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Retrospective Study on the Spatio-Temporal Distribution of Rabies in Animals in Plateau State, 2019 – 2023

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SUMMARY

Rabies is a highly fatal zoonotic disease of great public health importance primarily affecting humans and animals. Despite global efforts to control the disease, rabies remains a significant public health issue, particularly in developing countries where it causes substantial mortality. This study investigates the spatiotemporal distribution of rabies in animals in Plateau State, Nigeria, from 2019 to 2023. Data were retrospectively sourced from the Rabies Laboratory at the National Veterinary Research Institute (NVRI), Vom. A total of 668 samples were submitted during the study period, with 402 (60.17%) testing positive for rabies. The majority of cases (99.25%) were reported in dogs. Analysis revealed a high prevalence of rabies across the state, with notable peaks in cases during specific months and across various Local Government Areas (LGAs). The findings highlight the endemic nature of rabies in Plateau State and underscore the need for enhanced rabies prevention and control measures, including public awareness campaigns, mass vaccination, and strict enforcement of dog ownership regulations. This study emphasizes the importance of accurate data collection and reporting in the fight against rabies and supports ongoing efforts to eradicate the disease by 2030.

Key words: Rabies, Rabies virus, Spatio-temporal, Distribution, Nigeria.

INTRODUCTION

Rabies is an acute encephalitis or meningoencephalitis caused by a neurotropic virus of the genus *Lyssavirus*, family *Rhabdoviridae*, order *Mononegavirales*. It is transmissible to all mammals (WHO, 2018). The virus is one of more than 20 identified variants, all of which affect mammalian hosts and are zoonotic in nature (Crowcroft and Thampi, 2015). It can infect a wide host range which includes bats, foxes, raccoons and canids; however, dogs are the

greatest source of rabies infection for humans (Rupprecht *et al.,* 2002).

The disease has been reported to emerge in geographical areas where it was never present, and re-emerged in places where it was previously controlled or eradicated (Rupprecht et al., 2002). The global annual mortality of the disease in humans has been estimated to be 59,000 with the socially and economically disadvantaged sectors of society being the most vulnerable (Regea, 2017; Barbosa Costa et al., 2018; Tiwari et al., 2019). More than 99% of all human deaths from rabies occur in the developing world (Knobel et al., 2005). The mortality from rabies in Africa has been estimated to be 28,000 as at 2010, with West and Central Africa accounting for 21,500 deaths (Mbilo et al.,2021). In Nigeria, Rabies is grossly under reported as only 998 human and 273 dog-suspect rabies cases were reported respectively between 2017 and 2022 (Abubakar et al., 2023). A true representation of the scenario of rabies in Plateau State cannot be ascertained due to the paucity of data (Ahmed et al., 2000; Adedeji et al., 2010; Aghahowa and Ogbevon, 2010; Bata et al., 2011).

It is primarily maintained and transmitted through the bites of Free-Roaming Dogs (FRD) (Isloor et al., 2020) and is widespread in countries that either do not have legislation regulating movement and ownership of dogs or do not implement them strictly (Özen et al., 2016; Taylor et al., 2017) such as Nigeria. Although wild carnivores and bats are natural reservoirs of the rabies virus, it is the domestic dog, Canis lupus familiaris, which usually acts as the most common host and chief source of infection for humans. Rabies occurs worldwide except for several isolated islands and countries where it has never been reported or in several countries that have been successful in eradicating the virus in urban areas (WHO 2018).

The natural route of transmission is through a bite from a reservoir animal (Dietzschold et al., 2008). Although the virus cannot penetrate intact skin, it can gain entry through scratches, open wounds, or direct exposure across mucous membranes (Crowcroft and Thampi, 2015). Other reported routes of infection include consumption of infected carcasses by arctic foxes (Vulpes lagopus) or through inhalation of aerosols, either in a laboratory setting or from caving in areas with a large population of bats (Dietzschold et al., 2008). Although the virus may be present in body fluids such as lacrimal gland secretions/tracheal secretions and tissues such as pharynx, skeletal muscles, liver, kidney and skin during the first 5 weeks of illness, infected humans are generally dead-end hosts (Helmick et al., 1987). However, human-to-human transmission has been reported in corneal transplant recipients (Crowcroft and Thampi 2015; Helmick et al., 1987) and in the case of four recipients of organs from a common donor who died of rabies (Srinivasan et al., 2005).

The incubation period of rabies in dogs is 3-12 weeks, but it can last up to 10 months in some cases (Beran, 1994; Government of Alberta, 2021). In humans, the Rabies virus (RABV) has a variable incubation period that ranges from 5 days to several years (Rupprecht, 1996). The incubation period is usually influenced by the amount of virus in the inoculum, the nerve motor endplate density at the wound site and the proximity of the virus entry point to the central nervous system (Ugolini, 2007; Hemachudha et al., 2013).

