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Study of the Anti-Rabies Immune Response in Vaccinated Dogs in Boké, Guinea: Implications for Canine Rabies Control Strategies

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Abstract

Canine rabies remains a major public health concern in West Africa, where domestic dogs represent the principal reservoir for human transmission. Evaluating postvaccination immune responses under field conditions is essential to optimize vaccination strategies and sustain herd immunity. This study assessed the level of humoral immune protection induced by rabies vaccination in dogs in Boké, Guinea. A cross-sectional serological survey was conducted among vaccinated dogs in the urban municipality of Boké. Anti-rabies virus-neutralizing antibody titers were quantified using a commercial ELISA, and statistical analyses were performed using nonparametric tests. Seroconversion was observed in 97% of vaccinated dogs, and 87% exhibited protective antibody titers (≥0.5 IU/mL). Antibody responses varied significantly with vaccine type and dog age, with higher titers recorded in adult animals. Housing conditions had no measurable effect. A significant decline in antibody titers was associated with increasing time since vaccination. Rabies vaccination in dogs in Boké generally induces adequate immune protection; however, variability in antibody persistence underscores the need for strengthened postvaccination monitoring and adherence to vaccination schedules.

Keywords

Rabies, Canine Vaccination, Anti-Rabies Antibodies, Immune Protection, Zoonotic Disease, Guinea

1. Introduction

Rabies is an acute viral disease that affects the central nervous system of mammals, including humans, leading to fatal encephalitis in almost all cases once clinical signs appear [1] [2]. It is caused by the rabies virus (RABV), a single-stranded RNA virus of the genus Lyssavirus, and remains one of the most feared zoonoses worldwide, with nearly 100% lethality in humans. The virus is transmitted primarily through the bite of infected animals, particularly dogs, which constitute the main source of human infection [3]. Rabies occurs on all continents except Antarctica; however, it is frequently underreported and remains one of the most neglected diseases globally [4]. According to global statistics from the World Organization for Animal Health, rabies causes approximately 70,000 deaths annually, with over 95% of fatalities occurring in Asia and Africa, where canine rabies is enzootic [5] [6]. In 2025, the World Organization for Animal Health confirmed that most human and animal rabies deaths are due to inadequate access to care, disproportionately affecting Africa and Asia (>95% of fatal cases), with significant health and economic impacts in rural areas [7].

Canine vaccination campaigns are therefore critical not only for safeguarding animal health but also for reducing the risk of transmission to humans [8] [9]. In the Republic of Guinea, rabies remains a major public health concern. Low vaccination coverage among dogs was estimated at only 3% for biting dogs between 2002 and 2012, underscoring the urgent need to strengthen vaccination programs [10]. The measurement of anti-rabies antibody titers is an essential indicator for evaluating the efficacy of vaccination campaigns and the immune response of vaccinated dogs. The World Health Organization considers antibody titers ≥ 0.5 IU/mL to be protective against rabies infection. However, in Guinea, data on the persistence of immunity in vaccinated dogs are lacking, complicating the assessment of preventive strategies [11].

Boké, a coastal region with a substantial canine population, faces increasing challenges in rabies control. Vaccination coverage remains insufficient, and several human rabies cases have been reported in recent years. Limited access to veterinary services and socioeconomic constraints are major obstacles to improving canine vaccination. In this context, the present study was undertaken to assess the efficacy of rabies vaccination in dogs in the urban commune of Boké. This investigation aimed to determine whether rabies vaccination in Boké dogs confers sufficient protective immunity to optimize canine rabies control strategies and reduce the risk of transmission to humans.

2. Materials and Methods

2.1. Study Site

Boké Prefecture is in the western zone of Lower Guinea, between 10˚30' and 11˚45' North latitude and 13˚45' and 15˚00' West longitude. According to the General Population and Housing Census, it covers an area of 11,055 km^2 and has a population of 481,007, corresponding to a density of 43 inhabitants per km^2. Boké is situated approximately 250 km from the capital, Conakry. The field survey was conducted from October 2024 to December 2024.

