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Risk factors for Rift Valley fever virus seropositivity in one-humped camels (*Camelus dromedarius*) and pastoralist knowledge and practices in Northern Nigeria

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ABSTRACT

Rift Valley fever (RVF) is a complex emerging arboviral hemorrhagic disease that causes significant illness in animals and humans. Camel trade across the land borders between Nigeria and the Niger Republic occurs frequently and poses a significant risk for RVF transmission to pastoralists and traders. We carried a cross-sectional study between November 2016 and April 2017 in two northern States (Katsina and Jigawa) known for camel trade in Nigeria to investigate the seroprevalence and potential risk factors for RVFV occurrence. We collected 720 sera and administered questionnaire to pastoralists. We used the competitive enzyme-linked immunosorbent assay (c-ELISA) to determine the previous exposure to RVFV infection. We retrieved environmental information from public data sources that might explain RVFV seropositivity at the LGA level. To asses potential risk factors, we categorized LGAs with RVFV as "1" and those without a case" 0". We fitted a logistic model to the data and estimated odds ratios and 95% confidence intervals. An overall 19.9% prevalence was reported among camel herd—the highest seropositivity (33.3%) was recorded in SuleTankarkar LGA. In the multivariable model, only rain-fed croplands was significantly associated with RVFV antibodies occurrence $p = 0.048$ (OR = 0.87, 95% CI: 0.76–0.99). Only a minority of the respondents, 19.3% ($n = 17/88$), knew that RVF is zoonotic. Separation of healthy animals from the infected animals was carried out by 53.4% (47/88) pastoralists while 59.1% (52/88) pastoralists still use ethnoveterinary practices to control or mitigate disease outbreaks. Our study demonstrates the presence of RVFV antibodies among camel in Nigeria and the associated risk factors. These findings highlight the need for enhancing surveillance and control efforts and the public health education of camel pastoralists. Further investigation to unravel the zoonotic transmission potential to pastoralists and other animal species is pertinent.

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1. Introduction

RVF is a vector-borne arboviral hemorrhagic disease of animals (domestic and wild) and humans [1]. It is caused by the Rift Valley fever virus (RVFV), which belongs to the Genus *Phlebovirus* of the Family *Phenuiviridae* [2]. RVFV infection occurs primarily through bites of infected mosquitoes (*Aedes* and *Culex*) and other haematophagous arthropods. It also occurs through direct contact with infected animal materials and fluids due to occupational hazards [3]. RVF is endemic in Sub-Saharan Africa and has been reported in many African countries, including Kenya, Uganda, South Africa and Sudan- negatively impacting the affected communities' socio-economic livelihoods [4–7]. There have also been outbreaks of RVF on shores of Africa and the Arabian Peninsula involving ruminants and humans [8]. Nigeria reported the first case of RVF in 1959 among Merino sheep imported from South Africa [9]. Besides, it has also isolated RVFV from *Culicoides* and *Culex antennatus* on a farm [10]. A previous study reported the potential of RVF spread through the movement of viremic animals along trade and cattle routes [11]. RVF is mainly associated with high-rise neonatal mortality, abortions in ruminants, and decreased human productivity [11].

Camels are found primarily in the semi-arid and arid regions of Northern Nigeria [12]. They provide high-value sources of meat and milk, support efficient services in agriculture, and contribute to environmental-friendly transport leisure [12,13]. They were initially assumed to be resistant to most of the diseases affecting livestock. However, current evidence has shown that they are susceptible to several infectious diseases, including those with zoonotic potential like RVF [14–16]. Evidence suggests RVF is associated with several ecological factors, and scientists have used several methods to generate information on habitat suitability for different species and disease occurrence. For example, a study in Tanzania has demonstrated that soil type, precipitation, livestock density and rainfall patterns were significantly associated with RVF [17]. Another survey from Kenya observed a direct relationship between RVF and soil type [18]. Their model predicted that in an inter-epizootic period (IEP), low rainfall enhanced the maintenance of RVFV in non- El- Nino climatic seasons. A study in Nigeria has demonstrated an increase in the mosquito population, water bodies and vegetation as crucial drivers of RVF In cattle herd in Niger State [20]. A good understanding of RVFV occurrence using ecological determinants is essential for designing an effective control program.