The obvious presence of high dog population and paucity of data in Plateau state contributes to the endemicity of rabies in the study area, thus this study was carried out to determine the spatiotemporal distribution of rabies in animals in Plateau State, Nigeria.

MATERIALS AND METHODS

Area of Study

This study was carried out in Plateau State, located in the north central region of Nigeria,

which is the 12th largest of Nigeria's 36 States with Jos as its capital city. The State has 17 Local Government Areas (LGAs) and is located between latitude 80º24'N and longitude 80º 32' and 100º 38'E. It stands at an altitude of 1,280 meters above sea level with peaks as high as 1,829 meters above sea level. The indigenous people of Jos, Plateau state, in central Nigeria are mainly farmers and are also involved in dog rearing, The very high dog population is partly due to the fact that most of the communities eat dog meat (Alabi *et al.,* 2014). Plateau State is also a significant hub for dog trade with dogs from different parts of the country and neighbouring countries (e.g., Niger and Chad), transported to the Dawaki Market within the State for slaughter and/or onward movement to various destinations within the country. While dog trade for human consumption provides income to local small businesses, this market chain presents a significant risk to individuals involved in this trade (Mshelbwala *et al.,* 2021).

Study design and data source

This descriptive study used retrospective, secondary sourced data obtained from the records of the Rabies Laboratory of the National Veterinary Research Institute (NVRI), Vom. The variables captured in the data included the number of samples submitted, status of the tested samples (+/-) with positive cases confirmed using Fluorescent Antibody Test (FAT), the month and year of report and the names of the affected LGAs.

Data analysis

The data obtained were analysed using Microsoft Excel 2019 version to generate frequencies and proportions and the results presented as tables and charts. Quantum Geographic Information System (QGIS 3.16.11) was used to generate choropleth maps for the spatiotemporal distribution of rabies cross the affected LGAs.

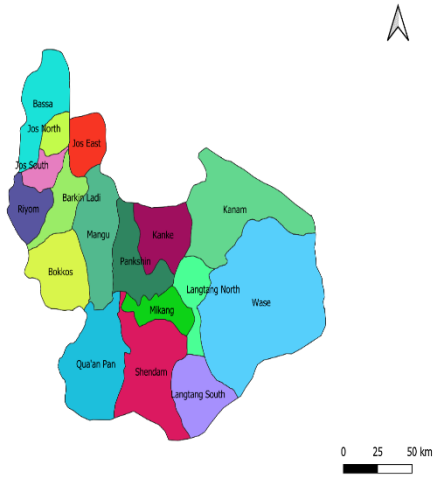

FIGURE I: Map of Plateau State showing the 17 Local Government Areas

TABLE I: Letter keys representing LGAs in Plateau State

LGA	KEY
Barkin Ladi	BL
Bassa	BSA
Bokkos	BKK
Jos North	JN
Jos South	JS
Jos East	JE
Kanam	KNM
Kanke	KNK
Langtang North	LGN
Langtang South	LGS
Mangu	MGU
Mikang	MKG

Pankshin	PKN
Qua'an pan	QPN
Riyom	RYM
Shendam	SDM
Wase	WS

Limitations

Secondary data have some limitations, as the interest of the primary collector may differ from that of the secondary user.

RESULTS

This five (5) year retrospective study spanning year 2019-2023 showed that a total of 668 samples were submitted to the Rabies reference lab at NVRI, Vom for confirmatory diagnosis out of which 402 (60.17%) samples were positive. The distribution of these positive cases over the 5-year period were 106 (66.25%), 55 (51.40%), 79 (55.24%), 92 (69.69%) and 70 (55.56%) for 2019, 2020, 2021, 2022 and 2023 respectively. The highest number of cases were reported in 2019 while the lowest were reported in 2020. The monthly distribution of positive rabies cases peaked between July and September for the years 2019, 2021, 2022 and 2023, with only the year 2020 showing peak cases in March (Figure II).

Out of a total of 402 positive cases of rabies in animals encountered within the state in 2019, 2020, 2021, 2022 and 2023, 399 (99.25%) were canine, 2 (0.50%) were feline and 1 (0.25%) was ovine, with the bulk of the cases being reported in the canine specie (399 (99.25%)).

Temporal occurrence of rabies in Plateau State

From Fig II below, it was observed that the year 2019 had the highest number of positive cases (106) for the period under review (2019 -2023), with peak number of cases encountered in the month of July (19). This was followed by the year 2022 with a total of 92 positive cases recorded, and a peak in cases seen during the month of September (13). The year 2021 came next with a total of 79 positive cases recorded and peak cases seen in August (13). The year 2023 had a total of 70 positive cases with peak cases reported in July (9) and the year 2020 had the least number of positive cases for the period under review (55), with the highest number of cases encountered in the month of March (11). Overall, it can be seen that rabies cases occurred all year-round within the years under review.