2.2. Sampling Technique

Five of the six administrative districts of Boké urban commune were selected by simple random draw. Within each selected district, vaccinated dog-owning households were identified with the assistance of local veterinary officers who maintained records of vaccination activities. This sampling approach was therefore random at the district level and purposive at the household level. To minimise clustering bias, only one dog per household was eligible for inclusion. Prior to blood sample collection, structured interviews were conducted with these dog owners. The dogs included in the study were household-owned dogs from the urban municipality of Boké. Owner consent was obtained prior to any blood sampling.

2.3. Sample Size

The required sample size was calculated using Cochran's formula [12] for proportions: $n_0 = Z^2pq/e^2$, where $Z = 1.96$ (95% confidence level), $p = 0.50$ (expected seroconversion prevalence, maximum variance assumption), $q = 1 - p = 0.50$, and $e = 0.1170$ (absolute margin of error, corresponding to a relative precision of 23.40% of p). Substituting these values: $n_0 = (1.96)^2 \times 0.50 \times 0.50/(0.1170)^2 \approx 70$. A total of 70 dogs were therefore targeted for inclusion.

2.4. Serological Analysis

The serological assessment of anti-rabies antibody titers was performed via the IDEXX Canine Anti-Rabies Ab ELISA Kit following the manufacturer's instructions. Blood samples were collected by venipuncture under simple manual restraint, without anesthesia, in accordance with standard veterinary practice. Serum samples were diluted 1:10 in the provided buffer solution and then added to the wells of ELISA plates, along with positive and negative controls. The plate was incubated at 37˚C for two hours to allow the binding of specific antibodies to rabies antigens. After incubation, the wells were washed to remove unbound components, and the conjugated antibody was added, followed by a second incubation. After a second wash, the TMB substrate was added to reveal the enzymatic reaction. The reaction was stopped with the provided stop solution, and the absorbance was measured at 450 nm via an ELISA plate reader.

Vaccination status, vaccine brand, and date of last vaccination were verified from vaccination cards (77% of dogs) or district veterinary officer logbooks (23%); no animal was included based solely on unverifiable owner recall. Absorbance values were converted to IU/mL using the IDEXX proprietary calculation spreadsheet according to the manufacturer's instructions. Samples below the assay's lower limit of quantification (<0.125 IU/mL) were assigned to this limiting value and classified as non-seroconverted. The protective threshold of ≥0.5 IU/mL was applied in accordance with WHO/WOAH recommendations.

2.5. Statistical Analysis and Interpretation

Survey data were analyzed via R and GraphPad Prism. Descriptive statistics (means, medians, and standard deviations) were calculated to characterize the distribution of the antibody titers. Data normality was assessed via the Shapiro-Wilk test. Nonparametric tests were applied: the Mann-Whitney test for comparisons between two independent groups and the Kruskal-Wallis test for comparisons among multiple groups. Correlation analysis was also conducted to evaluate the associations between adherence to the vaccination schedule and antibody levels. The significance threshold was set at $p < 0.05$.

Serological results were interpreted according to the following antibody titer thresholds: titers between 0.125 - 0.2 IU/mL were considered indicative of no seroconversion; titers between 0.2 - 0.5 IU/mL were classified as insufficiently seroconverted, requiring a booster vaccination; and titers between 0.5 - 4 IU/mL were considered indicative of adequate seroconversion, corresponding to a protective level against rabies. All comparisons between subgroups were conducted as unadjusted (univariable) analyses.

3. Results

3.1. Distribution of Respondents by Socioprofessional Category, Educational Level, and Participation in Vaccination Campaigns

The distribution of consenting respondents by socioprofessional category indicates that laborers, traders, and farmers were the most represented groups in this study, accounting for 20%, 20%, and 17% of participants, respectively, followed by civil servants (14%). With respect to educational level, secondary education was the most represented level (31%), whereas primary education accounted for only 13%. Furthermore, 93% of the dog owners who had benefited from vaccination campaigns provided consent for inclusion in this study (**Figure 1**).