Previous studies in Nigeria have looked at the occurrence of RVFV in cattle and sheep [19,20]. A study in Niger found that individuals
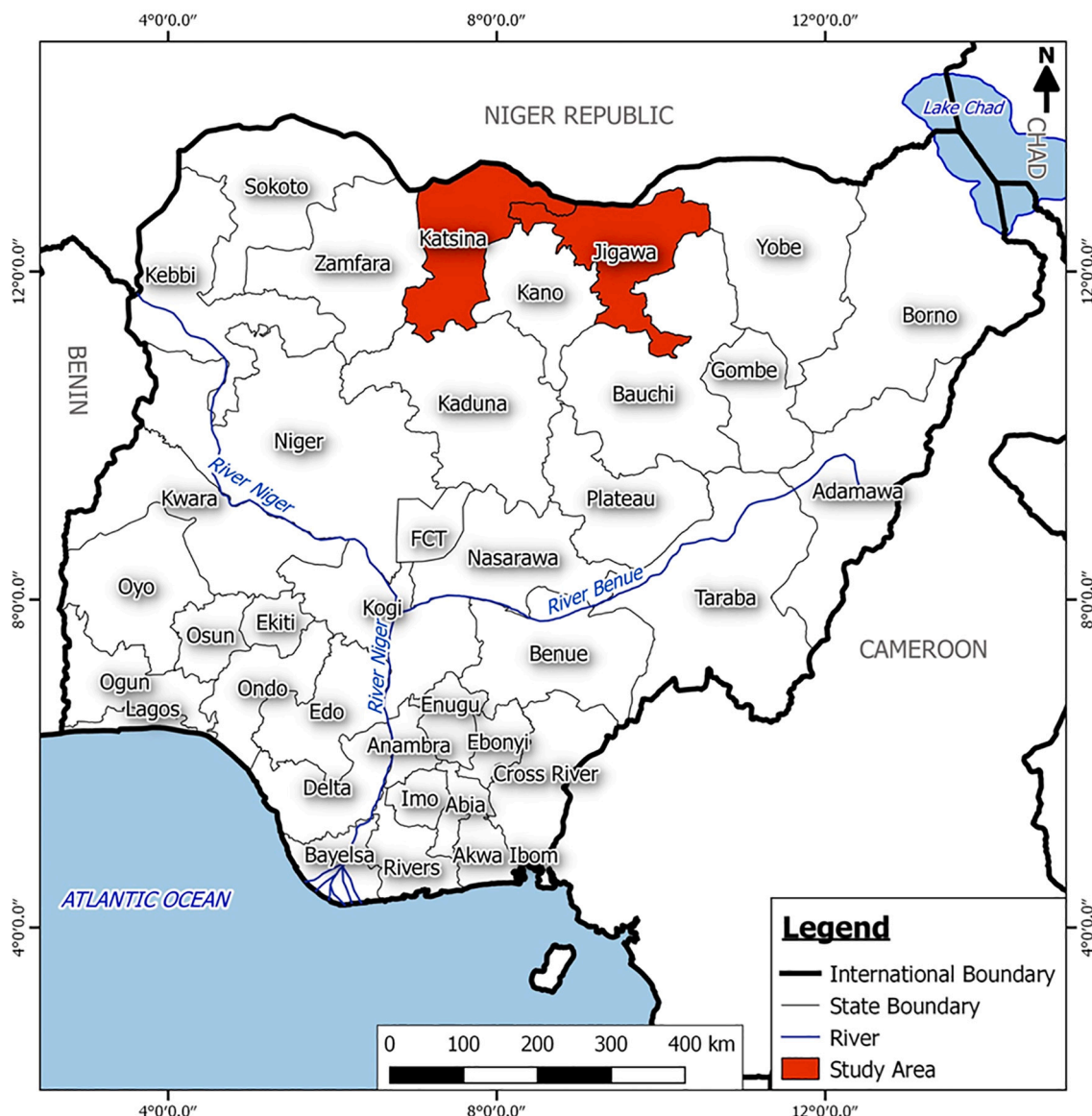