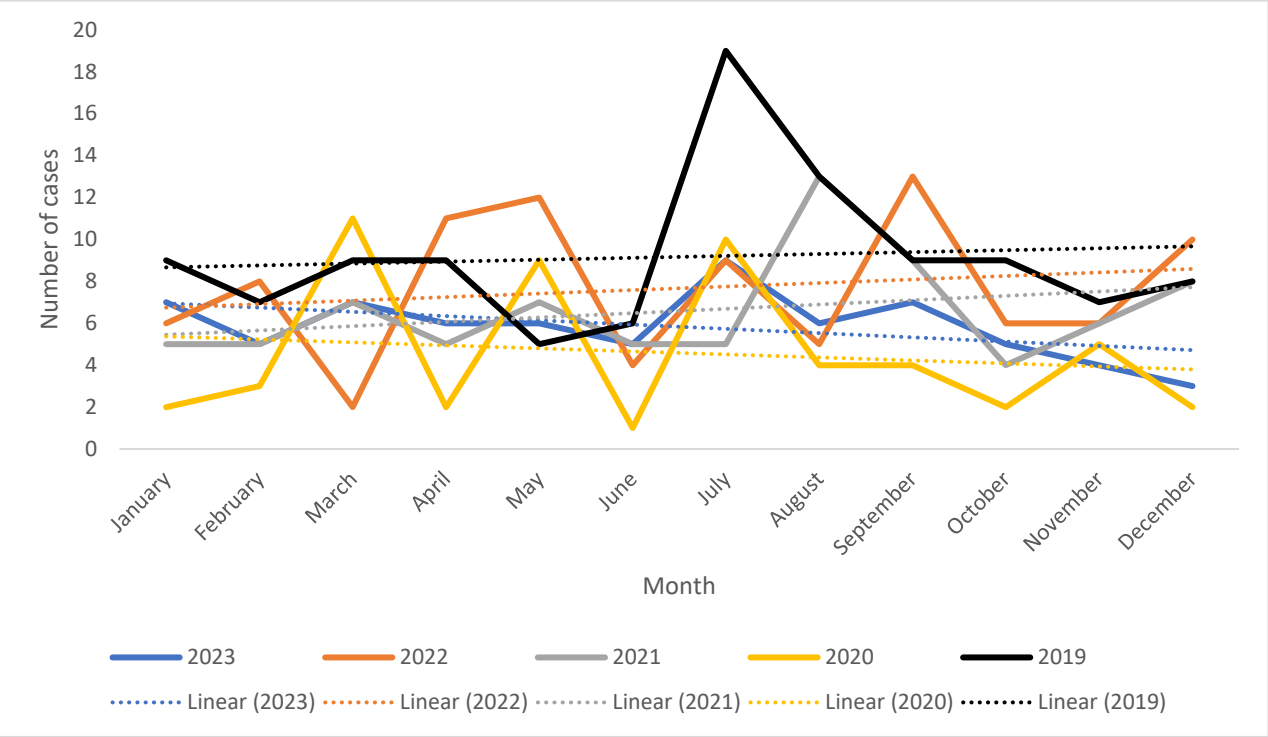

Figure II: Temporal distribution of reported rabies cases across various local government areas in Plateau state from the year 2019 to 2023

