Research Article

Seroprevalence of Rift Valley Fever Virus Infection among Slaughtered Ruminants in Jos, North-Central, Nigeria

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Abstract | Rift Valley fever (RVF) is a mosquito-borne emerging disease, capable of causing large epidemics in livestock accompanied by cases in humans, but with a complex cycle of transmission that makes it difficult to predict. The risk of infection in humans is more with livestock handlers who get occupationally exposed to Rift Valley fever virus (RVFV) because of frequent contact with infected vectors, animal body fluids and other tissues. We aimed to determine the prevalence of antibodies against RVFV in slaughtered ruminants in Jos, North-Central, Nigeria. Blood samples were collected from 100 livestock (cattle and goats) at selected slaughter locations in Jos Metropolis. Questionnaires were administered to obtain information on animal species, sex, and localities of origin. The blood samples were screened for RVFV antibodies using competitive Enzyme Linked-immunosorbent Assays (C-ELISA) to detect anti-RVFV IgG/IgM. Eleven out of 100 samples tested positive for anti-RVFV antibodies (prevalence=11%). Seropositive cases were more among cattle (16.0%) than goats (6.0%) (P=0.001). Seropositivity was also higher among the animals from Yan-shanu market, with 90.9% of the seropositive animals purchased from the said market. The mean duration of stay of animals at the abattoir/slaughter slab before slaughtering was not associated with the infection. The infection was more in females than males, though with no statistical significance. This study revealed high prevalence of RVFV infection in Jos, Nigeria, and highlights the endemic circulation of the virus despite the absence of clinical symptoms in animals sampled, suggesting the need to set up early warning surveillance and prevention/control strategies to mitigate the risk of unexpected outbreaks.

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Introduction

Rift Valley fever (RVF) is an emerging vector borne viral zoonotic disease that primarily affects ruminants, causing abortions in pregnant females, acute mortality in young susceptible livestock, and haemorrhagic fever (Wilson, 1994). It is caused by RVF virus (RVFV), which is a single stranded RNA virus classified under the Realm *Riboviria*, Kingdom *Orthornavirae*, Phylum *Negarnaviricota*,

Subphylum *Polyploviricotina*, Class *Ellioviricetes*, Order- *Bunyavirales,* Family- *Phenuiviridae,* and Genus- *Phlebovirus* (ICTV, 2020). RVF was first discovered in 1930 on a farm in the Great Rift Valley of Kenya (Daubney et al., 1931), and, to date, it has been reported mainly in the African countries and the Arabian Peninsula (Nanyingi et al., 2015).

Epizootics of RVF are sporadic and are often linked to persistent heavy rainfall and flooding, which result in the emergence of infected Aedes mosquitoes, after which transmission is amplified by other mosquito species including those belonging to the Anopheles and Culex genera (Tantely et al., 2015). In humans, the majority of infections result from direct or indirect contact with the blood or tissues of infected animals (Peyre et al., 2015; Warimwe et al., 2016) especially while assisting with animal birth; through wounds or cuts from knives, and aerosol inhalation during slaughtering/butchering of infected animals, or during disposal of carcass or aborted fetuses; or through consumption of raw meat and milk (Balkhy and Memish, 2003; LaBeaud et al., 2010). The several bites from infected mosquitoes belonging to species of *Aedes, Culex, Anopheles, Mansonia, Eretmapodites* and *Coquiellettidia* genera (Turell et al., 2008) cause mostly asymptomatic infections in the humans, or present with mild flu-like symptoms, and sometimes severe illnesses with symptoms such as hepatitis, encephalitis and retinitis, among others (Pepin et al., 2010).

Rift Valley fever is listed as an emerging zoonotic category A viral pathogen in the national institute of allergy and infectious diseases (NIAAID) list priority pathogens for biodefense research (Nishiyama et al., 2016). The disease has a severe socio-economic impact on food security, household nutrition, and trade to livestock producers in affected countries (Rich and Wanyioke, 2010). In livestock, RVFV infection can cause increased abortions and still births, and high mortality in neonates and juvenile animals. As a result, RVF outbreaks can lead to significant economic losses (Bird et al., 2009).