Fig. 1. Map of Nigeria indicating Jigawa and Katsina States.

involved in cattle rearing are deficient in public health knowledge about RVFV, including its transmission mode and clinical signs [20]. Those studies have provided insight into the virus existence in Nigeria and associated risk factors among the sheep and cattle population. Information about the status of RVFV among the camel population is lacking, despite the regular movement of camels between land borders located in Katsina and Jigawa States by pastoralists and traders. Understanding pastoralists attitudes and knowledge about RVF and the role of ecological drivers are central to designing a robust control program.This study aimed to determine the sero-prevalence of RVFV among one-humped camels (*Camelus dromedarius*) and to explore risk factors driving exposure among camels pastoralist in Northern Nigeria. And to assess pastoralists attitudes, knowledge and practices towards RVF to guide public health control and surveillance strategies to mitigate risks of outbreaks.

2. Materials and methods

2.1. Study area

The study was conducted in Jigawa and Katsina States (Fig. 1) in the Sudan savannah of Nigeria's North-West geopolitical zone. Jigawa State lies between latitude 11.00°N to 13.00°N and longitudes 8.00°E to 10.15°E, and Katsina State is located between latitudes 11°08′N and 13°22′N and longitudes 6°52′E and 9°20′E [21]. These states harbor's common transhumance routes that pastoralist and their livestock migrate every season. The agro-ecology of these states is strongly shaped by the proliferation of dams such as the Sabke dam in Maiadua, Jibiya dam, Dutsi and Mashi dams and rivers Hadejia Jama'are that support agricultural activities. The rivers and dams feed the fertile flood plains used for irrigation or flood recession farming and provide a suitable grazing environment for livestock across the states. The two states have international livestock markets located near their borders with the Niger Republic. And there is the continuous in-and-out movement of animals through the common porous borders without any form of disease monitoring or surveillance. Both states experience two distinct seasons; the dry season (harmattan), which begins in October and ends in May of the following year, and the wet season (rainy) runs from June to September. The two states have an average annual rainfall of 750 mm [22].

2.2. Study design and target population

We carried out a cross-sectional study between November 2016 and April 2017. The target populations were agro-pastoralists who engage in crop and livestock farming, including one-humped camels (*C. dromedarius*). And transhumance pastoralists that seasonally move in and out across international borders searching for livestock pasture and settle in distant areas across the states during the study.

2.3. Sample size and sampling procedure

Using the formula: $n = Z^2pq/d^2$ [23], we determine the sample size. Where, n-minimum sample size, *Z*-appropriate value for the normal standard deviation set 95% CI or 1.96, p- expected prevalence, and q-complementary probability. Expected prevalence was set at 50% with 4% absolute precision, and 95% confidence interval was used. We arrived at 600. However, we used 20% contingency because RVF was rare and also to increase precision, we increased the sample size to 720. We set the sample size for the questionnaire at an 11% margin of error to take care of non-response due to low literacy levels10% contingency was provided. The final sample size was 88. Sampling herds and households were purposively selected, and simple random sampling was used to select animals in each herd proportionally to each herd's size, although the average herd size was ten camels.

2.4. Sample collection and processing

First, we profiled individual camel to obtain age, sex and location; they were restrained in a crouching position after that. We then collected 5 mL of blood using a 10 mL syringe with an 18G needle through the jugular vein. The blood was gently transferred into a labelled non-anticoagulant sample bottle and allowed to stand in a slant position in cooler containers overnight and transported to the National Veterinary Research Institute (NVRI), Vom, Nigeria. At NVRI, we centrifuged at 10,000 ×*g* for fifteen minutes to properly separate serum from the clotted blood. We harvested the Sera using a sterile pipette into 2 mL cryovial tubes, labelled and stored at –20 °C for sample analysis.

2.5. Laboratory analysis

In this study, we used a competitive enzyme-linked immunosorbent assay (c-ELISA) to determine evidence of previous exposure to RVFV infection. We used the multi-species competitive ID Screen® RVF IgG ELISA kits (ID-Vet Innovative Diagnostics, Grabels, France) to test the serum samples for anti-RVFV IgG antibody per the manufacturer's instruction [24]. To validate the test, we calculated the mean value for the optical density at 450 nm ($OD_{450\ nm}$) when the positive control ($OD_{450\ nm}{}^{PC}{}_{c}$) was less than 0.3 of the negative control ($OD_{450\ nm}{}^{PC}$) and the mean value of the OD for negative control ($OD_{450\ nm}{}^{PC}$) was >0.7. We read the result using an ELISA reader set at λ = 450 nm. For individual sample, a competition percentage (S/N %) was calculated using S/N%= ($OD_{450\ nm}{}^{Sample}/OD_{450\ nm}{}^{NC}$) × 100. Samples with competition percentage (S/N %) less than or equal to 40% were deemed 'positive', those between 40% and50% were counted 'doubtful,' i.e. marginal/inconclusive. Samples with a competition percentage > 50% were regarded as 'negative'.

2.6. Environmental and demographic variables

We obtained an urban extent grid (v.1) showing the proportion of rural and urban areas in the Local Government Areas (LGAs) from the Global Rural-Urban Mapping Project(GRUMP v.1) [25] and population density 30 arc-second (~1 km at the equator) resolution from World Pop project site. Elevation (at 10-m resolution) and we extracted the mean temperature data was from WorldClim (v.2) (https://www.worldclim.org), and obtained land cover types from DIVA-GIS. Zonal mean values for each raster datasets were obtained at each LGA polygon using the Zonal Statistics module in the Spatial Analyst toolbox in ArcGIS software and stored in Microsoft Excel for further analysis.

2.7. Statistical analysis and variable selection

We set the LGAs within Katsina and Jigawa as the spatial unit of analysis. We classified LGAs within both states based on the absence or presence of RVF confirmed by ELISA. LGA with at least one positive case was classified "1" as one while those without classified "0". We performed univariable logistic regression to select factors associated with RVF at the LGA level in Katsina and Jigawa state. We assessed multicollinearity and removed highly collinear variable with a higher *p*-value. We entered any significant variables based on a conservative p-value (i. e., *p* < 0.25) in the univariable analysis into the multivariable model. We assessed confounder by examining remaining significant variables after removal of the potentially confounding variable. If the coefficient for one of these variables changed more than 25%, the removed variable was considered a confounder and retained in the model. A p-value of <0.05 was deemed to be significant. We used Statistical software Stata version 13.1 (Stata Corporation, College Station, TX, USA) for the data analysis.

2.8. Questionnaire design and data collection

The survey team embarked on advocacy visits a month before the commencement of the study to sensitize communities, grazing reserves and livestock routes on the significance of the research and the need for their cooperation and support. The team briefed the community leaders (*Ardos/ Sarkin rakuma*) and key informants on the research aim and obtained the necessary permission from the community leaders in charge of camels.

The team administered a pre-tested close-ended structured questionnaire to pastoralists selected from two herds before the administration of the real-time questionnaire, for the purpose of identifying and eliminating any problems before the actual data acquisition was conducted to ease data processing, minimize variation, and improve responses (Thrusfield, 2007). The questionnaire was in English but administered to the participants through an oral interview in "Hausa", a predominant local language in northern parts of Nigeria. We trained four enumerators fluent in English and Hausa languages as interviewers who administered the questionnaires daily under supervision. We obtained verbal consent from the respondent and briefed them about the study's objectives.

The questionnaire assessed their knowledge, practices and mitigation measures regarding RVF. Socio-demographic information such as their age, gender, occupation, and level of education. In addition, their knowledge of RVF-associated clinical signs, including anorexia, listlessness in newborn, abortion in pregnant animals, hemorrhages, fetid diarrhea, zoonosis, and endemicity. Participants were asked about practices deployed to quell the scourge of RVF, including the use of repellent against arthropods, avoiding swampy areas during grazing, contact with aborted fetuses, separation of healthy animals from infected animals, loaning of animals and the use of ethnoveterinary practices. Finally, we assessed some environmental risk factors, such as high mosquito density, rainfall, irrigated rice fields or dams, bushy vegetation and access to the presence of water bodies. They were assured of voluntary participation, in line with the Helsinki Declaration (World Medical Association Declaration of Helsinki [26].

