Journal of Sustainable Veterinary & Allied Sciences
P-ISSN-2695-2661 e-ISSN: 2811-1346
JoSVAS 2022, Vol 2, Issue 1: 14-19

Original Research Article

Rabies immune status of vaccinated and unvaccinated dogs in Kwara State, Nigeria.

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ABSTRACT

Rabies is one of the deadliest zoonoses that have existed for decades, affecting wide range of hosts globally. In Nigeria, there is paucity of data on routine antibody check of antirabies vaccinated dogs as quality assurance. This study was designed to investigate the seroprevalence of canine rabies virus in both vaccinated and unvaccinated dogs within Kwara State, Nigeria**.** A total of one hundred and eighty-two (182) blood samples collected from dogs were transported to the Virology and Immunology Laboratory of the University of Ilorin Veterinary Teaching Hospital for processing. Sera were harvested from the blood samples and rabies IgG was qualitatively determined by enzyme linked immunosorbent assay (ELISA) technique. Overall seroprevalence of 11% (20/182) was recorded in this study. One hundred and twenty-one (66.5%) and Sixty-one (33.5%) of the dogs used in this study had vaccination and non-vaccination status respectively. The study also revealed that several dogs (78.7%; 48/61) that were said to be vaccinated did not have rabies antibodies while some unvaccinated dogs (5.8%; 7/121) had rabies antibodies. There was a significant ($\chi2$ = 11.177, df = 4, P = 0.025) association between age group and rabies virus antibodies detection. The same significant ($\chi2$ = 9.995, df = 1, P = .002) association was observed for vaccination status of dogs sampled. On the other hand, sex has no significant ($\chi2$ = 0.71, df = 1, P = .790) association with rabies virus antibodies. Poor attitude to vaccination of dogs used for hunting in rural and semi-urban areas was generally observed compared to dogs kept for other purposes in urban areas. There is need for increased rabies awareness campaign, vaccine subsidies, and wider sero-surveillance activities engaging the relevant stakeholders with government sponsorship.

Keywords: Antibody, dogs, rabies, vaccinated, unvaccinated.

INTRODUCTION

Rabies, one of the most common zoonoses over the millennia, has existed for more than 4,300 years (Ogunkoya *et al*., 1990; Ojo *et al*., 2016; Alhassan *et al.,* 2020). Rabies is a vaccine-preventable illness that has been of public health concern in Nigeria for years (Ehizibolo *et al*., 2009; Kaltungo *et al*., 2018). It poses a risk to both human and animal health in Nigeria, as it does in other parts of the world. All warm-blooded animals, including humans, are affected by this illness, and most infected die from it (Adeyemi & Zessin, 2000).

Rabies is one of the deadliest diseases and has wide range of host (Aghomo *et al*., 1990, Knobel *et al*., 2005). The disease is estimated to kill 60,000 -100,000 people per year in 150 countries, with 95% of cases occurring in Africa and Asia (Ajayi *et al* 2006; Damodor *et al*., 2019). There are indications that this figure may not be a true reflection of rabies disease global burden but an underestimate (Sati *et al*., 2009; Ojo *et al*., 2016). In Nigeria, rabies is prevalent and may occasionally reach enzootic proportions. The infection is preserved in the country by dog-to-dog transmission. On the global scale, around 55,000 individuals die annually of rabies while bites from rabid dogs accounting for 99% of fatalities in humans (WHO, 2005; Bauer, et al., 2014).

Rabies could be enzootic in metropolitan centres where the dog is the primary reservoir host, as well as sylvatic in locations where wild animals are dominant. Due to the significant role dogs play in anthropophilic transmission of rabies to humans, the concept of systematic vaccination of dogs for the purpose of containing urban rabies has gained

http://doi.org/10.54328/covm.josvas.2022.066

widespread acceptance in recent years (Adeyemi and Zessin, 2000; Lembo *et al*., 2006; WHO, 2020). Assessment of antibody titres has proven to be useful in determining the immunological status of dogs following rabies immunization against the disease. It is possible to purchase and administer rabies vaccine from a variety of different companies but the standard method of determining whether a dog has adequate immunological titre is to measure virus neutralizing antibodies (VNA) using the fluorescent antibody virus neutralisation test (FAVN), which measures both IgM and IgG and conducting the test at an official standard laboratory. The standard method of determining whether a dog has adequate immunological titre is to measure serum antibodies at concentrations more than 0.5 IU per millilitre which is considered to give effective protection against rabies. An antibody titre that is less than this amount is considered a vaccination "failure," which means that the dog is less likely to be protected from the rabies virus (Kennedy *et al*., 2007; Fooks *et al*., 2014).

Rabies is extremely widespread and has one of the highest fatality rates since it can be acquired through bite of infected animals. Every bite poses a danger of rabies (Messenger *et al*., 2002; Brown *et al*., 2016). Transmission happens most frequently by bites or contact with the saliva of an infected animal (Ojo *et al*., 2016). In addition to the infection-transmission through bites of infected animals, other kinds of exposure to the infection include contamination of skin wounds and exposure to blood, saliva or tissue. Transmission of the infection can also occur via corneal and solid organ transplants (Aiyedun *et al*., 2021).

Continuous rabies vaccination programs are essential to protect animals from unknown and identified rabies exposures (WHO, 2010). Vaccines for rabies may be given to animals in animal shelters prior to being released, provided that a registered veterinarian supervises the process (Welborn *et al*., 2011; Coertse *et al*., 2021). Oral anti-rabies vaccines are available for use in wild life (Mähl *et al.*, 2014). Immunization following exposure to rabies is accomplished through administration of anti-rabies immune globulin and vaccine. Immunoglobulin should be administered within 24 hours of dog bite and should be followed by vaccination (Olugasa *et al*., 2011; Begeman *et al.*, 2018).

In Nigeria, routine antibody testing is not performed in order to measure the efficacy of the vaccine and the level of antibody titre provided to the animals. As a result, there is a scarcity of empirical data in rabies prevention and control efforts (Aiyedun *et al*., 2017). There is need to know the antibody titre level in dogs and also to determine the level of safety for people in the environment (Xu *et al*., 2021). This study was designed to investigate seroprevalence of canine rabies in both vaccinated and unvaccinated dogs within Ilorin metropolis of Kwara state, Nigeria.

MATERIALS AND METHOD

ETHICAL APPROVAL

All international, national and local guide on animals used for research were duly followed. Also, consent of dog owners was obtained before sample collection.

STUDY AREA AND DESIGN

The study was conducted in Kwara State of Nigeria located between latitudes 8° 30′N and 5° 00′E and encompassing an area of 35,705 Km (13,947.27 square miles) (Fig. 1). The study selected a total of 11 sampling sites involving urban, semi-urban and rural communities.

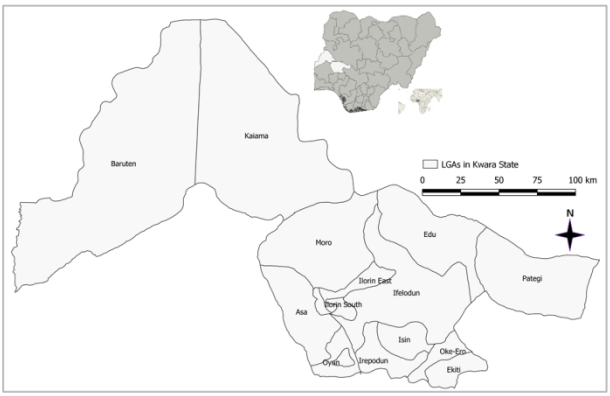

Figure 1: Map of Kwara state, Nigeria showing various local government areas

STUDY DESIGN

A cross sectional study design was used for the study.

SAMPLE COLLECTION AND PROCESSING

Blood (4ml) was collected through cephalic venupuncture under aseptic condition from 182 (61 vaccinated and 121 unvaccinated) dogs. The blood was dispensed in sterile plain tube and placed in slanting position in styrofoam box containing ice pack. The samples were then transported to the Virology/Immunology laboratory of the University of Ilorin Veterinary Teaching Hospital. Serum was harvested from the clotted blood after centrifugation at 5000 revolution per minute for 5 minutes. The sera were then stored in the freezer at -20^{o}C until use for assay.

