylvatic and epizootic cycles, which can spread the infection biologically and mechanically, respectively. RVF was first reported to occur in Lake Naivasha, Kenya in 1973 (Daubney *et al.*, 1931). Moreover, RVF has been found to be associated with anomalies in rainfall, vegetation index, and the El Nino Southern Oscillation (ENSO), which occurs in the Indian Ocean and causes heavy rainfall in the Greater Horn of Africa (Anyamba *et al.*, 2001). RVF was first reported in Sudan by Eisa (1984). More information and research are required to understand the epidemiology of RVF in Sudan. Therefore, this study aims to estimate the seroprevalence of RVF in Sudan and to determine the geographical distribution of RVF to understand the pattern of its occurrence in Sudan.

MATERIAL and METHOD

Study Area

This study was conducted in Central Sudan, including the Gezira, White Nile, Blue Nile, Sennar, Khartoum, and River Nile state. Most of the study areas are located in Central Sudan, where the largest agricultural state of Gezira is located. In addition, it is characterized as a rich savannah area where the ecological condition is suitable for the abundance of vectors as a risk factor for suspected human and animal host.

Sample Size Determination

Sample size was calculated using the following formula, as no information about seroprevalence was reported for previous outbreaks. Therefore, the expected prevalence was assumed to have a probability distribution of 0.5. (n = required sample size, $Pexp$ = expected prevalence , d = desired absolute precision).

$$\text{Sample Size } (n) = \frac{1.96 \times Pexp\ (1\text{-}Pexp)}{d^2}$$

As a result, 105.3 samples were required to determine an expected prevalence of 16%. Because the population was not randomly distributed, the sample was tripled and proportionally collected, resulting in 3,393 samples. This study was a retrospective study in which data were collected from the past. For example, 156 samples were collected during the RVF outbreak in 2007, but only serological test was performed. These data were mainly used to estimate the study parameter for seropositivity. Sample was collected using non-probability multistage cluster sampling by selecting the state as a stratum and within the stratum, the locality was randomly selected, and within the locality, the animal was the sampling unit during the 2007 and 2008 RVF outbreaks in Sudan where IgM serological test was used (Imadeldin *et al.*, 2013).

Study Population

The target population in this study was concentrated on livestock, especially sheep, goats, and cattle. The seroprevalence of RVF was estimated by calculating the percentage of positive samples obtained from optical density readings to the ELISA test of laboratory results.

Data Analysis

The seroprevalence was determined by descriptive statistics using SPSS version 16. Meanwhile, ArcGis was used to create geographical maps of the disease in the study area.

RESULTS

Seroprevalence of RVF in Study Population

In this study, the overall seroprevalence of RVF was estimated to be 16%. The highest seroprevalence recorded was 66% in cattle in River Nile (95% CI [60.37171, 73.44393]), whereas the lowest seroprevalence recorded was 0.8% in cattle in Blue Nile (95% CI [0.73293, 0.96704]) (**Table 2**). Percentage positivity was also drawn to explain the trend of RVF in the study area (**Figure 1**).

Geographical Distribution of RVF Seropositivity

In Gezira, the estimated prevalence were 27.8%, 61%, and 37.5% with 95% CI [26.93398, 28.72688], 95% CI [59.71469, 62.89708], and 95% CI [36.88486, 38.12284] in cattle, goats, and sheep, respectively. Meanwhile, in Sennar, the estimated

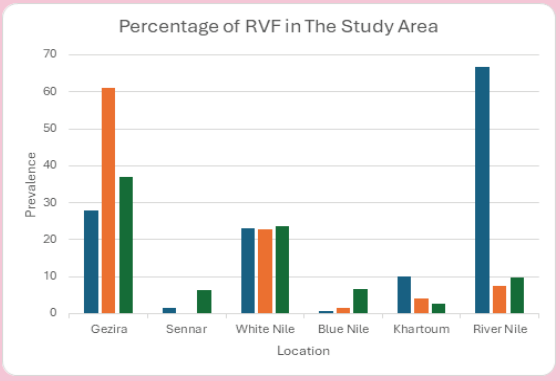

Figure 1. Percentage Positivity of RVF in The Study Area.

Table 1. RVF Seropositivity and Mean Difference in The Study Population (Cattle, Goats, and Sheep) Using the t-test

Variable	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Cattle	0.507	5	0.634	0.051	-0.21	0.31
Goats	0.555	5	0.603	0.047	-0.17	0.27
Sheep	-0.292	5	0.782	-0.016	-0.16	0.12

Note: Significant at 0.05. This study showed no statistically significant difference between the seropositivity percentage of RVF and the average population of sheep, goats, and cattle ($p > 0.05$).