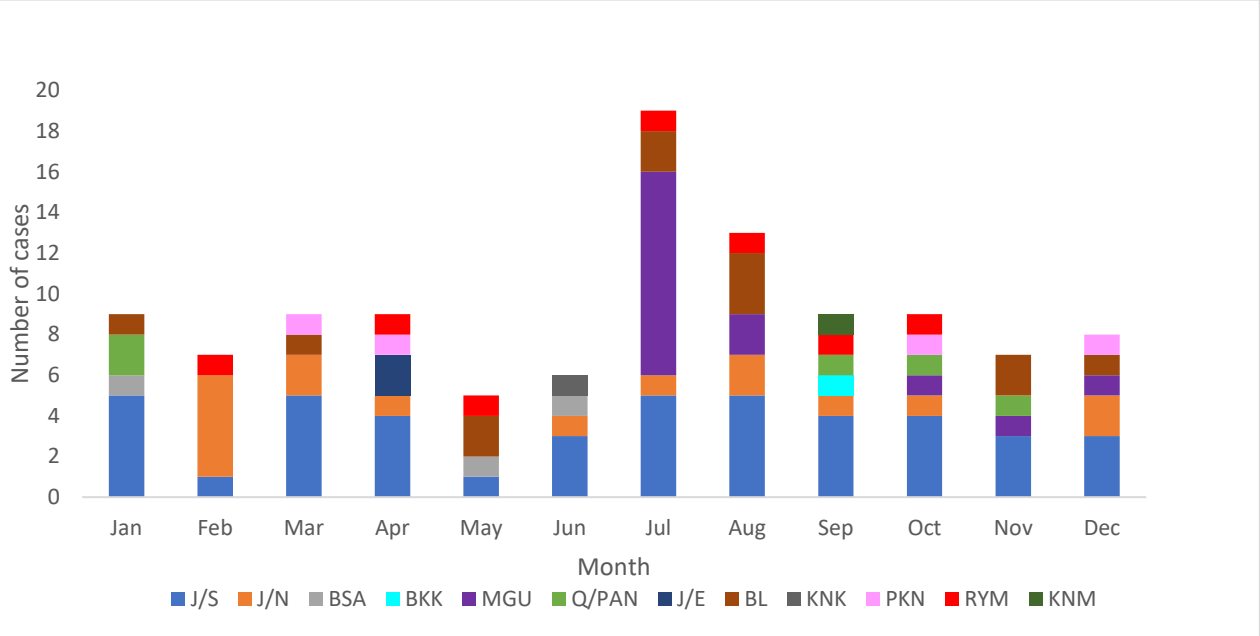

Figure III: Distribution of reported rabies cases across various local government areas in Plateau state from January – December, 2019

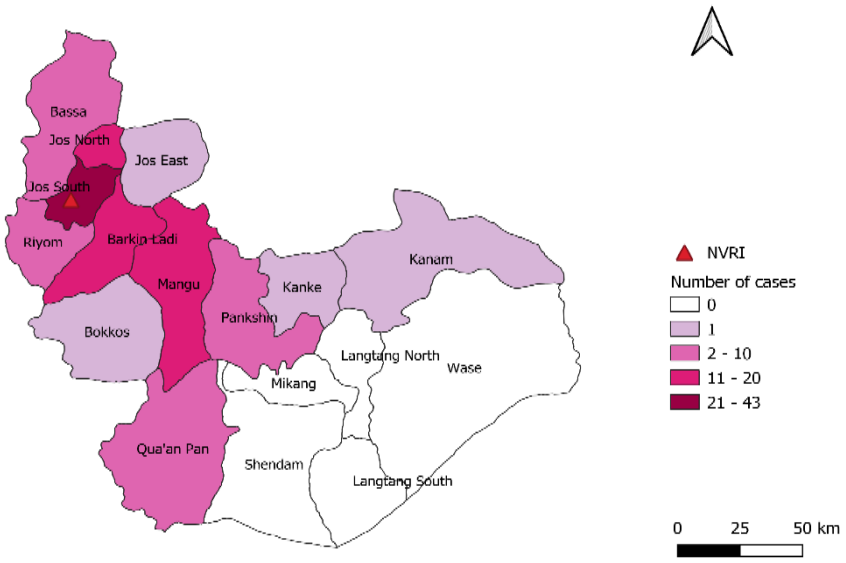

Figure IV: Spatial distribution of reported rabies cases across various local government areas in Plateau State for the year 2019.

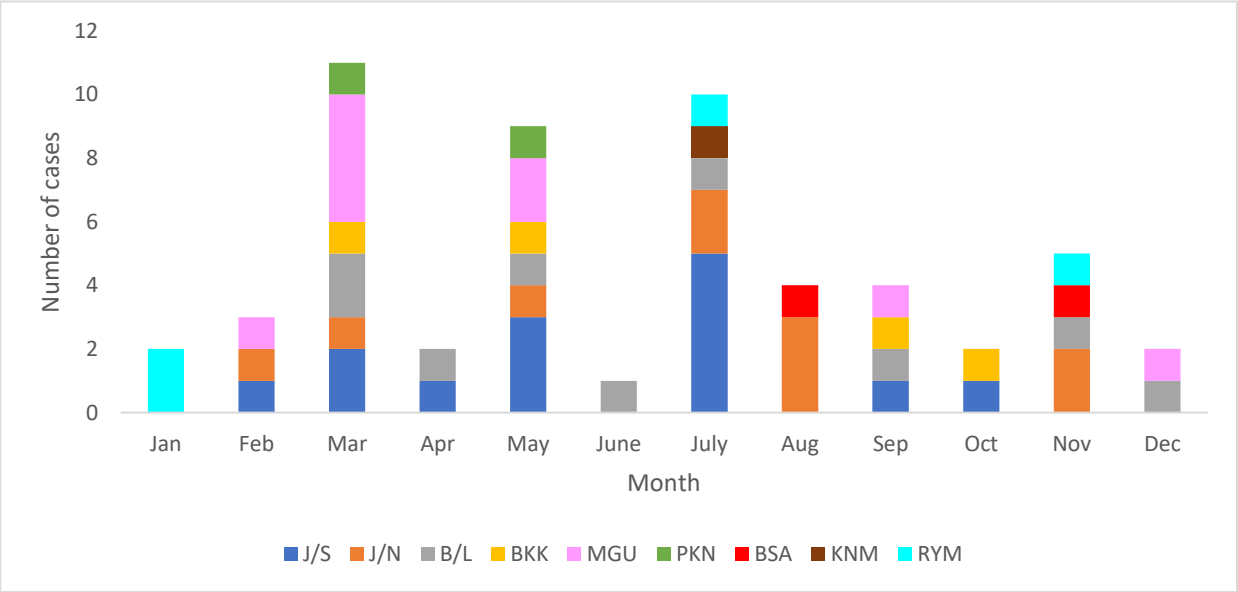

Figure V: Distribution of reported rabies cases across various local government areas in Plateau state from January – December, 2020.