RABIES IGG DETECTION

Indirect enzyme linked immunosorbent assay kit (BioTuva, UK) was used to detect rabies immunoglobulin G in the dog sera. The assay was done based on the manufacturer's instruction.

Test samples were initially diluted (using the diluent provided in the kit at 1:4 dilution) using a plain uncoated microtitre plate. Fifty microlitre of diluted samples were then loaded into the appropriate wells of the coated plate. Also, 50µl of each of positive and negative controls (duplicate) were dispensed into the wells while one well was left blank.

Then, the plate was incubated at 37^{o}C for 30 minutes and later washed six times using the wash buffer of the kit. Horse radish peroxidase-conjugate (50µl) was then added to all the wells with the exception of the blank well and the plate was incubated as before and subsequently washed (5 times). One hundred microliter of substrate (TMB) was then added to all the wells and the plate was left to incubate at 37^{o}C for 15 minutes in the dark. The reaction was finally stopped (stop solution) and optical density taken at 450nm. The result was recorded to be valid if the average OD value of the positive control is ≥ 1.00 while average negative control is ≤ 0.200 (Ling *et al*., 2021).

STATISTICAL ANALYSIS

The data obtained were entered into statistical package for social sciences version 23. Descriptive statistical and inferential statistical were calculated. Chi-Square test was used to determine the significance of association and this was set at 95% confidence interval at P-value ≤ 0.05.

RESULTS

AREAS OF SAMPLE COLLECTION

The highest number of samples 80 (44%) were collected from the Veterinary Teaching Hospital (VTH), Ilorin while the lowest 2 (1%) samples were from the State Veterinary Clinic, Ilorin. Eight (57%) of samples collected from Aromokeye Clinic, Ilorin were RABV positive (Table 1).

AGE AND RABIES VIRUS ANTIBODY DETECTION

The highest percentage of dogs that were positive for rabies virus antibodies was found in <0.5 year age group representing 18.9% of the sample collected in the group. However, the numerical number in this group is still less than 9 positive results obtained in 0.5-<1 year age group. The number of rabies virus antibodies detected in 3-5 age group was 4, while no antibodies were detected in higher age groups (3 – 5 years and > 5 years). There was a significant ($\chi 2$ = 11.177, df = 4, P = 0.025) association between age group and rabies virus antibodies detection. This portends that the lower the age of dog sampled, the more likely rabies virus antibodies are detected in them and vice versa.

DOG BREED AND RABIES VIRUS ANTIBODY DETECTION

Ninety-six (53%) samples were collected from mongrel compared to just one (1) sample collected from Pitbull, Siberian busky and Cane Corso breeds each. None of the five samples from English eskimo and Rottweiler showed positive Rabies Antibody Virus while three (75%) out of the 4 samples collected from Lhasa apso breed were positive for Rabies virus antibody. The numbers of positive samples in Alsatian and Mongrel breeds were 5 and 6 respectively. The very small number of samples in some dog breeds such as one sample in Pitbull, Siberian husky and Cane Corso could not enable the statistical analysis of these variables using Chi Square.

SEX AND RABIES VIRUS ANTIBODY DETECTION

Female dogs were found to be more seropositive for rabies having 11 (11.6%) positive than male dogs with 9 that represented 10.3%. There was no significance ($\chi 2$ = 0.71, df = 1, P = .790) association between sex and detection of rabies virus antibody. In other words, detection of rabies virus antibodies was not determined by or dependent on the sex of the dog sampled in the present study.

VACCINATION STATUS AND RABIES VIRUS ANTIBODY DETECTION

The results of the present study showed that 121 (66%) and 61 (34%) of dogs from which samples were collected were unvaccinated and vaccinated respectively. 13 (21.3%) of samples from vaccinated dogs were positive for Rabies Virus Antibody while 7 dogs from unvaccinated groups was also positive. There was a significant (P < 0.05) association between vaccination status of dog and detection of rabies virus antibody ($\chi 2$ = 9.995, df = 1, P = 0.002). This implies that vaccinated dogs are much more prone to show rabies virus antibodies than unvaccinated dog.