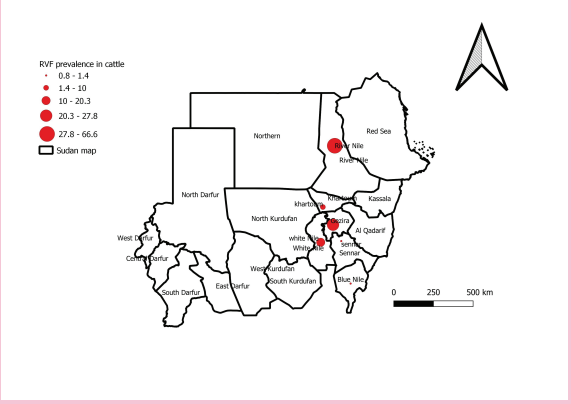

Figure 2. Estimated Prevalence of RVF in Cattle in Study Area.

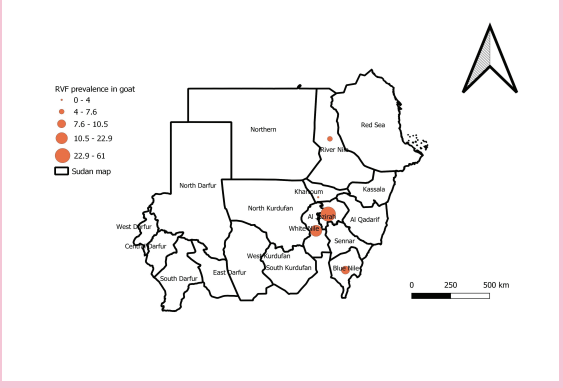

Figure 3. Estimated Prevalence of RVF in Goat in Study Area.

Table 2. Location, Species, and Seropositivity of RVF in The Study Area.

Location (State)	Species	Total Number (N)	Positive	Estimated Prevalence	95% Confidence Interval	
					Lower	Upper
Gezira	Cattle	133	37	27.8%	26.93398	28.72688
	Goats	93	57	61%	59.71469	62.89708
	Sheep	376	141	37.5%	36.88486	38.12284
Sennar	Cattle	70	1	1.4%	1.16875	1.72971
	Sheep	280	18	6.4%	6.13673	6.73075
White Nile	Cattle	172	35	20.3%	19.68306	21.03144
	Goats	296	68	22.9%	22.43182	23.52391
	Sheep	447	106	23.7%	23.26544	24.16833
Blue Nile	Cattle	237	2	0.8%	0.73293	0.96704
	Goats	209	22	10.5%	10.09334	10.97314
	Sheep	723	49	6.7%	6.58955	6.96909
Khartoum	Cattle	20	2	10%	8.68523	11.45944
	Goats	45	2	4%	3.86010	5.09309
	Sheep	35	1	2.8%	2.33751	3.45941
River Nile	Cattle	6	4	66.6%	60.37171	73.44393
	Goats	131	10	7.6%	7.17142	8.11785
	Sheep	71	7	9.8%	9.14898	10.61009