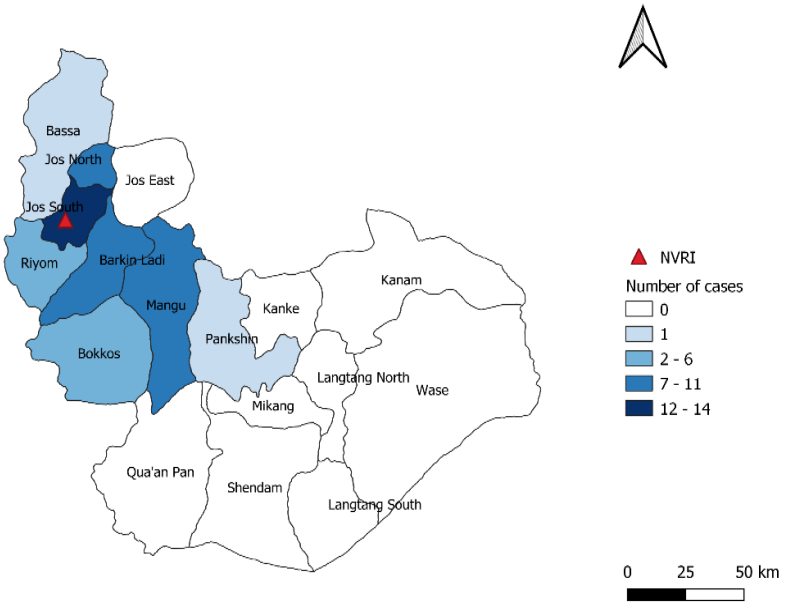

Figure VI: Spatial distribution of reported rabies cases across various local government areas in Plateau State for the year 2020.

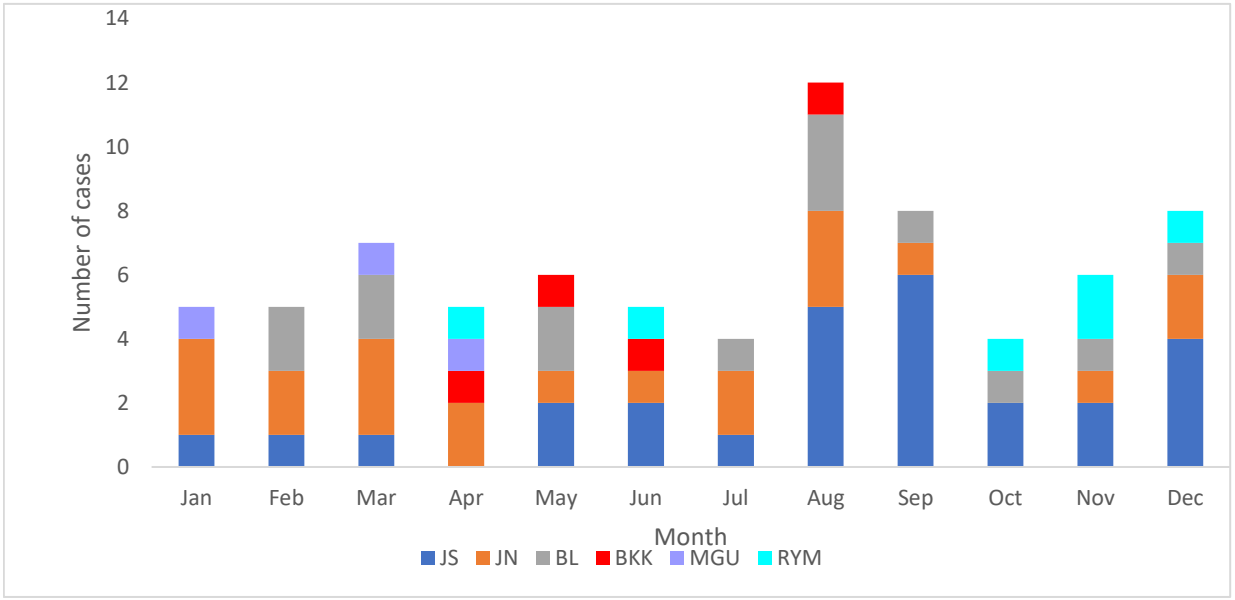

Figure VII: Distribution of reported rabies cases across various local government areas in Plateau state from January – December, 2021.