Table 1: Location Distribution of Rabies antibodies among dogs in Ilorin, Nigeria between November 2021 to January 2022

Location	Number sampled	RABV Positive %)
VTH, Ilorin	80	6 (7.5)
Shao, Ilorin	23	1 (4.3)
Aromokeye, Ilorin	14	8 (57.1)
Adeta, Ilorin	12	0 (0.0)
Akerebiata, Ilorin	12	0 (0.0)
Gaasaka, Ilorin	11	0 (0.0)
Olounlade, Ilorin	09	1 (11.1)
Itaalamu, Ilorin	08	1 (12.5)
Offa garage, Ilorin	06	0 (0.0)
Mandala, Ilorin	05	1 (20.0)
State Clinic, Ilorin	02	2 (100.0)

PURPOSE OF KEEPING THE DOGS

The most sampled dogs, 86 in number (47%) in the study area were kept for hunting purposes while one (1%) was kept for sporting reasons. The number of samples which were positive for RABV from dogs used for security and breeding were 6 (18.2% and 23.1%) respectively (Table II). The small number of samples in dogs used for sports activities

Table 2: Age, Sex, Breed, Vaccination Status, Purpose of Keeping Dog Distribution of Rabies Antibodies among Dogs in Kwara State of Nigeria

Grouping	Number sampled	Rabies Antibody Virus Positive (%)	Statistics
AGE (year)			
<0.5	37	7 (18.9)	
0.5 – <1	49	9 (18.4)	
1 – <3	51	4 (7.8)	$\chi2 = 11.177$
3 – 5	33	0 (0.0)	df = 4
> 5	12	0 (0.0)	P = .025
SEX			
			$\chi2 = 0.71$
Female	95	11 (0.9)	df = 1
Male	87	9 (10.3)	P = .790
BREEDS			
Mongrel	96	6 (6.2)	
Alsatian	29	5 (17.2)	
Caucasian	20	3 (15.0)	
Boerboel	11	2 (18.2)	
Dobberman	6	0 (0.0)	
English eskimo	5	0 (0.0)	
Rottweiler	5	1 (20.0)	
Lhasa apso	4	3 (75.0)	
Pug	3	0 (0.0)	
Pitbull	1	0 (0.0)	
Siberian husky	1	0 (0.0)	
Cane Corso	1	0 (0.0)	
VACCINATION STATUS			$\chi2 = 9.995$
Vaccinated	61	13 (21.3)	df = 1,
Unvaccinated	121	7 (5.8)	P = 0.002
PURPOSE OF KEEPING DOGS			
Hunting	86	4 (4.7)	
Security	33	6 (18.2)	
Pet	30	3 (10.0)	
Breeding	26	6 (23.1)	
Research	6	1 (16.7)	
Sporting	1	0 (0.0)	
Total	182	20 (11.0)	

could not enable the statistical analysis of these variables using Chi Square**.**

DISCUSSION

The study indicated that several dogs (78.7%; 48/61) that were said to be vaccinated did not have rabies antibodies. This suggests either vaccine failure which could be due to improper vaccine handling, loss of cold chain and/or poor quality vaccine (Brown *et al*., 2016). This further implied that dogs thought to be protected against rabies virus may eventually come down with the field strain and further put the owner and the general public at risk (Fooks *et al*., 2014). Hence, it will be very expedient to check the rabies antibody titre level post vaccination in dogs to validate immunization. The study further indicated that some unvaccinated dogs (5.8 %; 7/121) were exposed to field rabies virus. This might be attributed to the fact that the rabies virus is endemic in Nigeria (Alhassan *et al*., 2020). The low rate of rabies vaccination among dogs encountered in this study (61/182) indicated that dog owners and handlers are still not proactive towards achieving the global strategic plan tagged 'rabies to zero by 2030', a target set by World Organisation for Animal Health (WOAH) to eliminate human deaths from dog-mediated rabies by the year 2030.

This result disagrees with a similar study conducted in the same environment by Aiyedun (2013), who reported a significantly higher prevalence of 57.3%, 43.6%, and 25% for Ilorin East, Ilorin West and Ilorin South respectively. Also, the overall seroprevalence obtained in the present study is lower than result of Olugasa *et al.* (2011), who reported an overall sero-prevalence of 42.6% in a community-based assessment in Ibadan, Southwest, Nigeria. This discrepancy may be due to limited coverage of this work which was based mainly on clients coming to the clinic with their dogs. Time and season when the research was carried out may also be responsible for the lower prevalence recorded in this study (Aiyedun *et al*., 2021).

The public need to be educated properly and adequately about rabies so that they will be able to appreciate the importance of rabies vaccination in dogs as a cardinal factor towards control of human rabies.

This study indicated that dogs in the outskirts/rural areas of Ilorin such as Adeta-Ilorin, Olounlade-Ilorin, Mandala-Ilorin, Itaalamu-Ilorin, Akerebiata-Ilorin, Gaa–Saka, Ilorin and Offa-Garage, Ilorin have lower prevalence of rabies antibodies than their urban counterparts, putting the residents

of these rural areas at a higher risk of infection. This result demonstrates that residents of the study areas are generally at risk of contracting rabies due to the fact that the vast majority of dogs are not protected against rabies because most of their dogs were not given antirabies vaccination.

According to Kennedy *et al.* (2007) and Aydin *et al.* (2015), young animals less than one year of age generated a lower antibody response to rabies vaccination than adults, which doesn't corroborate with the result of this study in which 7 out of 37 (18.9%) dogs under six months of age were positive and 9 out of 49 (18.4%) dogs in the 0.5-1 year age group were positive. Four out of 51 (7.8%) dogs between the ages of 1-<3 years were positive, while none of the dog 45 dogs between the ages of 3-5 years and >5 years had antibodies against Rabies virus. This showed that owners of dogs sampled in the areas where the study was conducted paid more attention and concern to younger dogs, while adult dogs are left to fend for themselves.

Analysis indicated that dogs used for breeding and security were 6.2 times and 4.6 times respectively, more likely to be vaccinated against rabies virus than hunting dogs.

The higher number of female dogs found to be more seropositive for rabies than male dogs in this study is consistent with the findings of Mshelbwala *et al.* (2013), who reported that females had a higher prevalence in his study. Moreover, the increased prevalence in female dogs could be due to higher proportion of samples taken from female dog, which appeared to be more common and accessible than male dogs in the study area. Additionally, dog owners tend to care more for female dogs than male dogs because they reproduce and are of higher economics value.

This study discovered that exotic breeds such as Lhasa apso (75%), Rottweiler (20%) Boerboel (18.2%), Alsatian (17.2%) and Caucasian (15%) have a higher rate of rabies seropositivity than mongrel (6.2 %). This could be because exotic breeds are more economically valuable to their owners than mongrel, as some have paid a premium for these dogs, therefore more exotic breeds have rabies antibody compared to mongrels.

However, 6.2% of unvaccinated mongrel/indigenous dogs tested positive for rabies antibodies. This indicated that these dogs may have been exposed to the virus in the environment, either through contact with infected dogs or through contact with infected bats or other wild animals in the bush, as mongrel/indigenous breeds are primarily used for hunting (Aiyedun *et al*., 2017).

Dogs that had received vaccinations (21.3%) had higher sero-prevalence than their unvaccinated (5.8%) counterparts. Rabies antibodies are expected to be present in vaccinated dogs as a result of the vaccine-induced immunity, whereas may be present in unvaccinated dogs as a result of environmental virus exposure through contact with infected dogs or wild animals (Adeyemi & Zessin, 2000).

However, according to this study, only a low percentage of vaccinated dogs (21.3%) tested positive, which could be due to vaccination failure, possibly caused by improper vaccination or break in the cold chain in storing the vaccines (Brown *et al*., 2016).

This study also revealed that the majority of unvaccinated dogs in the study area were mongrels. Lack of awareness or financial resources to pay for vaccination by dog owners whose dogs were sampled in the study areas could be responsible for the high number of unvaccinated dogs (Fooks *et al*., 2014).

According to this study, the seroprevalence of rabies was higher in dogs used for breeding (23.1%), and those used for security (18.2%) than in mongrels that are used for hunting (4.7%). This could be as a result of the financial rewards associated with breeding dogs. These rewards and return on investments make dog breeders pay more attention to the welfare of these animals by providing excellent care such as regular vaccination and routine check-up. Similarly, owners of security dogs understand the importance of the animals' role in their business, safety and security which as a result, make owners provide adequate care that include regular vaccination for their dogs (WHO, 2021).