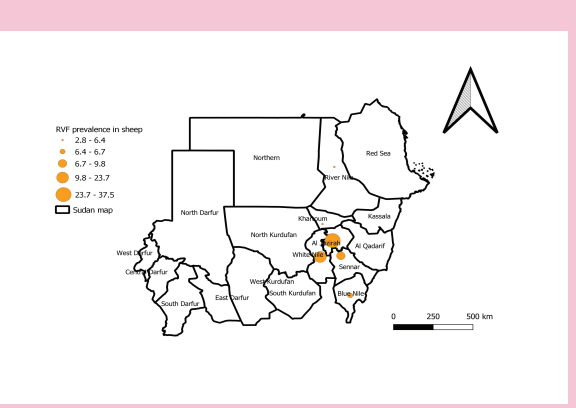

Figure 4. Estimated Prevalence of RVF in sheep in Study Area

prevalence were 1.4% and 6.4% with 95% CI [1.16875, 1.72971] and 95% CI [6.13673, 6.73075] cattle and sheep, respectively. In White Nile, the estimated prevalence were 20%, 22.9% and 23.7% with 95% CI [19.68306, 21.03144], 95% CI [22.43182, 23.52391], and 95% CI [23.26544, 24.16833] in cattle, goats, and sheep, respectively. In addition, the estimated prevalence in Blue Nile were 0.8%, 10%, and 6.7% with 95% CI [0.73293, 0.96704], 95% CI [10.09334, 10.97314], and 95% CI [6.58955, 6.96909] in cattle, goats, and sheep, respectively. Moreover, the estimated prevalence in Khartoum were 10%, 4%, and 2.8% with 95% CI [8.68523, 11.45944], 95% CI [3.86010, 5.09309], and 95% CI [2.33751, 3.45941] in cattle, goats, and sheep, respectively. Finally, the estimated prevalence in River Nile were 66.6%, 7.6%, and 9.8% with 95% CI [60.37171, 73.44393], 95% CI [7.17142, 8.11785], and 95% CI [9.14898, 10.61009] in cattle, goats, and sheep, respectively (**Table 2**, **Figure 2,3**, and **4**).

DISCUSSION

Rift Valley fever (RVF) is mosquito-borne disease that can affect small ruminants, such as sheep, goats, cattle, camels, and humans. It has direct consequences on public health and the trade of livestock and livestock products. Moreover, RVF has economic and social consequences on the vulnerable

society. RVF is considered as one of the neglected infectious diseases although it plays a significant role in the understanding of ecosystem health and one health approach (Feburay, 2015). RVF can be transmitted by direct contact with infected tissues or ingestion and/or consumption of raw milk. The transmission and epidemiology of RVF is mainly correlated with biological vector, density, and survival in the environment (Iranpour *et al.,* 2011). The RVF virus can flare up and spread after heavy rains, which is reported to be significantly associated with weather abnormalities in the Greater Horn of Africa, leading to RVF outbreak especially in East African countries (Davies *et al.,* 1985). In addition, RVF is classified as a nationally notifiable disease. The occurrence of RVF in Sudan was reported in Kosti, White Nile and spread to other states.

This study reported the seroprevalence of RVF in selected states of Sudan in livestock population of sheep, goats, and cattle. This study aims to understand the geographical pattern and association with seropositivity of RVF in the study area. The overall estimated seroprevalence was 16%, thus providing an indicator for the disease situation among the study population, namely sheep, goats, and cattle, which was important in providing an understanding of the epidemiology and disease mapping and surveillance in the country. This study recorded a lower prevalence than another preliminary study on RVF in same species in Sudan (Eisa, 1984). Another study found that the prevalence of RVF was 9.6% in dromedary camels in Khartoum (Maiy *et al.,* 2016). In addition, RVF was reported in 33% of cattle, 50% of goats, and 17% of sheep (Mohamed *et al.,* 2013). Another study reported the prevalence of RVF was estimated to be 52.6% in cattle in Sudan (Sado *et al.,* 2022). A seroprevalence of 17% for RVF was also reported in Malawi (Kainga *et al.,* 2022). The finding of this study is also consistent with a study that reported a prevalence of 18.3% for RVF in abattoir workers in Kenya (Nyamota *et al.,* 2023). In another study, a 2.4% mortality rate was recorded in sheep, while 2.1% was recorded in goats (OIE, 2019). However, while sheep, goats, and cattle have similar susceptibility to RVF infection, this study showed no host preference for RVF infection. The geographical distribution of RVF was estimated by the percentage positivity in the study area. The highest seropositivity was 66.6% in cattle in River Nile, while the lowest seropositivity was 0.8% in cattle in Blue Nile. This study concluded that epidemiological analysis of RVF in livestock in Sudan would provide information for understanding this particular disease and provide more information required to thoroughly understand the epidemiology and risk factors associated with the seropositivity of RVF in suspected animal species and areas. Moreover, it would lead to the establishment of RVF knowledge which is important to prevent and plan active and passive surveillance, early warning system, management, and control of RVF.

CONCLUSION

This study concluded that the overall seroprevalence of RVF was estimated to be 16%. Vaccination coverage is a significant factor for estimating the epidemiology of RVF in Sudan. No further information was available on vaccination against RVF due to the lack of data on suspected groups and foci of infection where vaccination can reduce the prevalence of the infection in the country. In addition, retrospective information provides a roadmap for transboundary disease management and control that have had an impact on human health.

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CONFLICT of INTEREST

The authors declare that they have no conflicts of interest.

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ETHICAL APPROVAL

This study received ethical approval from the Central Veterinary Research Laboratory, Sudan.

AUTHORS' CONTRIBUTIONS

M.E collected and wrote the manuscript, A.A provided disease information and data, S.K designed the geographical maps, A.E revised the manuscript, and T.M provided the diagnostic test results.

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