

Serological Detection of West Nile Virus in Single-Humped Camels in Northern Nigeria

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1. Introduction

West Nile virus (WNV) is an important arbovirus that affects both animals and humans. It is a flavivirus member of the Flaviviridae family and is primarily spread by *Culex* mosquitoes. The main enzootic cycle of WNV occurs between birds and mosquitoes, with horses and humans serving as dead-end hosts. Although most human infections are inapparent, the virus can cause flu-like malaise (20%) and severe neuroinvasive disorders (<1%), and there is no specific treatment or approved human vaccines.^[1] WNV was first reported in 1937 in a febrile woman in the West Nile District of Uganda. Over the decades, WNV has caused numerous outbreaks worldwide, ranging from mild febrile illness to severe meningoencephalitis, particularly in the elderly.^[2]

Experimental studies have demonstrated that although domestic animals, such as sheep, pigs, and calves, rarely develop high viral titers or clinical symptoms after exposure to WNV, they do develop neutralizing antibodies, indicating asymptomatic infection. In contrast, a significant percentage of dogs and horses have shown serological evidence of WNV infection, with some developing disease symptoms.^[3,4] In their study, Jupp and colleagues found that 46% of dogs examined had hemagglutination inhibition (HI) antibodies to WNV, and it was isolated from one of the HI-negative dogs in South Africa.^[3] In another experimental study in South Africa, infected horses did not develop clinical signs. However, 11% of the yearlings seroconverted in

the first year, while 75% of their dams had antibodies.^[4] Approximately 2% to 13% of the annual neurological cases in horses in South Africa have been attributed to WNV lineage 2 (which has a 30% mortality rate). In addition, the virus was detected in a locally bred Ayrshire cow (*Bos taurus*) and a Boer goat (*Capra aegagrus hircus*) with neurological symptoms. This suggests that locally bred livestock may also be susceptible to the virus, although they are not as closely monitored as horses.^[5]

Despite the widespread detection of WNV across various species in sub-Saharan Africa, detailed studies of the epidemiology of WNV, particularly in camels in Nigeria, remain limited. Several countries have established surveillance systems based on the detection of the virus in birds, mosquitoes, and vertebrates, including horses.^[5] Historical data since 1978 show that the virus has been detected in mice (*Mus musculus*), black drongo (*Dicrurus macrocercus*), Krukrihan thrush (*Turdus libonyanus*), and grass mice (*Arvicanthus niloticus*), underscoring the need for comprehensive surveillance and understanding of WNV transmission dynamics in broader species contexts, including camels in Nigeria. Given the limited data, this study aims to investigate the seroepidemiology of WNV in camels in northern Nigeria.

2. Research Presentation

This study adhered to ARRIVE reporting guidelines and received ethical approval from the Ministry of Agriculture and Natural Resources, Kano State, Nigeria (approval number REF.VET/80/EC.21). Plasma was collected by proper restraint of each camel at Fagge abattoir, Kano State, Nigeria, before slaughter from June 2021 to May 2022. Rostral dentition was used to age the camels, which were further categorized as either young (if less than six years) or adult (at least six years). Body condition was assessed using fat accumulation and thigh circumference as either very thin, thin, good, or very fat, as previously described.^[6] A total of 184 plasma samples were collected from single-humped camels. The ID Screen® kit from Innovative Diagnostics Vet (France) was used to detect WNV anti-pr-E antibodies using competitive ELISA according to the manufacturer's instructions.

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Data were analyzed using R version 4.0.3 and presented as frequencies and percentages, with the prevalence of WNV calculated using the Clopper–Pearson interval method. Table 1 shows the prevalence of WNV, its associated characteristics, and the 95% confidence interval (CI) calculated using the Clopper–Pearson interval method. A total of 184 camels were examined, of which 6 were negative (3.26%) and 178 were positive for WNV (96.74% (95% CI: 93.04%, 98.79%)). Twenty-nine camels (15.76%) were less than six years old, of which 1 tested negative and 28 tested positive for WNV. The prevalence of WNV in this age group was 96.55% (95% CI: 82.24%, 99.91%). The prevalence of WNV in 155 (84.24%) camels aged six years and above was 96.77% (95% CI: 92.63%, 98.94%). The prevalence of WNV was lower in females (96.67%, 95% CI: 92.39%, 98.91%) than in males (97.06%, 95% CI: 84.67%, 99.93%). Ninety-seven camels (53%) had a score of less than four, of which 3 were negative and 94 were positive, with a prevalence of 96.91% (95% CI: 91.23%, 99.36%). On the other hand, of the 87 (47%) camels with a body score of at least four, 3 tested negative and 84 tested positive, giving a prevalence of 96.55% (95% CI: 90.25%, 99.28%).

3. Discussion

This study shows that WNV is endemic in one-humped camels in Nigeria. The high seropositivity observed can be attributed to camel trade and movement across the Sahel region, which are considered major risk factors for the spread of arboviruses, including WNV. Most of the camels slaughtered at the Kano abattoir are purchased from the Maigatari and Mai'adua international livestock markets in Jigawa and Katsina states, respectively. Camels and other livestock are imported from neighboring African countries and adjoining states. A previous study in both locations reported the presence of an arthropod-borne virus–Rift Valley fever virus.^[7] As most WNV infections are asymptomatic, detecting the virus in animals reinforces the need for increased human surveillance.

Camels thrive in semiarid and arid zones; therefore, they are expected to be least susceptible to arboviruses. The desert areas of the Ahaggar and Tassili n'Ajjer national parks in Algeria and the Kawar and l'Air oases in the Niger Republic share a land border with Nigeria and are hotspots for WNV infection. This is attributed to close contact between wild birds and mosquitoes around the oases in these areas, creating an enzootic

transmission cycle. Similarly, northern Nigeria has over 200 oases that serve as derived ecological niches for *Culex species* breeding, resulting in endemic arboviruses. A previous study has reported the presence of 17.7% of WNV in camels in Nigeria,^[8] but our present study found a prevalence of 96.74%. Several factors may be responsible for this high prevalence, including climate change, intense vector breeding, and reservoir host interactions in the complex dynamics of the high seropositivity of WNV in camels. Climate change and vectors have been shown to affect WNV transmission through pathways such as increased temperature, which directly affects mosquito distribution, activity, and abundance, thereby extending their breeding season.^[9] In addition, the movement of camels through diverse ecological systems in the Sahel region further exposes them to wild birds, which are known reservoirs of WNV. This, coupled with the presence of *Culex*, which is known to thrive in areas with high temperatures and humidity, may influence the distribution of WNV across multiple hosts. In this study, a higher number of cows (female camels) were sampled. This is because female camels are kept mainly for breeding purposes; therefore, they stay in the herd longer and are infected more often. However, bulls (male camels) had slightly higher seropositivity than cows (female camels). With respect to age, seropositivity was high in both age categories, further demonstrating the endemicity of WNV in camels in the study area. Similarly, high seropositivity for WNV antibodies has been reported in horses in northern Nigeria, underscoring the competence of the vector to actively transmit the virus.^[10]

We acknowledge the following limitations of the study. Only camels slaughtered in abattoirs were tested. Cross-reactivity with other flaviviruses could occur with ELISA; therefore, it is necessary to confirm the specific strains of WNV. However, neutralizing antibodies were not detected, as the aim of the study was to obtain preliminary data by performing a serosurvey. A comprehensive study of the molecular epidemiology at the human–animal–environment interface will be conducted using the One Health approach.

In summary, this study reports high levels of antibodies against WNV in camels in Nigeria, suggesting the possibility of the cryptic circulation of WNV that is not influenced by the sociodemographic variables studied. Therefore, there is a need to strengthen surveillance by establishing sentinel chickens to monitor arboviruses, including WNV, as part of epidemic preparedness and spillover events to humans.

Table 1: Distribution of West Nile virus seropositivity in camels based on sociodemographics

Characteristic	No. tested	Negative	Positive	Prevalence, percentage (95% CI) ^a
Overall	184	6	178	96.74 (93.04, 98.79)
Age group, n (%)				
<6	29	1	28	96.55 (82.24, 99.91)
≥6	155	5	150	96.77 (92.63, 98.94)
Sex, n (%)				
Female	150	5	145	96.67 (92.39, 98.91)
Male	34	1	33	97.06 (84.67, 99.93)
Body score, n (%)				
<4	97	3	94	96.91 (91.23, 99.36)
≥4	87	3	84	96.55 (90.25, 99.28)

^aClopper–Pearson interval. CI, Confidence interval.

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Author Contributions

Meschach M. Maina, Arhyel Malgwi, Bukang Ali, Emmanuel David and Shedrach B. Pewan contributed to research investigation and research materials. Abdulrahman M. Adeiza and Reuben S. Bala contributed to research investigation, sample collection. Oyelola A. Adegboye contributed to research investigation, data analysis, writing-original draft, writing-editing. Anyebe B. Onoja and Andrew M. Adamu contributed to research investigation, writing-original draft, writing-editing. All authors read and approved the final manuscript.

Conflicts of Interest

None.

Data Available Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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