There is no approved specific treatment for RVFV infection in humans or animals at the moment, although Peters et al. (1986) reported that Ribavirin at an initial dose of 50mg/kg, followed by 10mg/kg 8-hourly for about nine days can elicit recovery from the disease in humans. Supportive care is therefore recommended as it can prevent complications and decrease mortality in both humans and animals (Elliot et al., 2013). Some inactivated and live attenuated vaccines have been developed and have been efficacious in animals (Mansfield et al., 2015). Development of human Rift Valley fever virus vaccine has been challenging due to the safety of the vaccine, although Frank-Peterside (2000) reported an erstwhile use of the vaccine in Nigeria. To better understand the utility of Rift Valley fever virus vaccine in a particular setting, the prevalence of disease in humans and animals must first be understood.

The epidemiology of RVFV in nomadic pastoral herds in Nigeria is poorly understood due to paucity of research and surveillance information on the disease. In Nigeria, there has been no report of outbreak of RVF among humans, but antibodies against the virus have been found in few studies in livestock and humans. The prevalence of the virus infection ranged from 0.7 to 14.8% in animals and humans, respectively (Opayele et al., 2019; Ezeifeka et al., 1982; Adeyeye et al., 2011; Olaleye et al., 1996; Tomori, 1980).

Jos metropolis is characterized by conducive weather, good rainfall with pockets of forest, and good grazing fields for ruminants. During the dry season, many temporary mining pools which exist in the metropolis are used for irrigation-based farming system, and these provide a favorable condition for the proliferation of RVFV vectors. These factors aid the transmission of RVFV infection. Meanwhile, large populations of ruminants are reared in Jos metropolis with additional numbers of animals being received from different parts of the Northern region, and this favors the cohabitation of animals from different locations with different vegetations, and their sellers and buyers may become at enhanced risk of zoonotic transmission of the disease. Also abattoir workers, including those in Jos, who are constantly exposed to animal blood and tissues are at higher risk of exposure and infection (Abu-Elyazeed et al., 1996; Opayele et al., 2018). It is obvious that there is a silent circulation of RVFV in Nigeria among this group of humans without clinical evidence, suggesting that the epidemiology is inadequately understood. This therefore, highlights the need to investigate the extent of RVFV infection in animals slaughtered in Jos metropolis. This study therefore aimed at investigating the sero-prevalence of Rift Valley fever, and the distribution and frequency of the infection in relation to sex and the source location

among cattle and goats slaughtered in Jos metropolis North-Central, Nigeria.

Materials and Methods

Study design and sample collection

The study, which was of a descriptive cross-sectional design, was conducted in Jos metropolis (Jos and Bukuru) Abattoir/slaughter slab of Jos East and Jos South Local Government Areas of Plateau State respectively. It targeted both cattle and goats slaughtered at Jos Abattoir and Bukuru slaughter slab in relation to breed, gender and source locations. There was also a structured questionnaire which was administered and filled at the point of sample collection. A verbal explanation of the study was done to the individual butchers before administering the questionnaires at the abattoir and slaughter slab, and then collecting the samples. Data on each animal sampled was collected on separate questionnaire indicating the breed, gender, source location, and number of days at the abattoir/slaughter slab before slaughtering. The ethical approval for this study was obtained from the Plateau State Veterinary Teaching Hospital, Jos, Nigeria. Sampling involved the collection of 5mls of blood from the jugular vein of animals upon slaughtering into sterile EDTA samples bottles. The samples were transported in cold box with ice packs to the laboratory where the plasma samples were separated and stored at -80°C until analyzed.

Sample analysis

We determined RVFV infection using Competitive Enzyme Linked Immuno Sorbent Assay (C-ELISA) for the detection of IgG and IgM antibodies against RVFV. This was achieved using ID screen® Rift Valley fever competition multi-species ELISA kit (IDVET, Montpellier, France) according to the manufacturer's instructions. The diagnostic kit was designed to detect the presence of antibodies (both IgM and IgG without discrimination) directed against the RVFV nucleoprotein (NP) in the plasma or serum. The test was considered valid when the mean value of the negative control OD (OD_{NC}) was greater than 0.7 and the ratio of the mean values of the positive and negative control ODs (OD_{PC}/OD_{NC}) was less than 0.3. Samples that had competition percentage (S/N %) of ≤ 40% were considered positive, those between 40% and 50% were considered doubtful, and those with competition percentage greater than 50% were considered negative.