3. Results

3.1. Prevalence of Rift Valley fever virus in camel herds

The study recorded an overall prevalence of 19.9% to RVFV among camel herds from the two states. Camels in SuleTankarkar LGA of Jigawa State recorded the highest seropositivity of 33.3%, while those from Daura LGA of Katsina State had the least prevalence (3.33%) (Table 1). The spatial distribution of RVFV antibodies (Fig. 2) with more seropositivity cases in LGAs bordering the Niger Republic.

Table 1
Prevalence of Rift Valley fever virus antibodies in camels in the sampled LGA'sof Jigawa and Katsina States, Nigeria.

State	Location	Total no. sampled	Positive on Ig	Percentage (%)	95% confidence interval
Jigawa	Maigatari	220	37	16.8	12.31, 22.20
	Babura	100	18	18.0	11.38, 26.45
	SuleTankarkar	60	20	33.3	22.31, 45.93
	Gumel	40	8	20.0	9.75, 34.47
Katsina	Maiadua	150	37	24.7	18.27, 32.04
	Jibiya	90	21	23.3	15.47, 32.89
	Daura	60	2	3.3	0.56, 10.58
	Total	720	143	19.9	17.07, 22.90

CI - Confidence interval.

3.2. Environmental determinants of Rift Valley fever virus antibodies in Jigawa and Katsina, Nigeria

Our univariable result determined that RVF occurrence within LGAs in Katsina and Jigawa were significantly associated with elevation, urban areas, Mosaic vegetation, and rain-fed croplands (Table 2). In the multivariable model, rain-fed croplands were significantly associated with RVFV antibodies occurrence, while the urban area was marginally significant (Table 3).

3.3. Socio-demographic information

All selected 88 pastoralists participated in the study. The highest response of 27.3% (*n* = 24/88) was recorded from age group 40–49, and all the respondents were males. A vast majority, 65.9% (*n* = 58/88), had no formal education. On occupation, 56.8% (*n* = 50/88) of the participants were transhumance or nomadic pastoralists while 43.2% (*n* = 38) were resident agro-pastoralists (Table 4).

3.4. Knowledge about Rift Valley fever

Respondents were assessed on the knowledge of their perceived clinical signs associated with RVF, and 33% (*n* = 29/88) of them indicated abortion in pregnant camels as their major observation. Only 19.3% (*n* = 17/88) mentioned that RVF has a zoonotic implication. However, 28.4% (*n* = 25/88) of pastoralists indicated that RVF is endemic in their environments (Table 5).

3.5. Mitigation measures practice against Rift Valley fever

On the mitigation measures against the disease, 72% (*n* = 64/88) of pastoralists indicated avoiding the tradition of animal loaning, borrowing and dowry payment with camels. At the same time, 17.1% (*n* = 15/88) used repellents on animal against arthropods. Furthermore, 17.1% (n = 15/88) of the respondents also indicated measures such as avoiding ponds or swampy areas while grazing were the mitigation measures practised against RVF in camel settlements in the study locations. In addition, 53.4% (*n* = 47/88) of the pastoralists practice the biosecurity method of segregation of healthy animals from infected ones, and 59.1% (51/88) employed ethnoveterinary practices to control or mitigate disease outbreaks (Table 6).

3.6. Precipitating factors that influenced camels' exposure to Rift Valley fever virus in Northern Nigeria

The precipitating factors are components or elements that trigger the onset/ occurrence of RVF given the right environmental conditions. Here, we looked at these factors in relation to nomadic and agro pastoralists animal rearing practices. Nomadic pastoralists that move from one place to another in search of pasture for their camels. In a comparison of precipitating factors that could influence the exposure of RVFV, nomadic pastoralists' respondents had a higher percentage concerning access to high mosquito density (72%), high rainfall (64%), irrigated rice field/dams (68%), bushy vegetation (74%) and availability of water bodies (78%) compared to agro-pastoralists (Table 7).

4. Discussion

In this study, we surveyed two states in Nigeria for evidence of RVFV antibodies and analyses ecological determinants associated with RVFV at the LGA level in two Northern Nigeria States known for camel trade. We also administered the questionnaire to camel pastoralists to assess their awareness of RVF. The overall presence of 19.9% was obtained in this study, which is higher than previous reports in Nigeria. This finding could be explained due to the increased movement of camels via transhumance from Nigeria to neighboring countries and back into
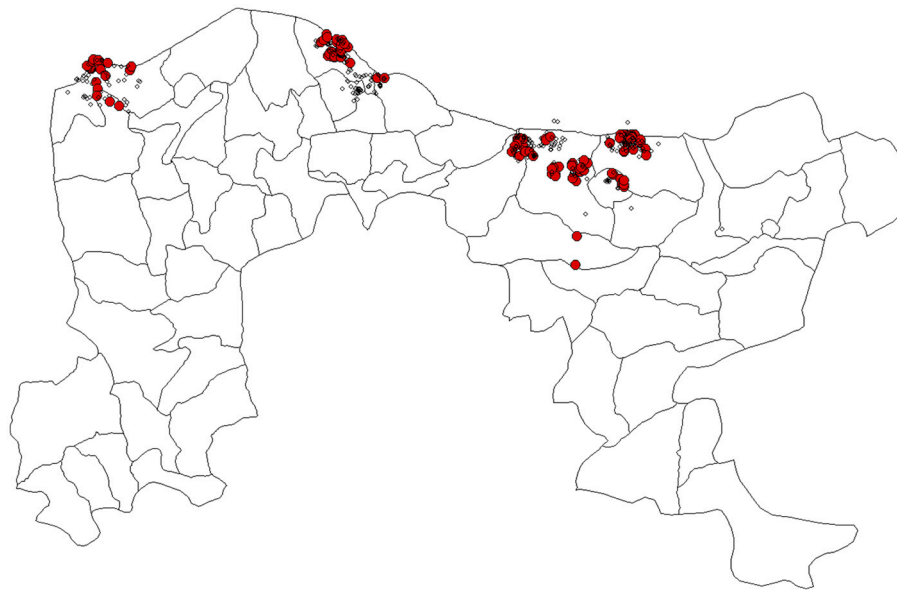
Fig. 2. Spatial distribution of seropositive camels in Katsina and Jigawa States, Nigeria with more cases in LGAs bordering Niger Republic.

Table 2

Univariable Analysis of Ecological risk factors associated with RVF in Jigawa and Katsina State, Nigeria.

Variables	Odds ratio (95CL)	p-value
Elevation	0.99 (0.98–1.00)	0.123
Urban- (proportion of urban in Jigawa and Katsina , Nigeria)	3.88 (0.65 23.29)	0.137
Population density	1.31 (0.99–1.182)	0.688
Mosaic vegetation	0.99 (1.99–1.00)	0.101
Rainfed croplands	0.92 (0.83–1.02)	0.096
Average temperature	0.65 (0.11–3.95)	0.639
Sparse (<15%) vegetation	1.13 (0.72–1.75)	0.591
Grassland, savannas or lichens/mosses	1.12 (0.912–1.38)	0.273
Shrub land	0.90 (0.57–1.41)	0.659

Table 3

Multivariable model Analysis of Ecological risk factors associated with RVF in Jigawa and Katsina State, Nigeria.

Variables	Odds ratio (95CL)	p-value
Mosaic vegetation	1.007354 (0.9959172–1.018922)	0.208
Elevation	0.9862615 (0.96–1.59)	0.168
Urban	36.51 (0 0.78–1707.77)	0.067
Rainfed croplands	0.87 (0.76–0.99)	0.048*

* P < 0.05 is significant.

Nigeria. Besides, both states share an international border with the Niger Republic, with unhindered animal movement occurring between the land borders, providing an opportunity for a disease outbreak. Besides, RVF has been previously reported [27].Consistent with the report from Egypt, where RVF was introduced through animal movement from Sudan, which suggested the need for RVF surveillance between land borders [28].