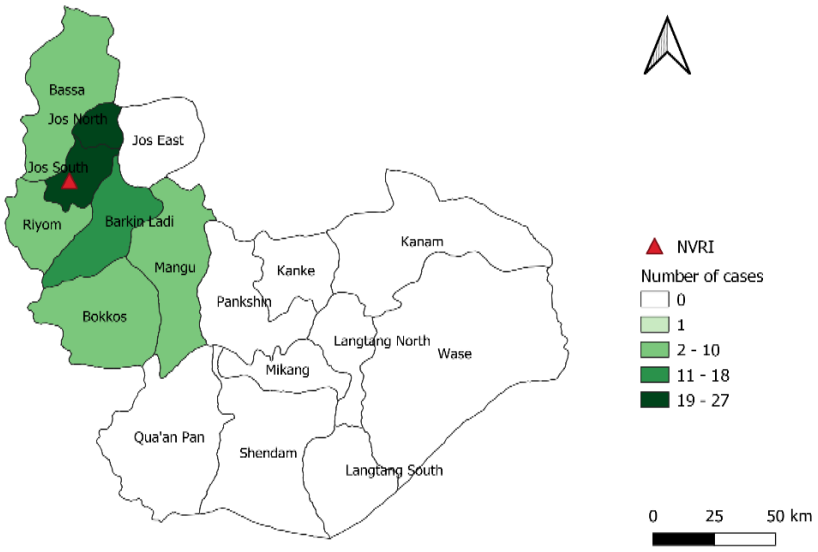

Figure VIII: Spatial distribution of reported rabies cases across various local government areas in Plateau State for the year 2021.

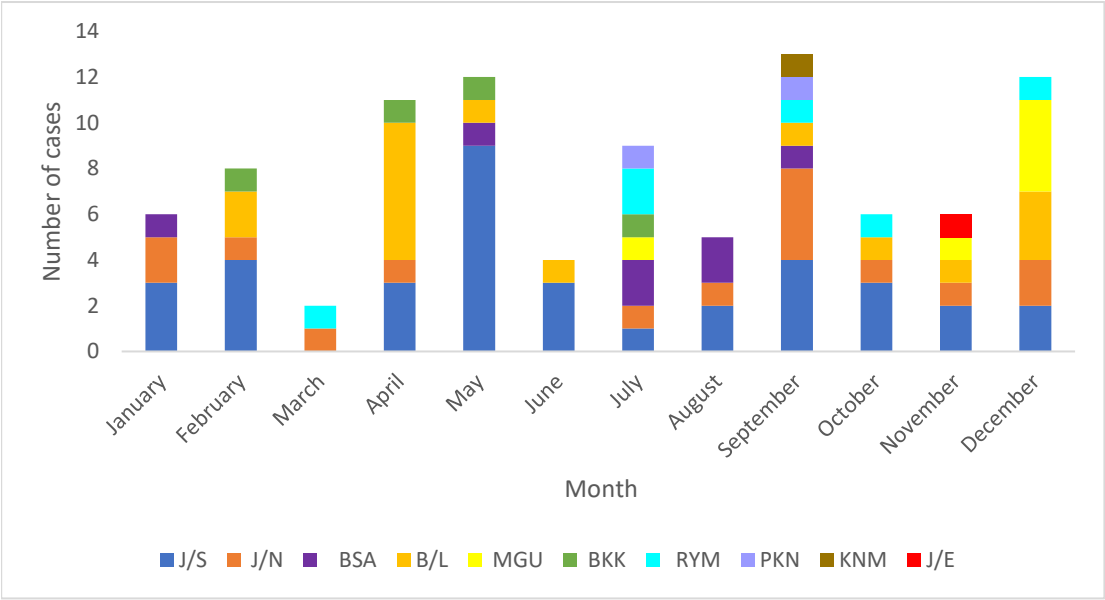

Figure IX: Distribution of reported rabies cases across various local government areas in Plateau state from January – December, 2022.

