

RESEARCH ARTICLE

# Assessing Local Knowledge to Support Vulture Conservation in Northern Cameroon, Central Africa

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## Abstract

**Background:** African vulture populations has fallen drastically, with some species declining by over 90%. In Cameroon, these declines remain unquantified due to a critical shortage of structured baseline data on distribution, status and demographic trends, often hindered by logistics and safety in remote zones. To bridge this gap, this study leverages ethno-biological sighting patterns to evaluate vulture dynamics around abattoirs and the Bénoué and Bouba-Ndjida National Parks.

**Methods:** Ethno-ornithological surveys were conducted across 67 villages using semi-structured questionnaires and Focus Group Discussions. This involved 118 respondents: 81 from abattoir interviews and 37 from focus group discussions near the National Parks.

**Results:** While vultures still occur in these areas, 91.5% of surveyed residents reported massive population declines. Additionally, 63.3% of respondents have not seen a vulture recently, with historical memories of abundance stretching back to 1985. The most frequently observed species were the Hooded Vulture (57.5%) and White-backed Vulture (33.3%). Sighting frequencies were significantly higher at abattoirs (67.2%) than in Vicinities of National Parks, occurring mostly during the dry season when birds were eating (71.6%) or resting (20.7%). Statistically, vulture sighting frequencies and reported counts were heavily driven by socio-demographic factors: older, long-term residents (51–75 years) and primary-educated individuals reported significantly higher historical counts and deeper ecological knowledge than younger or unschooled peers.

**Conclusion:** Designing appropriate conservation efforts to safeguard vulture populations requires careful consideration of community socio-demographic factors.

**Keywords:** Vultures' decline, Local ecological Knowledge, Sighting pattern, Time Elapsed Since Last Sighting (TELS), Cameroon.

## 1. Introduction

Avian scavengers, particularly vultures, provide indispensable ecosystem services by accelerating biomass decomposition, recycling nutrients, and restricting the proliferation of infectious diseases at carcass sites (Mundy et al., 1992 ; Buechley & Şekercioğlu, 2016). Despite their ecological

importance, african vulture populations have experienced catastrophic, continent-wide declines over the past few decades a phenomenon widely described as the « African Vulture Crisis » (Ogada et al., 2016 ; Botha et al., 2017). In West and Central Africa, these declines are exceptionally severe, driven heavily by anthropogenic pressures including habitat

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degradation, retaliatory poisoning, and the highly destructive illegal trade of vulture body parts for magico-traditional medicine and belief-based practices (Thiollay, 2006 ; Ogada et al., 2016 ; Botha et al., 2017 ; Buij et al., 2024). Vulture species occurring in West and Central Africa are listed in the Bonn Convention on Migratory Species (CMS) and in Appendix II of the Convention on International Trade in Endangered Species (CITES). These species include White-backed Vulture (*Gyps africanus* Salvadori, 1865), Rüppell's Vulture (*Gyps rueppelli* Brehm, 1852), White-headed Vulture (*Trigonoceps occipitalis* Burchell, 1824) and Hooded vulture (*Necrosyrtes monachus*) which are Critically Endangered (CR) and Lappet-faced vulture (*Torgos tracheoliotus* Forster, 1791) endangered (EN). In Central Africa, Palmnut vulture (*Gypohierax angolensis*), a Least concern species, and endangered Egyptian vulture (*Neophron percnopterus*), a migrant species (Borrow and Demey, 2014), also occurred.

Scanty information exist on scavengers in Cameroon (Scholte, 1998 ; Thiollay, 2001 ; Buij et al., 2014). Data suggest that human activities constitutes the primary catalysts of vulture mortality (Buij et al., 2016). As ecological surveys on vultures are often restricted by seasonal accessibility, logistical constraints and safety concerns, local ecological knowledge (LEK) seems to be suited to face unquantified decline. Protected areas play a vital role in West African vulture conservation by acting as crucial refuges for these threatened species (Rondeau & Thiollay, 2004 ; Wachter et al., 2013 ; Salewski, 2017). Even though they are the last strongholds for most species, declines have also been reported in many of them (Wachter et al., 2013 ; Onoja et al., 2014 ; Salewski, 2017). Furthermore, in rapidly developing landscapes where wild megafauna has declined, municipal abattoirs and open-air slaughterhouses have become the primary foraging sites for human-adapted avian scavengers, such as the Hooded vulture (*Necrosyrtes monachus*) (Henriques

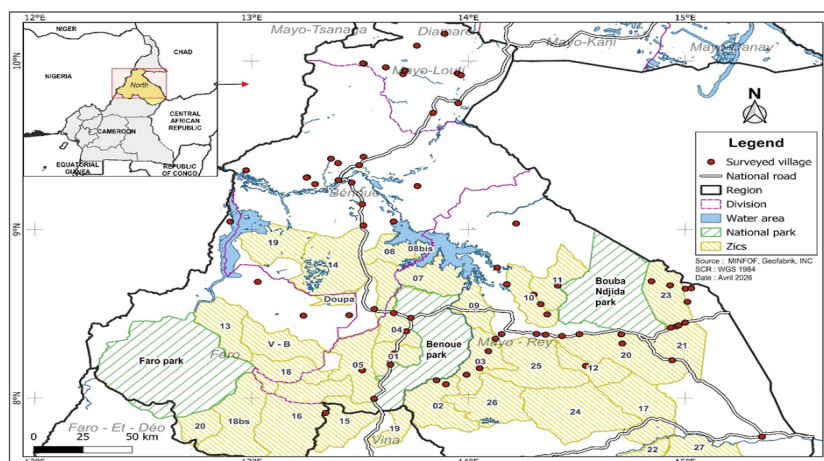
et al., 2018 ; Djekadjim et al., 2026). However, with respect to Cameroon, very little is known about the extent and status of vultures, especially around slaughter areas and remote protected areas, and their roles in conservation initiatives.

Integrating community perceptions and local ecological understanding into conservation strategies is paramount for the long-term survival of threatened species (Weladji et al., 2003 ; Baldus et al., 2003 ; Epana et al., 2019). This study initiated an ethnornithology survey to discern sighting patterns of vultures and their population trend in urban area, and the vicinities of Benoue and Bouba Ndjida National Parks in North Cameroon.

## 2. Methods

### 2.1 Study Area

The study was conducted across the Mayo Rey, Bénoué, Mayo Louti, and Faro administrative Divisions within the North Region (8.3468° N, 13.8744° E) of Cameroon (Figure 1). This region is part of the North Cameroon Conservation Complex, an expansive, contiguous network of protected areas covering approximately 730,000 hectares that includes Faro, Bénoué, and Bouba-Ndjida National Parks. The area is integral to the Biodiversity Conservation and Management Project in Cameroon and features 34 surrounding zones of hunting Interest (ZIC). The landscape is characterized by a mosaic of Sudano-Sahelian savanna woodlands, gallery forests, and seasonal floodplains, with an extensive hydrographic network primarily drained by the Bénoué River, the only permanent watercourse (Gomsé and Mahop 2000). The region supports exceptional biodiversity, hosting the last remaining populations of the Critically Endangered Kordofan Giraffe (*Giraffa camelopardalis antiquorum*) and the African Savanna Elephant (*Loxodonta africana*).



**Figure 1.** Map of the North Region of Cameroon with the surveyed villages.

It also sustains significant populations of Derby Eland (*Taurotragus derbianus*), