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Paper

Seroprevalence of Rift Valley Fever Viruses Antibodies in Domestic Livestock in the Tahoua Region of Niger

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Abstract

Rift Valley Fever (RVF) remains a significant public health and economic concern in Niger, particularly in the Tahoua region. This study aimed to update seroprevalence estimates of Rift Valley Fever Virus (RVFV) and identify high-risk areas and animal populations. A cross-sectional survey was conducted between January and May 2024, during which 615 domestic ruminants (cattle, sheep, goats, and camels) were sampled and tested for RVFV-specific antibodies using a competitive enzyme-linked immunosorbent assay (cELISA). The overall RVFV seroprevalence in the Tahoua region was 11.87% (±2.55%). Camels exhibited the highest seroprevalence (36.56%), followed by cattle (17.69%), while small ruminants showed much lower rates: 3.55% in goats and 3.37% in sheep. Significant geographic heterogeneity was observed, with the highest prevalence recorded in Birni N'Konni (30.53%, $p < 0.05$). No statistically significant differences in seroprevalence were found by sex ($p = 0.909$) or age ($p = 0.876$), although adults and females tended to have slightly higher rates. These findings confirm ongoing RVFV circulation in the region and identify camels as the most affected species. The results underscore the need for enhanced, species-specific surveillance, targeted vaccination campaigns, and vector control strategies in high-risk areas to prevent future outbreaks and protect both animal and human health.

Keywords

Rift valley fever, seroprevalence, Livestock, Niger

Introduction

Rift Valley Fever (RVF) is a mosquito-borne viral zoonosis with major health and economic impacts in sub-Saharan Africa. The disease is caused by the Rift Valley Fever virus (RVFV), a Phlebovirus within the Phenuiviridae family, first identified in Kenya in 1931 (Linthicum et al., 2016; Aman et al., 2024). It primarily affects domestic ruminants, leading to high neonatal mortality, abortion storms, and severe economic losses in livestock-dependent regions (Wright et al., 2019). Transmission occurs primarily through Aedes and Culex mosquitoes, which act both as reservoirs and amplifiers of the virus (Grossi-Soyster et al., 2019). Humans can also become infected through direct contact with animal tissues or fluids, or by consuming raw milk (Grossi-Soyster et al., 2019). While most human infections are mild or asymptomatic, severe cases may result in hemorrhagic fever, encephalitis, or ocular complications, with fatality rates varying by outbreak (Lagare et al., 2019). Given its impact on livestock production and public health, RVF remains a major concern in Niger, where the economy is strongly reliant on animal husbandry.

The first documented RVF outbreak in Niger occurred in 2016 in the Tahoua region, with 266 reported human cases and 32 deaths (Lagare et al., 2019). This outbreak caused heavy livestock losses, and subsequent serological

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surveys confirmed widespread viral circulation among domestic ruminants. Further studies indicated that RVFV had been circulating prior to the outbreak, with evidence of silent infections in livestock. Phylogenetic analyses linked Niger's RVFV strains to those previously detected in Senegal and Mauritania, suggesting transboundary spread facilitated by ecological factors and livestock trade (Lagare et al., 2019). A second major outbreak occurred in December 2021 in the Tassara department, with 399 human cases and 33 deaths. Serological investigations revealed an overall livestock seroprevalence of 7%, though prevalence varied by species and region, with higher rates observed in cattle, goats, and sheep (Barka, 2023; Hama et al., 2019).

RVF outbreaks in Niger are closely linked to heavy rainfall and flooding, which create favorable breeding conditions for mosquitoes and enhance viral amplification (Tariku & Rebuma, 2024). These environmental factors, together with seasonal livestock movements, trade networks, and vector dynamics, contribute to the persistence and re-emergence of RVFV in the region. Despite prior research, significant gaps remain in understanding the current epidemiological trends of RVF in Niger (Rissmann et al., 2020).

This study, conducted within the framework of the ongoing RVF surveillance program, aims to assess the seroprevalence of RVFV in domestic ruminants in the Tahoua region. Specifically, it seeks to determine species-specific susceptibility, identify high-risk geographic areas, and compare current findings with previous data to evaluate epidemiological trends. Addressing these questions will provide crucial insights into RVF epidemiology in Niger and support the implementation of evidence-based surveillance and control strategies.

Materials and methods

Study Area

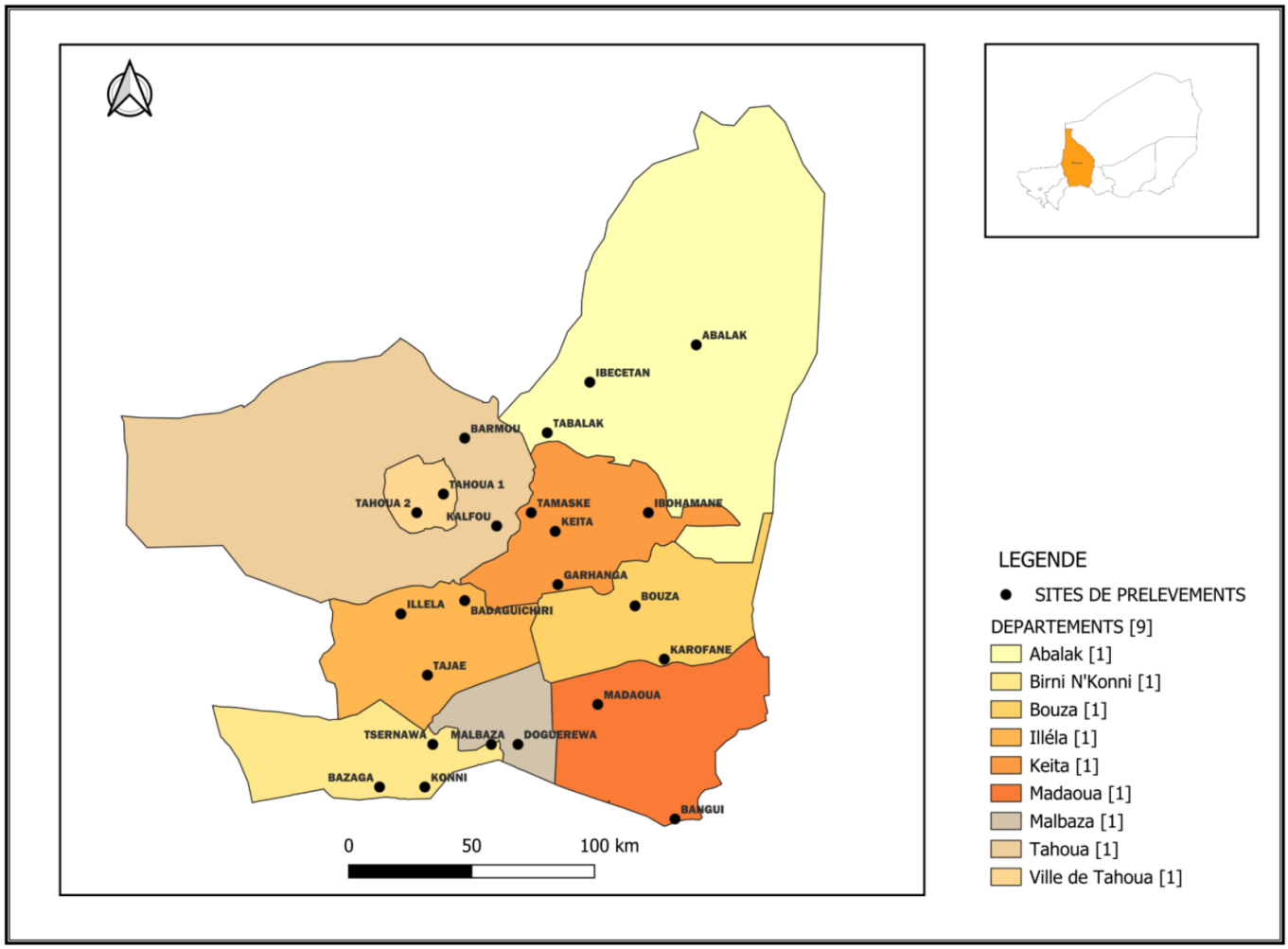

Figure 1. Map of the study area.

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The study was conducted in the Tahoua region of Niger, which spans both the sub-Saharan and savanna zones and covers an area of 113,371 km^2, representing 8.95% of the national territory. Geographically, the region lies between latitudes 13°42′ and 18°30′ North and longitudes 3°53′ and 6°42′ East (Ousseini, 2023). It is bordered by Agadez to the north, the Federal Republic of Nigeria to the south, Maradi to the east, and the Dosso and Tillabéry regions as well as the Republic of Mali to the west. Recognized as an endemic area for Rift Valley Fever (RVF), Tahoua presents ecological and geographical conditions that favor the persistence and transmission of the virus.

In 2018, the estimated livestock population included 14,363,595 cattle, 14,132,592 sheep, 19,585,749 goats, and 1,882,961 camels (Ousseini, 2023).

This study was conducted as part of an epidemiological survey carried out from January to May 2024 in response to suspected RVF cases in the Keita department of the Tahoua region, a recognized RVF-endemic zone. The investigation was led by the Central Livestock Laboratory (LABOCEL) in Niamey following the report of suspected RVF cases in Keita. The sampled areas are shown in Figure 1.

Study Design

This cross-sectional study aimed to assess the seroprevalence of Rift Valley Fever Virus (RVFV) antibodies in domestic ruminants in the Tahoua region of Niger. A stratified random sampling strategy was applied to obtain a representative distribution of sampled animals while minimizing selection bias. Sampling was carried out across 22 districts and 31 villages, purposively selected based on key epidemiological risk factors: livestock density, transhumance activity, proximity to water bodies, and accessibility. Only locations with stable security conditions and logistical feasibility were included.

A multi-stage sampling technique was employed. Districts were purposively selected for their endemic potential for RVF, with guidance from veterinary authorities to account for epidemiological risks and prioritize areas with suspected or previously reported RVF cases. Within these districts, villages were chosen using the ballooning technique, following a predefined list to ensure proportional geographic representation. At the village level, simple random sampling was applied to select herds and farms. Herd owners gathered their animals, from which individuals were randomly chosen without predetermined criteria, ensuring equal selection probability and avoiding bias related to age, sex, or health status.

The study included cattle, sheep, goats, and camels, representing the key livestock species susceptible to RVFV. Blood samples were collected using standard veterinary procedures, ensuring reliability and compliance with animal welfare standards. Serological testing was performed to detect anti-RVFV antibodies.

Sample Size Determination

The sample size was calculated using EpiTools epidemiological calculators, assuming an estimated RVFV seroprevalence of 20.18% (Hama et al., 2019), with a 95% confidence level and a 5% margin of error. Based on the standard formula for prevalence studies, the minimum required sample size was 248 animals. To increase statistical power and ensure broad species and geographic representation, a total of 615 blood samples were collected from domestic ruminants across 22 districts and 31 villages in the Tahoua region.

Sample allocation by district was proportional to the livestock population size in each district relative to the combined population of all districts, ensuring balanced geographic representation. The final sample included 147 cattle, 178 sheep, 197 goats, and 93 camels, providing adequate representation of each species according to their prevalence and significance in the region.

Blood Samples Collection

Blood samples were collected from cattle, sheep, goats, and camels using standard veterinary procedures to ensure accurate serological analysis while minimizing animal stress. Sampling was carried out by trained veterinary professionals using sterile dry vacutainer tubes (Venoject ND, 10 mL). Approximately 5 to 8 mL of blood was drawn from the jugular vein using sterile 18- to 21-gauge needles, depending on the species and body size, under aseptic conditions.

Immediately after collection, tubes were labeled with unique identification codes, including sampling site, animal species, sex, and age. Samples were stored in cool boxes at 4 °C with ice packs to maintain stability during transport. Within six hours of collection, blood samples were centrifuged at 1500 × g for 10 minutes to separate the serum. The

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serum was then aliquoted into sterile microtubes, with at least 2 mL stored at −20 °C for further analysis.

All sample handling procedures adhered to strict biosafety protocols to prevent contamination and ensure the reliability of serological results.

Laboratory Analysis

RVFV antibody detection was performed using a competitive Enzyme-Linked Immunosorbent Assay (cELISA), specifically the ID.vet Screen Rift Valley Fever Competition Multi-Species ELISA Kit. This assay is based on the competition between a monoclonal anti-RVFV antibody and antibodies present in the test sera.

The assay was conducted according to the manufacturer's instructions. Optical density (OD) readings were obtained at 450 nm using an ELISA plate reader, and the resulting data were exported to Microsoft Excel. Data processing was carried out using the Template ETE-32 FT and FC 33 c-ELISA RVF Kit software (ID.vet). The percentage inhibition (PI) was calculated for each sample, with samples showing a PI ≥ 40% classified as positive, indicating prior exposure to RVFV.

Quality control samples, including both positive and negative controls, were included in each run to validate assay performance. Results were interpreted according to the cut-off values recommended by the kit manufacturer.

Ethical Considerations

This study was conducted in accordance with ethical guidelines for animal research and zoonotic disease surveillance, with ethical approval granted by the veterinary and livestock authorities of Niger. Informed consent was obtained verbally from livestock owners and herders after they were provided with clear information regarding the study objectives, procedures, potential benefits, and assurances of voluntary participation. All sampling procedures were performed under the supervision of trained veterinary officers, following standard veterinary protocols to minimize stress and discomfort to the animals.

Data Management and Analysis

Data were entered into Microsoft Excel® 2019 and analyzed using IBM SPSS Statistics version 20 for both descriptive and inferential statistical analyses. Descriptive statistics, including prevalence estimates, frequency distributions, and 95% confidence intervals (CIs), were calculated to summarize serological findings.

Associations between RVFV seroprevalence and categorical variables such as species, sex, age, and geographic location were assessed using chi-square (χ^2) tests. Seroprevalence was also analyzed by sampling site to evaluate regional variations in antibody distribution.

Overall seroprevalence was calculated as the proportion of seropositive animals among all tested. Stratified analyses were conducted to compare prevalence across species, sex, age groups, and geographic locations. Statistical significance was established at $p < 0.05$.

Results

Seroprevalence of RVFV in the Tahoua Region in Niger

The analysis revealed notable variations in the distribution of RVFV antibodies across the Tahoua region, influenced by species, geographic location, and demographic factors such as age and sex (Table 1). Based on the competitive ELISA results, 73 samples tested positive, corresponding to an overall seroprevalence of 11.87% ± 2.55%.

RVFV antibodies were detected in all eight departments of the Tahoua region. The highest seroprevalence was recorded in Birni N'Konni (30.53%), followed by Bouza (10.53%) and Abalak (10.14%). Additional affected departments included Malbaza (9.60%), Illela (9.26%), Keita (7.92%), Tahoua (7.32%), and Madaoua (5.26%).

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Department	Tested Samples	Positive Samples	Prevalence (%)	95% CI (%)
Abalak	69	7	10.14	5.00 - 19.49
Bouza	76	8	10.53	5.43 - 19.42
Illela	54	5	9.26	4.02 - 19.91
Keita	101	8	7.92	4.07 - 14.86
Birni N'Konni	95	29	30.53	22.17 - 40.39
Madaoua	76	4	5.26	2.07 - 12.77
Malbaza	62	6	9.68	4.51 - 19.55
Tahoua	82	12	7.32	3.10 - 15.94
Total	**615**	**82**	**13.33**	**10.87 - 16.25**

Table I. Distribution of RVFV seroprevalence across the departments of the Tahoua region, Niger.

Prevalence rates across the districts showed considerable variation (Figure 2). Birni N'Konni and Bazaga were the most affected districts, with prevalence rates of 44% and 30.95%, respectively. These were followed by Tamaske (23.81%) and Tahoua 1 (19.05%). Moderate prevalence rates were observed in Tsernawa (17.86%), Ibecetan (16.67%), and Doguerewa (14.81%). Relatively high prevalence was also recorded in Illela (13.64%) and Bouza (13.51%).

Lower prevalence rates were reported in Tajae (8.30%), Karofane (7.69%), and Bangui (7.32%), while even lower levels were noted in Tabalak (6.6%), Malbaza (5.71%), Kalfou (5.26%), and Badaguichiri (5%). Similar prevalence rates of 4.5% were observed in both Barmou and Garhanga. Notably, no seropositive cases were detected in Tahoua 2, where prevalence was zero.

Statistical analysis revealed significant differences in prevalence between districts ($p = 0.000$).

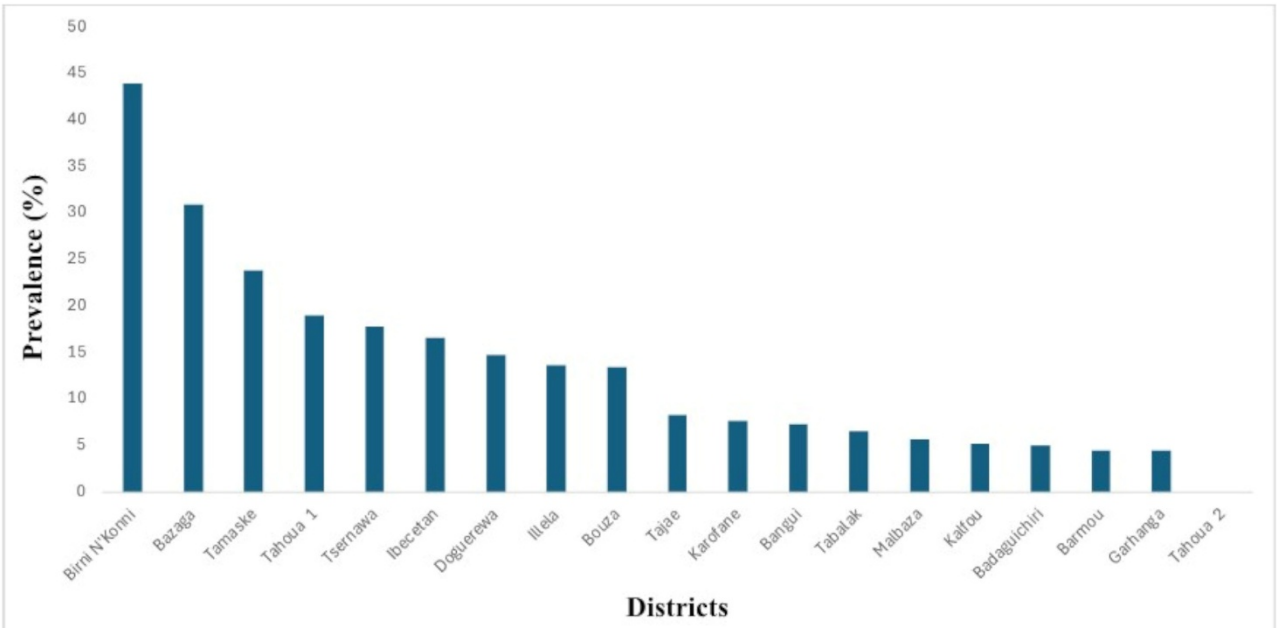

Figure 2. Geographical distribution of Rift Valley Fever Virus antibodies prevalence across districts in the Tahoua region of Niger.

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Distribution of RVF seroprevalence in livestock species in the Tahoua Region

Seroprevalence data indicated that camels had the highest infection rates, with a prevalence of 36.5%, followed by cattle at 17.69% (Figure 3). Small ruminants, including sheep and goats, showed lower prevalence rates of 3.37% and 3.55%, respectively. A significant difference in prevalence was observed between species ($p = 0.05$). Among small ruminants, the highest infection rates were recorded in the Konni district, where 12% of sheep and 8% of goats tested positive. Lower prevalence rates were observed in Bouza and Tahoua, while no antibodies were detected in sheep and goats from Abalak and Illela. Statistical analysis revealed no significant difference in infection rates between sheep and goats across districts ($p = 0.229$).

Among large ruminants, camels showed the highest prevalence in Konni (76.47%), followed by Bouza and Illela (50%). In cattle, prevalence ranged from zero in Bouza and Madaoua to 39.29% in Konni and 28.57% in Illela. No significant differences in prevalence were found between bovines and camels within districts ($p = 0.120$ for bovines; $p = 0.070$ for camels).

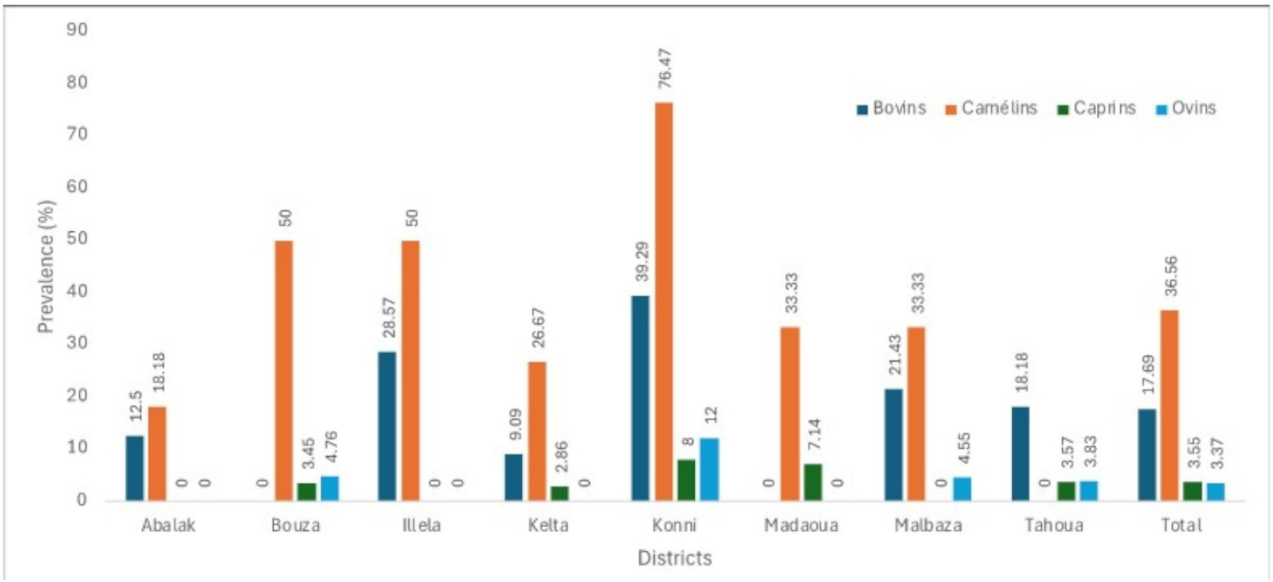

Figure 3. Prevalence of Rift Valley Fever Virus Antibodies across districts by species in the Tahoua region of Niger.

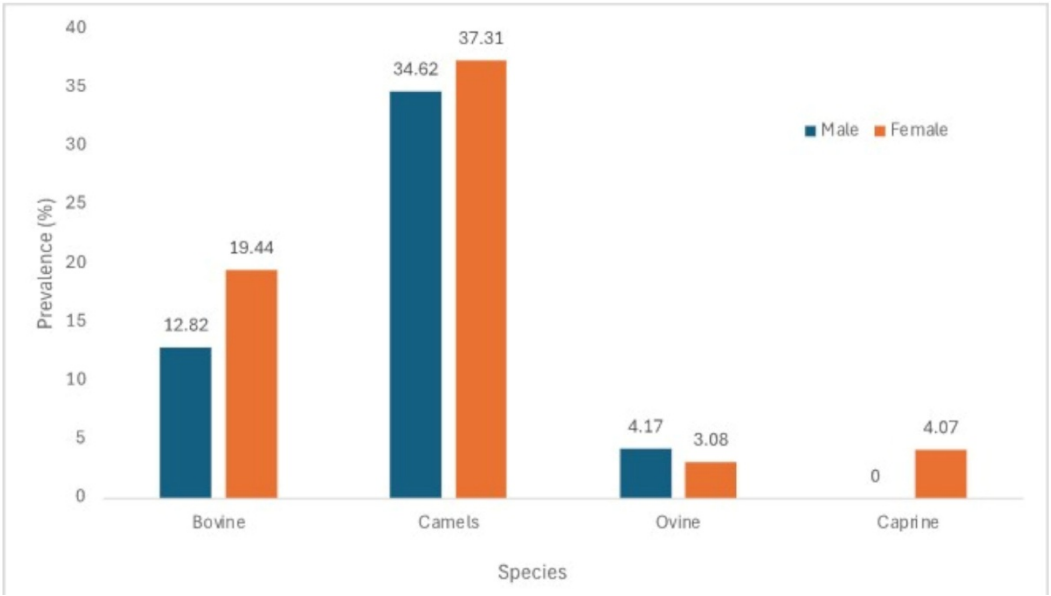

Figure 4. Prevalence of Rift Valley Fever Virus antibodies across species by sex in the Tahoua region of Niger.