Data entry and analysis

Data that were generated from questionnaires and each of the results obtained from laboratory analysis were entered into Microsoft excel. These were analyzed using Statistical Package for Social Sciences (SPSS) version 20.0 software (Armonk, NY USA) program and comparison between variables were done using descriptive statistics and comparison by chi square. The Fisher's exact test was used to test the significance of variables at 95% confidence interval. The differences were considered significant if the P-values was less than 0.05.

Results and Discussion

A total of 100 ruminants comprising of 50 cattle and 50 goats were tested for antibodies (IgM and IgG) against RVFV, and 11 samples were positive (overall prevalence =11%). Of the 50 goats sampled, 29 were male (bucks) and 21 were female goats (does). Out of the 29 bucks, one (1) was positive (prevalence = 3.4%), while two (2) of the does were positive (prevalence = 9.5%). Out of the 50 cattle, there were equal numbers of males and females, each having 4 (16.0%) positive results. Therefore, cattle had overall eight (8) positive results (prevalence = 16.0%), while goats had three (3) positive results (prevalence=6.0%). Majority of the positive cases were cattle (Table 1). Based on the source localities, animals from Yan-shanu, Jos had more positive cases (10 cases), while only one positive case came from Adamawa State. Seropositivity in cattle based on source localities therefore had a significant *P* value of 0.001 (Table 2). Also the mean durations of animals' stay at the abattoir/slaughter slab before slaughtering were compared, and it was found that this had no statistically significant effect on seropositivity (Figure 1). Female animals had higher prevalence of the disease, though the difference was not statistically significant (Table 1).

This study was aimed at investigating the sero-prevalence of Rift Valley fever among cattle and goats slaughtered in Jos, as this would reveal the level of exposure of humans and animals to RVFV in the study area. To the best of the authors' knowledge, this was the first reported study to quantify directly the sero-status of cattle and goats slaughtered in Jos, Nigeria. In this study, the overall seroprevalence of RVFV in cattle and goats was 11.0% (16.0% in cattle and 6.0% in goats). Our finding was higher than earlier reports in slaughtered ruminants in Southern Nigeria by

Opaleye et al. (2019); cattle= 0.4%, and goats= 2.3%. This could be as a result of the fact that they detected only IgM as compared to this study that detected both IgM and IgG without discrimination. Other studies in Northern Nigeria also reported lower prevalence of 6.6%, 2.8% and 1.0% in sheep, cattle and goats, respectively (Ezeifeka et al., 1982), while Alhaji et al. (2018) reported a prevalence of 11.3% in cattle. These findings suggest that there is an ongoing circulation of RVFV among livestock in the country.

Table 1: *The prevalence of rift valley fever among the animals based on sex.*

Location	Goats		Cattle	
	No. of sample	No. positive (%)	No. of sample	No. positive (%)
Male	29	1 (3.4)	25	4 (16.0)
Female	21	2 (9.5)	25	4 (16.0)
Total	50	3 (6.0)	50	8 (16.0)
χ^2; p-value	0.799; 0.372		0.000; 1.000	

Table 2: *The prevalence of rift valley fever based on origin of the animals.*

Location	Goat		Cattle	
	No. of sample	No. positive (%)	No. of sample	No. positive (%)
Toro (Bauchi)	10	0 (0.0)	7	0 (0.0)
Abattoir	5	0 (0.0)	-	-
Adamawa	10	1 (10.0)	-	-
Bukuru	7	0 (0.0)	16	0 (0.0)
Kano	6	0 (0.0)	-	-
Yan-shanu	12	2 (16.7)	18	8 (44.4)
Sokoto	-	-	9	0 (0.0)
Total	50	3 (6.0)	50	8 (16.0)
χ^2; p-value	4.492; 0.481		16.931; 0.001**	

** = *significant association exists at* $p \leq 0.01$

There were higher prevalence in females than males, which is consistent with earlier findings that female livestock are left to stay longer than male counterparts in the herd, resulting in longer periods of exposure to risks of infection (Sumaye et al., 2013; El-Mamy et al., 2011).