3.2. Distribution of Study Dogs by Breed, Age, and Housing Type

The distribution of the study dogs by breed revealed that 96% were local breeds, whereas only 4% were exotic breeds. Half of the dogs (50%) were adults aged 2 - 7 years, followed by young dogs aged 3 months to 2 years (46%). Dogs older than 7 years were less represented (4%). Furthermore, 53% of dogs lived in complete freedom, whereas caged and mixed housing systems represented 20% and 27%, respectively (**Figure 2**).

3.3. Dog Owner's Knowledge of Rabies

The level of knowledge regarding rabies among the dog owners was assessed. The results revealed that 69% of the consenting participants had previously heard of rabies, whereas 31% had never heard of the disease (**Figure 3(a)**). Among those aware of rabies, 27% were unfamiliar with the disease's clinical manifestations, whereas 18% and 16% recognized signs of agitation and nervousness, respectively.

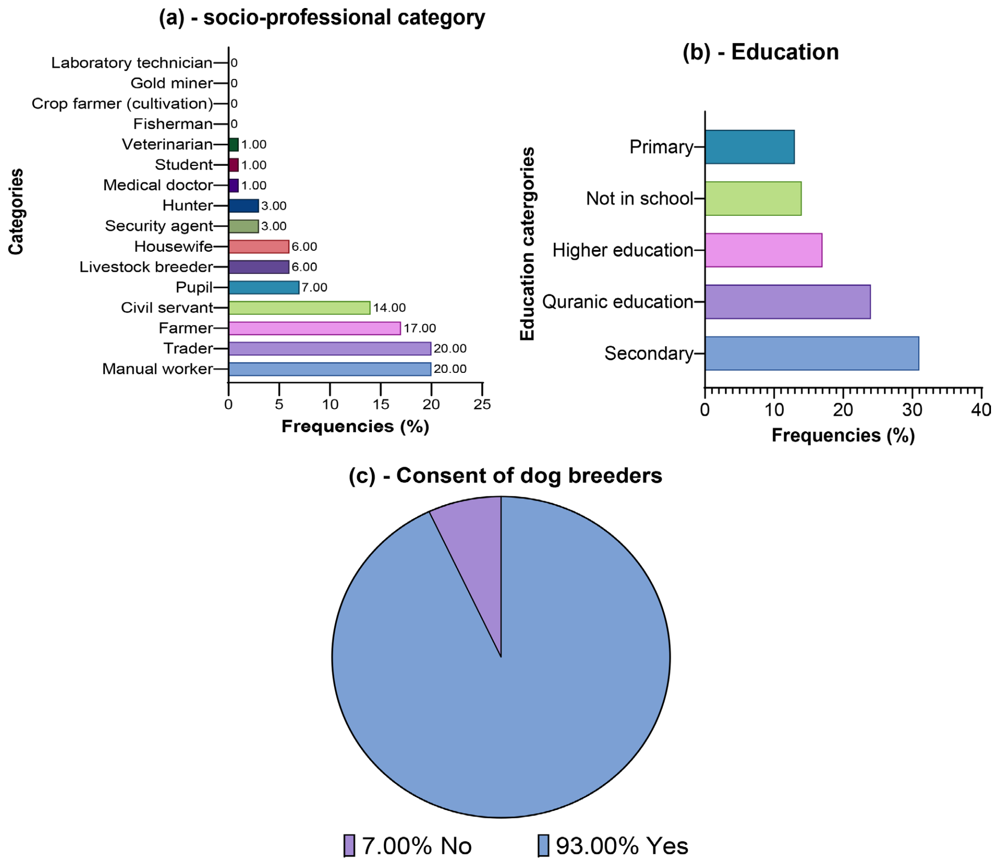

Figure 1. Distribution of consenting respondents: by socioprofessional category (a), educational level (b), and participation in vaccination campaigns (c).