With respect to sex, females showed a slightly higher prevalence (11.95%) compared to males (11.59%), with higher infection rates in females observed among camels, cattle, and goats (Figure 4). In contrast, male sheep exhibited a

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higher prevalence than females (4.17% vs. 3.08%). However, the difference in prevalence between sexes was not statistically significant (p = 0.909).

Results indicated that adults had higher infection rates than younger animals, with prevalence rates of 12.28% and 9.80%, respectively (Table 2). Among bovines, camels, and goats, adults were more frequently affected, with prevalences of 20%, 38.10%, and 4.05%, respectively. In contrast, in sheep, younger animals showed a higher prevalence (5.88%) compared to adults (3.10%). Despite these differences, the variation in seroprevalence by age was not statistically significant (p = 0.876).

Species	Adults Prevalence (%)	Adults 95% CI (%)	Young Prevalence (%)	Young 95% CI (%)
Bovins	20.00	13.5 - 28.5	13.46	4.0 - 31.5
Camelins	38.10	28.0 - 49.0	22.22	7.2 - 50.0
Caprins	4.05	1.7 - 9.1	0.00	-
Ovins	3.11	1.2 - 7.8	5.88	1.0 - 23.3
Total	12.28	9.7 - 15.5	9.80	5.2 - 17.4

Table II. Seroprevalence of Rift Valley Fever Virus antibodies based on age and species in the Tahoua region of Niger.

Discussion

This study assessed the prevalence of Rift Valley Fever Virus (RVFV) antibodies in the Tahoua region of Niger, focusing on variations by species, age, sex, and geography. The ELISA results revealed the presence of IgG antibodies, confirming the continued circulation of RVFV in the region, consistent with previous findings (Hama et al., 2019; Adamu et al., 2021). The overall seroprevalence was 11.87%, higher than earlier studies in Niger. Bada (1986) reported a prevalence of 2.8%, while Morou (1999) documented 5.59%. The higher prevalence observed in this study may be attributed to broader geographic coverage and the inclusion of both suspected and non-suspected cases, compared with the more geographically limited studies of Bada and Morou. However, it was lower than the 20.18% reported by Hama et al. (2019).

Regional differences were marked, with Birni N'Konni recording the highest prevalence (30.53%), followed by Bouza (10.53%) and Abalak (10.14%). These differences likely reflect environmental conditions: Birni N'Konni and Bouza, located in the Sahelian zone, receive higher rainfall, providing favorable habitats for mosquito vectors of RVFV. Similar associations between rainfall and RVFV seroprevalence have been observed in Uganda (Budasha et al., 2018) and Cameroon (Sado et al., 2022). In Abalak, the relatively high prevalence despite lower rainfall may be explained by the presence of the Tabalak Pond, Niger's largest permanent water body, which serves as a major mosquito breeding site, combined with its proximity to Tchintabaraden, the epicenter of the 2016 outbreak (Lagare et al., 2019). These findings underscore the critical role of environmental and spatial factors in RVFV transmission.

Species-specific variations were also evident. Camels exhibited the highest prevalence (36.56%), followed by cattle (17.69%). Sheep and goats had lower rates, 3.3% and 3.5%, respectively. These findings align with Musa et al. (2020), who reported higher camel infection rates, likely related to their migratory nature, increasing exposure to RVFV vectors in endemic regions such as neighboring Nigeria (Adamu et al., 2021; Trabelsi et al., 2023). Cattle prevalence peaked in Birni N'Konni (39.29%), an area with abundant rainfall conducive to vector proliferation. In contrast, no antibodies were detected in camels from Tahoua, likely due to urban-based management practices limiting exposure to vectors. The absence of RVFV antibodies in cattle from Bouza and Madaoua may reflect small sample sizes, as the virus was detected in other species from these areas. Comparable patterns have been documented elsewhere: in Kenya, Nanyingi et al. (2017) reported a seroprevalence of 27.6% in ruminants, with higher rates in sheep (32.2%) and cattle (33.3%) than goats (25.8%), while in Cameroon, cattle reached 42.2% compared to 25.7% in other domestic ruminants (Sado et al., 2022). These findings highlight the combined impact of species susceptibility, environmental conditions, and livestock movement on RVFV epidemiology.

Age was another key factor. Adults had higher seroprevalence (12.28%) than younger animals (9.80%). Among

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species, adult cattle, camels, and goats showed higher rates (20%, 38.10%, and 4.05%, respectively), suggesting cumulative exposure and potential partial immunity with age. In sheep, however, younger animals were more affected (5.88% vs. 3.11% in adults), consistent with their greater susceptibility and the higher mortality often observed in young stock during outbreaks. Similar patterns have been reported in Garissa, Kenya, where younger cattle and small ruminants showed higher seroprevalence than adults (Nanyingi et al., 2017).

Females exhibited a slightly higher prevalence (11.95%) compared with males (11.59%). This may reflect the predominance of females in Saharan herds, as males are frequently sold or culled, and the longer lifespan of females, which increases cumulative exposure. Additionally, hormonal influences may enhance susceptibility, consistent with previous reports linking RVFV infection with higher abortion rates in females (Sumaye et al., 2013; Hama et al., 2019).

Currently, RVF vaccines are not registered for use in Niger, and no national vaccination programs for domestic livestock are in place. None of the animals sampled in this study had a history of vaccination, indicating that the detected anti-RVFV antibodies resulted from natural exposure rather than immunization. This highlights the epidemiological significance of the observed seroprevalence, confirming ongoing or past virus circulation in the study area.

Overall, these findings stress the need for sustained surveillance and targeted control measures. Surveillance should prioritize areas with high rainfall, mosquito breeding habitats, and significant livestock movement. Exploring vaccination strategies in high-risk regions, coupled with robust vector control efforts, may be essential to reduce RVFV transmission and prevent future outbreaks. A comprehensive understanding of the interplay between environmental, species-specific, and age-related factors remains crucial for the effective control of RVF (Nanyingi et al., 2017; Ngoshe et al., 2019; Sado et al., 2022).

Conclusion

This study provides critical insights into the prevalence and distribution of Rift Valley Fever Virus (RVFV) among domestic ruminants in the Tahoua region of Niger. The overall seroprevalence of 11.87% confirms the widespread presence of RVFV, with marked variations by species and geography. Camels were the most affected species, followed by cattle, while small ruminants showed comparatively lower infection rates. Higher prevalence rates in areas with increased rainfall highlight the significant role of environmental factors, particularly mosquito breeding sites, in shaping viral transmission. These findings confirm the continued circulation of RVFV in the region and emphasize the urgent need for targeted interventions to reduce its impact.

To mitigate the spread of RVFV in Tahoua, surveillance should be intensified in high-risk areas, with particular attention to camels and cattle. Species-specific vaccination strategies, where feasible, and continuous monitoring are essential, supported by enhanced vector control measures focused on mosquito breeding habitats. Improved livestock management practices, including the use of insecticide-treated nets and appropriate carcass disposal, should be promoted. In addition, molecular studies are recommended to identify circulating RVFV strains and refine evidence-based control strategies.

Acknowledgments

We gratefully acknowledge the Enabel Niger for its funding and support, as well as the Central Livestock Laboratory (LABOCEL) in Niamey for their invaluable assistance. Our thanks extend to all participants and stakeholders who contributed to the success of this study.

Ethical approval

For this study, informed consent was obtained from the animal owners in accordance with ethical guidelines. Blood sampling was performed humanely to reduce the animals' stress as much as possible, in line with the Ethical Guidelines for Animal Welfare.

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Conflict of interest

The authors declare that they have no conflict of interest.

Author Contributions

The research concept was developed by Mireille Catherine Kadja, Rianatou Bada-Alambedjiand Souhaibou Sourokou Sabi. Karimou Hamidou Ibrahim collected the samples. Laboratory analyses were conducted by Karimou Hamidou Ibrahim under the supervision of Amadou Yahaya Mahamane and Haladou Gagara. Karimou Hamidou Ibrahim and Edmond Onidje performed statistical analysis. The manuscript draft was prepared by Edmond Onidje. Benjamin Obukowho Emikpe reviewed and edited the draft. All authors have read and agreed to the published version of the manuscript.

Data availability

The data supporting this study are available upon reasonable request from the corresponding author, Mireille Catherine Kadja.

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