CONCLUSION AND RECOMMENDATION

Sampled dogs in Ilorin had a low prevalence of rabies antibodies during the study period (November 2021–January 2022). Rabies is preventable through consistent and effective vaccination of dog and investigation of rabies antibody. There is need for increase public awareness and the provision of free anti-rabies vaccine in local areas. Further studies on this subject covering a higher percentage of dog population in the country are suggested.

REFERENCES

Adeyemi, I. & Zessin, K. (2000). Retrospective dog rabies vaccination evaluation at the University of Ibadan, Nigeria (1988-1992). *Veterinarski Arhiv*, 70(5), 223–230.

Aghomo, H. O., Tomori, O., Oduye, O. O. & Rupprecht, C. E. (1990). Detection of Mokola virus neutralising antibodies in Nigerian dogs. *Research in Veterinary Science, 48(2), 264*

Aiyedun, J, O. (2013). Community-based Investigation of Rabies Antibody Profile of Dogs and Control in Ilorin , Kwara State , Nigeria. *Journal of Environmental Issues on Agriculture in Developing Countries*, 5(2), 51–55.

Aiyedun, J. O. Oludairo, O. O, Daodu, B. O, Akanbi, B. O & Nwoha, R.I O (2021). Major Emerging Viral Zoonosis Reported in Nigeria: A Review. *Journal of Veterinary Biomedical Sciences*, 3(2), 47–57.

Aiyedun, J. O., Oludairo, O. O. & Olorunshola, I. D. (2017). Roles of wildlife in epidemiology of rabies: A mini-

review. *Journal of Advanced Veterinary and Animal Research*, 3(2), 47–57.

Ajayi, B. B., Rabo, J. S. & Baba, S. S. (2006). Rabies in apparently healthy dogs: histological and immunohistochemical studies. *The Nigerian Postgraduate Medical Journal*, 13(2), 128–134.

Alhassan, S. A., Garba, B., Bello, B., Musa, S., Ali, M. K., Tanko, Y., Umar, Y. & Saidu, B. (2020). A case of fatal rabies in a donkey in dawakintofa, Kkano state, Nigeria. *Journal of Animal Health and Production*, 8(1), 40–44.

Aydin, S. (2015). A short history, principles, and types of ELISA, and our laboratory experience with peptide/protein analyses using ELISA. *Peptides*, 72, 4–15

Bauer, A., Nolden, T., Schröter, J., Römer-Oberdörfer, A., Gluska, S., Perlson, E., & Finke, S. (2014). Anterograde Glycoprotein-Dependent Transport of Newly Generated Rabies Virus in Dorsal Root Ganglion Neurons. *Journal of Virology*, 88(24), 14172–14183.

Begeman, L., GeurtsvanKessel, C., Finke, S., Freuling, C. M., Koopmans, M., Müller, T., Ruigrok, T. J. H. & Kuiken, T. (2018). Comparative pathogenesis of rabies in bats and carnivores, and implications for spillover to humans. *The Lancet Infectious Diseases*, 18(4), e147–e159.

Brown, C. M., Slavinski, S., Ettestad, P., Sidwa, T. J. & Sorhage, F. E. (2016). Compendium of animal rabies prevention and control. *Journal of the American Veterinary Medical Association*, 248(5), 505-517

Coertse, J., Geldenhuys, M., Le Roux, K. & Markotter, W. (2021). Lagos bat virus, an under-reported rabies-related lyssavirus. Viruses, 13(4), 1–19.

Damodar, T., Mani, R. S. & Prathyusha, P. V. (2019). Utility of rabies neutralizing antibody detection in cerebrospinal fluid and serum for ante-mortem diagnosis of human rabies. *PLoS Neglected Tropical Diseases*, 13(1), e0007128.

Ehizibolo, D., Ogunsan, E., Muhammad, M., Nwosuh, C., Olaleye, S., Chuckwu, O., Sugun, M., Sati, N., Waziri, N., Egwu, O., Kamani, J., Meseko, C., Idachaba, S. and Dogo, G. (2009). Diagnosis of canine rabies by the direct fluorescent antibody technique in Plateau State, Nigeria. *Nigerian Veterinary Journal*, 29(2), 20-24.