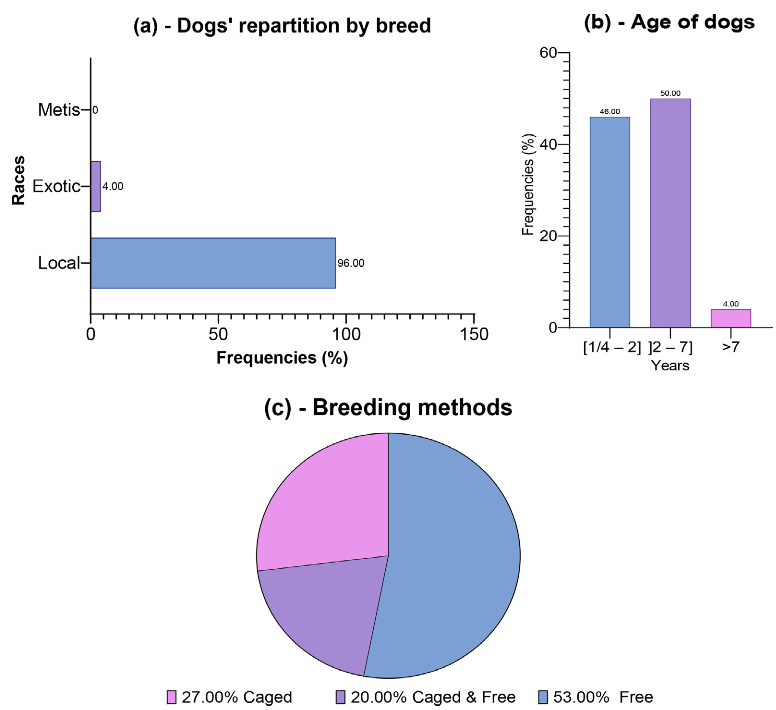

Figure 2. Distribution of dogs by breed (a), proportion of study dogs by age group (b), and housing type of study dogs (c).