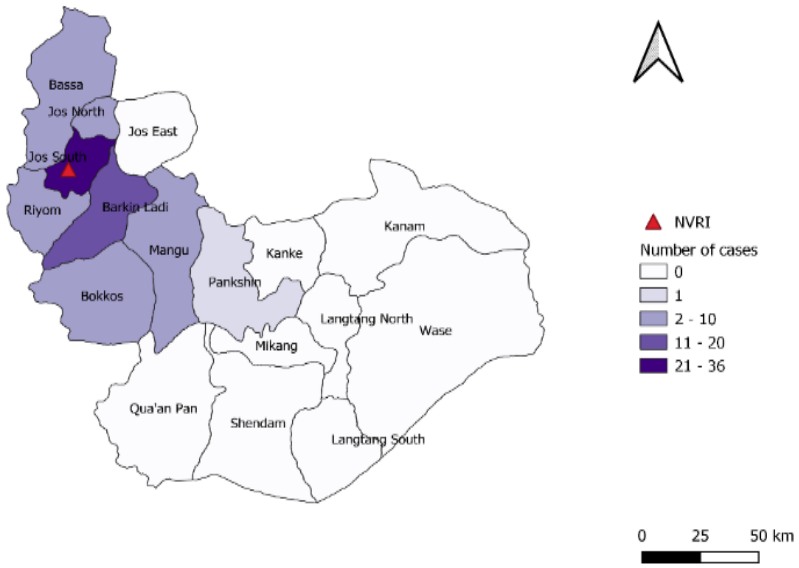

Figure X: Spatial distribution of reported rabies cases across various local government areas in Plateau State for the year 2022.

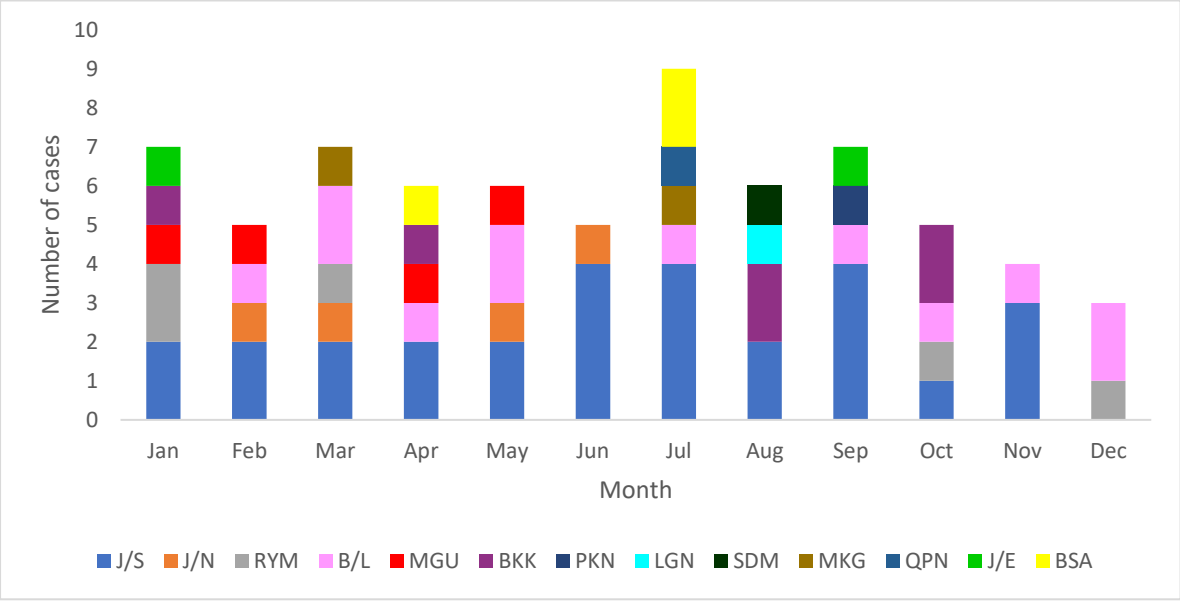

Figure XI: Distribution of reported rabies cases across various local government areas in Plateau state from January – December, 2023.

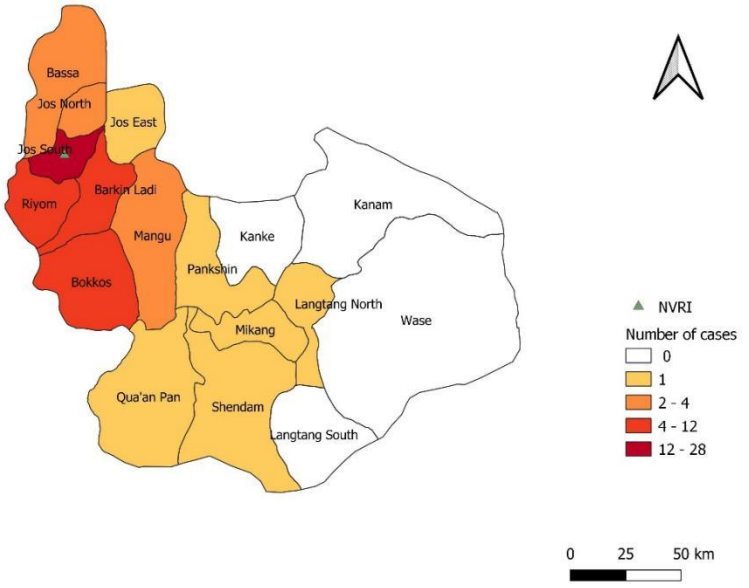

Figure XII: Spatial distribution of reported rabies cases across various local government areas in Plateau State for the year 2023.