Fooks, A. R., Banyard, A. C., Horton, D. L., Johnson, N., McElhinney, L. M. & Jackson, A. C. (2014). Current status of rabies and prospects for elimination. *The Lancet*, 384(9951), 1389–1399. https://doi.org/10.1016/S0140-6736(13)62707-5

Kaltungo, B. Y., Audu, S. W., Salisu, I., Okaiyeto, S. O. & Jahun, B. M. (2018). A case of rabies in a Kano brown doe. *Clinical Case Reports*, 6(11), 2140-2143

Kennedy, L. J., Lunt, M., Barnes, A., McElhinney, L., Fooks, A. R., Baxter, D. N. & Ollier, W. E. R. (2007). Factors influencing the antibody response of dogs vaccinated against rabies. *Vaccine*, 25(51), 8500–8507.

Knobel, D. L., Cleaveland, S., Coleman, P. G., Fèvre, E. M., Meltzer, M. I., Miranda, M. E. G., Shaw, A., Zinsstag, J. & Meslin, F. (2005). Re-evaluating the burden of rabies in Africa and Asia. *Bulletin of the World Health Organization*, 2005, 83(5), 360–368.

Lembo, T., Niezgoda, M., Velasco-Villa, A., Cleaveland, S., Ernest, E. & Rupprecht, C. E. (2006). Evaluation of a direct, rapid immunohistochemical test for rabies diagnosis. *Emerging Infectious Diseases*, 12(2), 310–313.

Ling, W., Doi, S. A. R., Lau, C. L., Mills, D. J., Kostoulas, P. & Furuya-Kanamori, L. (2021). Diagnostic accuracy of ELISA kits for measurement of rabies antibodies. *Journal of Travel Medicine*, 28(5), 1–3.

Mähl, P., Cliquet, F., Guiot, A. L., Niin, E., Fournials, E., Saint-Jean, N., Aubert, M., Rupprecht, C. E. & Gueguen, S. (2014). Twenty year experience of the oral rabies vaccine SAG2 in wildlife: A global review. *Veterinary Research*,45(1), 77-78

Messenger, S. L., Smith, J. S. & Rupprecht, C. E. (2002). Emerging epidemiology of bat-associated cryptic cases of rabies in humans in the United States. *Clinical Infectious Diseases*, 35(6), 738–747

Mshelbwala, P. P., Ogunkoya, A. B. & Maikai, B. V. (2013). Detection of Rabies Antigen in the Saliva and Brains of Apparently Healthy Dogs Slaughtered for Human Consumption and Its Public Health Implications in Abia State, Nigeria. *Veterinary Science*. https://doi.org/10.1155/2013/468043

Ogunkoya, A. B., Beran, G. W., Umoh, J. U., Gomwalk, N. E. & Abdulkadir, I. A. (1990). Serological evidence of infection of dogs and man in Nigeria by lyssaviruses (family Rhabdoviridae). Transactions of the Royal Society of Tropical Medicine and Hygiene, 84(6), 842–845.

Ojo, D., Nwadike, V., Onyedibe, K., Kalu, I., & Ojide, K. (2016). Rabies in Nigeria: A review of literature. *African Journal of Clinical and Experimental Microbiology*, 17(2), 159.

Olugasa, B. O., Aiyedun, J. O. & Emikpe, B. O. (2011). Prevalenzadell'anticorpoantirabbia in caniconfinati, liberi e randagi in unacittà di transito in Nigeria. *VeterinariaItaliana*, 47(4): 453–460.

World Health Organization (WHO). (2010). WHO Technical Report Series 931 Who Expert Consultation on Rabies First Report 2 WHO Library Cataloguing-in-Publication Data. World Health, 1–121.

World Health Organization (WHO). (2021). Rabies: Key facts. Available at: https://www.who.int/news-room/fact-sheets/detail/rabies. Accessed May, 31st, 2022.

Xu, C., Lau, C. L., Clark, J., Rafferty, A. C., Mills, D. J., Ramsey, L., Gilbert, B., Doi, S. A. R. & Furuya-Kanamori, L. (2021). Immunogenicity after pre- and post-exposure rabies vaccination: A systematic review and dose-response meta-analysis. *Vaccine*, 39(7), 1044–1050.