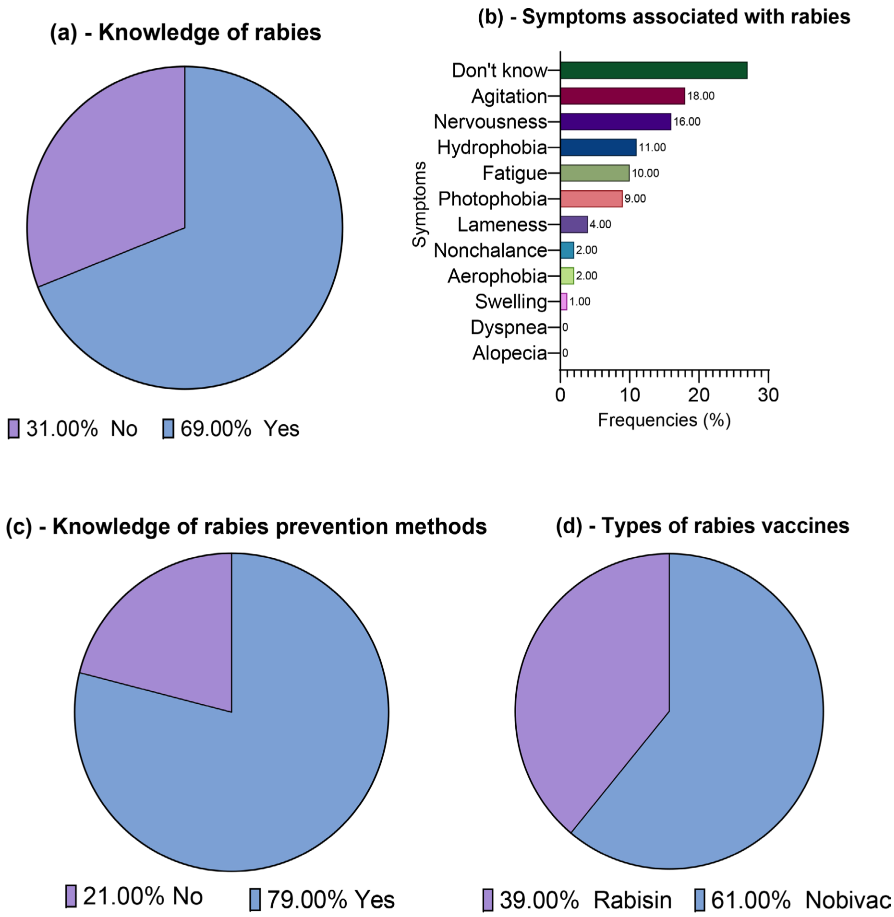

Figure 3. Dog owners' knowledge of rabies: awareness of rabies (a); reported rabies-associated clinical signs (b); knowledge of rabies prevention measures (c); types of anti-rabies vaccines used (d).

Overall, 79% of the participants were aware of preventive strategies, whereas 21% had no knowledge of such measures. Nobivac was the most frequently used vaccine, reported by 61% of the respondents, whereas Rabisin was less commonly used (39%) (**Figure 3**).

3.4. Seroconversion Levels in Vaccinated Dogs

The seroconversion status of dogs was assessed. Among the sampled dogs, 87% exhibited protective antibody levels (≥0.5 IU/mL), whereas 10% and 3% had insufficient and undetectable antibody levels, respectively. Overall, 97% of the dogs seroconverted, whereas 3% had no detectable antibodies (**Table 1**).

3.5. Comparison of Antibody Titers According to Vaccine Type, Dog Age, and Housing Type

The influence of vaccine type on the immune response was assessed by comparing antibody titers between dogs vaccinated with Nobivac and those receiving Rabisin via the Mann-Whitney U test (**Figure 4**). A significant difference was observed between the two groups ($p < 0.05$). The median antibody titer was greater in dogs

Table 1. Seroconversion levels in vaccinated dogs.

Interval of Antibody Levels (IU/mL)	Interpretation	Percentage
[0.5 - 4]	Sufficiently Seroconverted	87%
]0.2 - 0.5[	Insufficiently Seroconverted	10%
]0.125 - 0.2]	Did Not Seroconvert	3%
Total	–	**100%**