DISCUSSION

From the lowest prevalence of 51.40% for the year 2020, to the highest prevalence of 69.69% encountered in 2019, a five-year average of 59.63% was obtained and this closely agrees with the findings of Tekki *et al.,* (2016) who reported a 61.1% prevalence in Nigeria. This shows that rabies has high occurrence in Plateau State and Nigeria as a whole and needs to be given great priority in terms of control and eradication.

From the results, Fig II and III showed that cases of rabies were highest within the months of July, then August, January, March and September in 2019. The distribution of cases of rabies across the year (2019), indicated that rabies can occur at any time of the year with ($p = 0.8888$) and an even spread across both the rainy and dry seasons. This result agrees with that of Bolajoko *et al.,* (2016) who reported that no month-wise seasonal pattern of canine rabies was identified in Plateau State, though other authors (Ehimiyein *et al*., (2014) and Ezeokoli and Umoh (1987)) stated that the occurrence of rabies was highest during the rainy season with clusters seen around the months of April and September characterized by dog fights over breeding rights which may subsequently lead to the spread of the virus.

The difference observed for the occurrence of rabies across the affected LGAs in 2019 was statistically significant with a p-value of

p<0.0001. Jos South LGA had on record the highest number of cases which was probably as a result of its close proximity to the reference laboratory (NVRI), Vom, thereby making it easier and faster for samples to get submitted and it might also be due to the high dog population seen within the Jos south metropolis (Ogbu *et al*., 2020).

The results in Figure V, showed the distribution of rabies cases across the months of January to December, 2020, with the month of March recording the most cases of rabies, then July. This also showed that rabies could occur both during the dry and rainy seasons as already seen under Figure III above. There was statistically no significant difference in occurrence of rabies across the affected LGAs (p=0.0881) in Plateau State in the year 2020.

For the year 2021 depicted in Figure VII, the month of August had the most cases of rabies, then the months of April, March, September and December. Jos South, Jos North and Barkin Ladi had on record the most cases, which may also be attributed to their relative proximity to the reference laboratory (NVRI), Vom. The difference observed for the occurrence of rabies across the affected LGAs for the year 2021 was statistically significant with a p-value of p<0.0001.

From Figure IX above, the month of September had on record the greatest number of positive cases of rabies, then the months of April, May and December. Only 11 out of the 17 LGAs submitted samples to the reference laboratory during this time period. The difference observed for the occurrence of rabies across the affected LGAs for the year 2022 under review was statistically significant with a p-value of p<0.0001, with Jos South LGA reporting the highest number of cases then Barkin Ladi, this might also be due to their relative closeness to the reference laboratory (NVRI), Vom and the observed high dog population as had been previously observed for the year 2019.

The results from Figure XI covering the year 2023, had the highest number of positive cases in the month of July, followed by January, March and September. Out of the 17 LGAs within the state, 13 LGAs submitted samples to the reference laboratory, with Jos South LGA having the highest number of positive cases reported (28 cases) out of a total number of 70 positive cases reported, followed by Barkin Ladi (12) and Bokkos (6). This may be due to higher dog populations within these Local Government Areas as seen in a prior cited publication by Ogbu *et al.*, 2020, or it might still be due to the relatively close proximity of these LGAs to the reference laboratory. With a value of p>0.05, there was no significant difference in the occurrence of rabies across the months and across the LGAs.

Rabies has previously been reported in other LGAs of the State which were not reported within this study period hence the absence of these LGAs being mentioned but that is not to say there is a total absence of the disease within these areas because Ojo *et al.,* (2016) had earlier stated that rabies occurs worldwide.

Rabies, a zoonotic infection with high fatality and 100% mortality is also 100% preventable by vaccination. There is presently an ongoing effort towards mass vaccination of dogs within the state in order to control rabies by the year 2030, however the mass vaccination program has experienced some challenges such as failure by some dog owners to ensure their dogs are

vaccinated and a total disregard to dog leash laws. Poor knowledge of dog ecology and estimates of dog population within the state has also affected proper planning and execution of a coordinated approach to control rabies within the state. There is also poor knowledge on the part of the general populace about rabies with resultant lack of trust in vaccines, vaccinators or officials by some communities, this is acerbated by local beliefs and superstition. There is also a shortage of skilled manpower to adequately coordinate the approach in controlling the disease (United Against Rabies, 2023).

To combat the challenges above, there is need to create more awareness about the disease and prompt vaccination of dogs and cats should be encouraged. Government should enforce enacted dog leash laws and ban the movement of stray dogs**.** Provision of vaccination inputs, incentives and oral anti-rabies vaccines will help in achieving the targeted eradication of rabies within the state. In addition, having an estimate of dog population and a significant knowledge of dog ecology within the state will provide a good background for proper planning and execution of a coordinated approach to control the disease in the future.

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Conflict of interest; the authors declare no conflicting interest.

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