This study was carried out during the dry season (in the month of December), and the high prevalence suggests that RVFV transmission may be active all the year round, which corroborates the earlier reports that RVF could occur in all seasons of the year in Nigeria (Alhaji et al., 2018; Opaleye et al., 2019). This however contradicts the reports from Central African Republic of Congo (Nakouné et al., 2016; Clark et al., 2018) and here Nigeria (Olaleye et al., 1996), that virus transmission may be more active during the rainy (wet) season due to vector availability and activities. This assertion would however need to be interpreted with care because this study detected both IgM and IgG without discrimination. Consequently, it was difficult to state whether the animals were infected recently or long before slaughtering. Though due to recent large outbreaks of RVF in parts of Africa and Arabian Peninsula, the disease has gained some level of etiological and entomological awareness (Alhaji et al., 2018; Clark et al., 2018), it may be interesting to note that transhumance pastoralists could also play a key role in the occurrence of RVF in Jos metropolis apart from environmental and seasonal factors.

The source locations from which the animals were purchased were also considered to investigate which of the states had the highest prevalence. We had most of the positive cases among the animals (both cattle and goats) purchased from Yan-shanu market, Jos, and only one case from Adamawa; ten out of the 30 animals from Yan-shanu, and one out of the ten animals from Adamawa were positive, while the rest of the animals, including the ones from Bauchi, Sokoto, Kano States were negative (Table 2). The reason for the high record of positivity among animals from Yan-shanu was not known as of the time of this publication but Yan-shanu is a big livestock market receiving large numbers of animals from different parts of Jos and the Northern Nigeria. These animals from different sources are kept together for reasonable duration of time, allowing for possible transmission of disease agents among them. The market also has a nearby water body which can serve as a breeding point for the vector. Meanwhile, extraction of information on the sources of the animals form the butchers was not without some challenges because record keeping among the butchers was not a norm. This highlights the need for improved record keeping by those involved in the business of selling and slaughtering animals. Government officials involved in monitoring the industry would also need to step-up sensitization and awareness on the importance of record keeping in relation to epizootics and disease surveillance.

We also investigated the mean in the duration of days that the animals spent at the abattoir/slaughter slab before being slaughtered. The cattle and goats with positive

Figure 1: *Map of Nigeria showing (arrows) Jos Metropolis, the study location within Plateau State in the North-Central Region.*

results had mean duration of 3 and 4 days respectively, while the animals with negative results spent a mean duration of 5 days. This suggest that RVFV infection among the animals may be beyond the abattoir and slaughter slab, and could be factors of various localities within and outside Jos metropolis from where the animals were brought, which we do not have data to substantiate this claim. However, we hypothesize that the presence of mining ponds (pools) scattered all over the Jos Metropolis could be one of the precipitating factors for the high prevalence observed in this study. These ponds provide breeding grounds for vectors and source of drinking water for the animals, and this increases contacts between animals and infected vectors that could aid transmission of the virus. However, understanding the emergence of RVF and subsequent spread of zoonotic viral diseases is a critical global health challenge. Therefore, adequate awareness of the diseases by livestock farmers is desirable to aid early warning alerts for timely outbreak interventions.

The limitation of this study was the small sample size which may not allow for some generalizations, but serves as a contributory baseline data for tracking and forecasting of RVF outbreak in Plateau State and Nigeria.

Conclusions and Recommendations

In conclusion, the results of this study suggest that RVF is emerging and continues to circulate sub-clinically in Nigeria; hence there is a strong need for the relevant authorities to consider the climate, vector activities, animal health, and human behaviors in order to prevent future outbreaks. Prevention of significant epizootics and epidemics is important in endemic areas due to the severe economic impact. Though, this study showed increased serological evidence of the presence of RVFV infection, there is need for nationwide surveillance based on serology and molecular characterization of the RVFV genotypes circulating in the country. Furthermore, a more

integrated One-health approach is urgently needed to improve RVF research, surveillance, prevention and control that will secure food safety and public health.

Author's Contribution

JA-O conceived, designed the analysis and drafted the manuscript. SJ and GC data collection. OOA assisted in data collection and manuscript draft. JA, DOA and JAO contributed to analysis tools and manuscript draft. OIU and OJO performed the analysis and read the manuscript. OA read and approved the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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