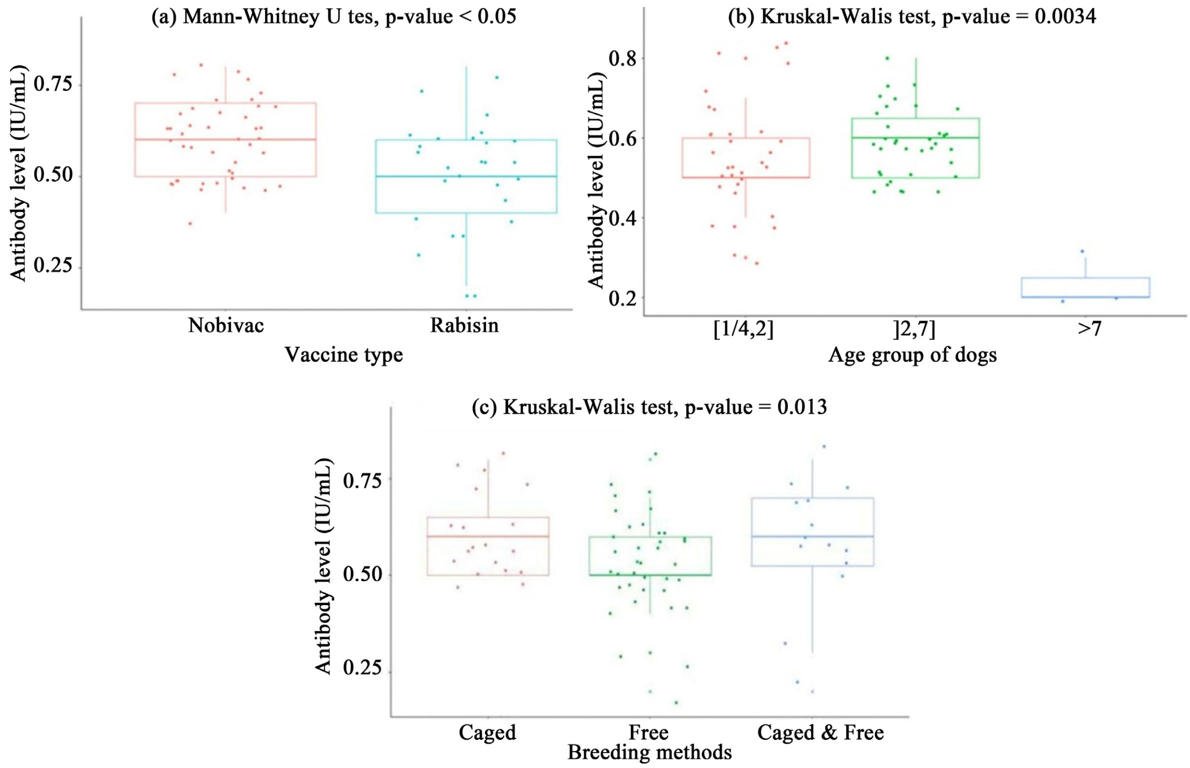

Figure 4. Antibody titers according to vaccine type, dog age, and housing type.

vaccinated with Nobivac (0.6 IU/mL) than in those vaccinated with Rabisin (0.5 IU/mL). Additionally, the effect of dog age on the immune response was evaluated: analysis revealed a significant difference in antibody levels according to age ($p < 0.05$). Dogs aged 2 - 7 years presented higher median antibody titers (0.6 IU/mL) than dogs aged 3 months to 2 years (0.5 IU/mL) and those older than 7 years (0.2 IU/mL). Furthermore, housing type had no statistically significant effect on the vaccination response ($p > 0.05$).

3.6. Comparison of Antibody Titers According to Time Since Vaccination

A comparison was conducted between recently vaccinated dogs and those vaccinated over one year prior via the Mann-Whitney U test (Table 2). The results revealed a statistically significant difference in antibody levels based on the time elapsed since vaccination ($p < 0.05$). Dogs vaccinated more than one year ago presented significantly lower antibody titers (median = 0.5 IU/mL) than dogs vaccinated within the past year (median = 0.6 IU/mL).

Table 2. Comparison of antibody titers according to time since vaccination (Test U Mann-Whitney; U = 261; r = 0.49).

Characteristics	≤1 Year (N = 42)	>1 Year (N = 28)	p Value
Median Antibody Titer (IU/mL)	0.6	0.5	<0.001

3.7. Correlation between Antibody Titers and Time Postvaccination

Biserial correlation analysis revealed a significant negative correlation between time postvaccination and antibody titers ($Rpb = -0.51$; $t = -4.85$; $p < 0.001$) (Table 3). This relationship indicates that antibody levels gradually decrease over time following vaccination.

Table 3. Correlations between antibody titers and time postvaccination (point-biserial correlation).

Statistic	≤1 Year (N = 42)	>1 Year (N = 28)	p Value
Rpb	−0.51	–	<0.001
T	−4.85	–	–

4. Discussion

This study addresses canine rabies, a viral zoonosis that is almost invariably fatal and whose control relies primarily on the induction of effective herd immunity within dog populations. In Boké, where close interactions between dogs and human populations constitute a major epidemiological risk factor, evaluating the postvaccination immune response is particularly important. The results of this study provide critical scientific evidence for assessing the true effectiveness of canine vaccination coverage, identifying potential immune deficiencies, and guiding the optimization of rabies prevention and control strategies.

The findings revealed that three socioprofessional categories—laborers, traders, and farmers—predominantly with a secondary education level, were the most represented among dog owners with vaccinated animals. This distribution reflects the predominance of certain occupations in the study area and aligns with observations from Ghana, Nigeria, and Kenya, where farmers constitute the largest group, followed by traders [13] [14].