The highest seropositivity recorded in Suletankarkar LGA of Jigawa state could result from two transhumance routes that traverse the LGA to the different grazing reserves across the state. Also, adjacent to this LGA, there exist an international livestock market in Maigatari where various livestock conglomerate from other African countries and states in Nigeria for trading, thereby exposing healthy animals with sick animals

Table 4

Socio-demographic characteristics of camel pastoralists in Jigawa and Katsina States.

Variable	Frequency (n)	Percentage (%)
Age (in years)		
20–29	8	9.1
30–39	19	21.5
40–49	24	27.3
50–59	17	19.3
60–69	18	20.5
70–79	2	2.3
Gender		
Male	88	100.0
Female	0	0.0
Marital status		
Married	81	92.1
Single	7	7.9
Occupation		
Agro pastoralists	38	43.2
Nomadic/transhumance pastoralists	50	56.8
Formal education		
None	58	65.9
Primary	19	21.6
Secondary	8	9.1
Tertiary	3	3.4

Table 5

Pastoralists' knowledge about RVF occurrence in camel herds in Northern Nigeria.

Variable	Yes (n)	Percentage (%)	95% CI
Sign of RVF in camel			
Anorexia	22	25.0	16.8–34.82
Listlessness in newborn calves	12	13.6	7.61–22.03
Sudden deaths in newborns	18	20.5	13.0–29.83
Abortions in pregnant animals	29	33.0	23.75–43.26
Hemorrhages	15	17.1	10.25–25.98
Fetid diarrhea	26	29.6	20.73–39.69
All of the above	5	5.7	2.11–12.14
Zoonotic nature of RVF			
RVF can be transmitted from camels to humans	17	19.3	12.07–28.56
Endemic nature			
RVF is endemic in the area	25	28.4	19.74–38.48

CI - Confidence interval

Table 6

Mitigation measures practiced by pastoralists against RVF in camel settlements in Northern Nigeria.

Practice	Yes (n)	Percenatge (%)	95% CI
Use of repellants on animalsagainst arthropods	15	17.1	10.25–25.98
Avoiding ponds and swampy areas during grazing	15	17.1	10.25–25.98
Avoiding contacts of healthycamels with aborted fetuses	30	34.1	24.77–44.44
Separation of healthy animals from infected ones	47	53.4	42.96–63.64
Avoiding culture of animal loaning, borrowing or dowry	64	72.7	62.73–81.25
Ethno-veterinary practices	52	59.1	48.6–68.99

Table 7

Precipitating factors that influence Rift Valley fever occurrence in camel settlements in Northern Nigeria.

Factors	Poor influence (%)	Satisfactory influence (%)
High mosquitoes density		
Agro pastoralists	25 (65.8)	13 (34.2)
Nomadic pastoralists	14 (28.0)	36 (72.0)
High rainfall		
Agro pastoralists	21 (55.3)	17 (44.7)
Nomadic pastoralists	18 (36.0)	32 (64.0)
Irrigated rice fields and dams		
Agro pastoralists	27 (71.1)	11 (28.9)
Nomadic pastoralists	16 (32.0)	34 (68.0)
Bushy vegetation		
Agro pastoralists	24 (63.2)	14 (36.8)
Nomadic pastoralists	13 (26.0)	37 (74.0)
Presence of water bodies		
Agro pastoralists	31 (81.6)	7 (18.4)
Nomadic pastoralists	11 (22.0)	39 (78.0)

whose disease can be amplified by vectors. This assertion agrees with previous studies [29,30]; where they observed that transboundary animal diseases could spread over a considerable distance if the conditions are favorable for virus survival.

The significance of rain-fed croplands could be due to the various proliferation of dams and agricultural irrigation schemes in the two states to alleviate the scourge of food insecurity challenges. These rain-fed croplands can serve as suitable breeding sites for *Aedes* mosquitoes which is the chief vector of RVF virus due to high humidity. This finding is in agreement with a previous study that observed that the *Aedes* genus is mainly associated with short term water bodies such as flooded area, temporary pond, puddles, and rice fields [31].

This study was the first to evaluate pastoralists' knowledge and practices regarding RVF in camels in Nigeria. Most of the surveyed pastoralists lack formal education from our research, which makes the dissemination of information about the disease pattern through symposia herculean task. Formal and informal education should utilize to expand risks awareness for RVF in vulnerable communities in Nigeria. Pastoralists in the age group of 40–49 years and above possessed requisite facts and consciousness about RVF due to longer close contact relationships during animal husbandry than those in the lower age categories. Unexpected abortion in pregnant camels was the predominant clinical manifestation stated by most respondents; we observed a low knowledge level regarding other RVF clinical signs reported in Tanzania among herders [5]. The observed low proportion of pastoralists with awareness regarding RVF could result from an absence of informed programs earmarked for educating herders on emerging and re-emerging infectious diseases. A previous study in Nigeria has reported limited surveillance efforts across the Nigerian States [32]. Limited surveillance for emerging and neglected tropical diseases in parts of Nigeria can result in sporadic cases going unreported, which

hinders overall public health responses. The essential element in designing a RVF control strategy for surveillance and implementing mitigation measures in animals and humans is fundamental to "One Health" Approach [33]. This approach will be collaborative strategy between various stakeholders such as virologists, livestock economists, medical professionals, veterinarians, environmental scientists, entomologists, risk communicators, anthropologists, pastoralists and policy makers to map out an effective public health preventive and control measures of RFV. This can be done through public health education, surveillance, monitoring, reporting and sharing information between member countries. Low pastoralists knowledge about RVF zoonosis may be attributed to a low level of formal education, making them susceptible to potential risks of infection. And indeed a farmer from Northern Nigeria died due to preventable RVF zoonotic disease [1].

Knowledge of the mode of transmission of RVFV plays a vital role in guiding effective action plans focused on disease mitigation. We found the use of repellents on livestock against arthropods to be low among the respondents. This may be due to a lack of proper dissemination of information by extension workers on best practices on preventing vector-borne diseases like RVF [34,35], which is chiefly transmitted by *Aedes* and amplified by other arthropods. There is a need for enlightenment in view of mitigating the occurrence and spread of RVF. Our study found that participants responded poorly to RVF questions via exposure to aborted fetuses and segregation of healthy animals from infected ones. These precarious traditions increase the likelihood of the pastoralists to zoonotic diseases such as RVF.

Traditionally, nomadic pastoralists migrate seasonally in search of pasture and water as their essential requirement. This makes both nomads and livestock vulnerable to infectious pathogens. As a result of this movement, healthy animals contact infected animals, wildlife and arthropods, most often reservoirs of zoonosis agents such as RVFV [36–38]. Precipitating risk factors in this study had the highest respondents among nomadic pastoralists. They move strategically to different countries, searching for ecologically viable resources as a source of feed for their animals. The findings of this study should be interpreted in light of some limitations. Due to limited responses from pastoralists on knowledge, attitude and practices, we could not carry out a quantitative analysis. As future direction to this study, sampling non-transhumance pastoralists that live closely with camels will shed more light on the status of RVF in the human- animal interface.

5. Conclusion

This study has found a 19.9% prevalence of RVFV antibodies among one-humped camel in Northern Nigeria and identified risk factors for its occurrence. We also observed a low level of awareness among Camel pastoralists. There is a need for targeted public health intervention by the government and other stakeholders in Nigeria and entire West African regions to improve public health awareness against this zoonotic disease, which will mitigate possible outbreak and enhance food security.

Ethics statement

The Ahmadu Bello University Ethical Committee Animal Care Unit approved this study (ref ABUCAUC/2020/67). Approval was also granted by Directors of Veterinary Services in both States (Jigawa and Katsina states). The study conforms to the Declaration of Helsinki.

Authors contribution

AAM, AL, SKBA, ANB,BEO and SAY conceived and designed the

study and interpreted the results. AAM, PPM, M-MS,ISI, AAA, NWD,GBS and OA conducted data collection and analysis. BOE, PPM and DAA performed data interpretation and edited the manuscript. AAM and SAY edited and wrote the final manuscript. All authors gave consent to the final version of the manuscript.

Declaration of Competing Interest

The authors declare no conflict of interests regarding the publication of this study.

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