Half of the dogs were aged 2 - 7 years, most lived free-roaming, and the majority were of a local breed. These results are consistent with findings from Burkina Faso, where 91.8% of the studied dogs were local breeds [15] [16]. Similarly, in Zambia, 62.9% of the dogs studied were free-roaming [17]. A lack of awareness of animal welfare and insufficient education among owners on domestication may be the primary factors contributing to the free-roaming behavior of dogs.

Several previous studies reported high proportions of individuals who had heard of rabies. Studies conducted in Côte d'Ivoire, Burkina Faso, and Nigeria have shown similar results [18]-[20]. This pattern highlights respondents' knowledge of rabies prevention measures among those already aware of the disease. These findings are consistent with a study conducted in Uganda, which reported that 80% of dog-owning respondents were informed about rabies prevention strategies [21]. This similarity may be explained by the fact that most surveyed dog owners had previously participated in rabies vaccination campaigns, which are typically accompanied by educational initiatives on preventive measures.

This result contrasts with findings from Kigali in 2019, where Nobivac vaccination was used in only a minority of cases. This discrepancy could be related to better accessibility of the Nobivac vaccine in our study area, where large quantities are often distributed by the government during vaccination campaigns [22] [23].

Most of the dogs in this study exhibited protective antibody levels. This outcome is consistent with studies conducted in Brazil and Indonesia, where similar proportions of dogs had neutralizing antibodies against the rabies virus [24] [25]. Comparison of antibody levels via the Mann-Whitney test revealed significantly greater titers in dogs vaccinated with Nobivac than in those vaccinated with Rabisin, suggesting a difference in immunogenicity [26] [27]. Similar findings were reported in Zambia, where the type of vaccine significantly influenced the anti-rabies antibody response [17].

Regarding dog age, adult dogs showed higher antibody titers, which may be explained by a more effective immune system in adults, whereas young and elderly dogs may exhibit less efficient immune responses due to immune immaturity or age-related decline [28] [29]. Regarding the duration of vaccine-induced protection, the results indicated that antibody titers progressively declined over time, consistent with findings from the United States [30] and France [31]. These concordant findings highlight the critical need for regular serological monitoring and booster vaccinations to maintain protective immunity against rabies.

It should be noted that all statistical associations reported in this study are unadjusted. Because age, vaccine type, and time since vaccination may be mutually correlated in this population, the independent contribution of each factor cannot be definitively separated. A multivariable regression approach in a larger sample would be needed to disentangle these effects.

5. Conclusion

This study, which analyzed anti-rabies antibody titers in vaccinated dogs in the urban commune of Boké, allowed for the evaluation of rabies vaccine efficacy and the assessment of the immune response following vaccination. The results demonstrated variability in seroconversion, indicating that several factors, including dog age, vaccine type, and time postvaccination, affect the effectiveness of immunization. Although vaccination remains the primary preventive strategy against rabies, a significant proportion of vaccinated dogs exhibit insufficient protective antibody levels. This finding underscores the importance of postvaccination monitoring to ensure durable immunity against this disease. Furthermore, these results highlight the need to strengthen dog owners' awareness of the importance of vaccination and adherence to the vaccination schedule. Improving the storage and handling conditions of vaccines by veterinarians and animal health workers could also contribute to optimizing the postvaccination immune response.

Author Contributions

C.D.K. and A.S.S.: Conceptualization; C.D.K.: Methodology; O.D.: Software; D.K, O.D.C., and R.A.: Validation; A.K.K.: Formal Analysis; C.D.K.: Investigation; S.S.: Resources; C.D.K. and O.D.: Data Curation; C.D.K. and O.D.: Writing-Original Draft Preparation; C.D.K. and H.D.: Writing-Review and Editing; A.D.: Visualization; D.K. and O.D.C.: Supervision; D.K.: Project Administration. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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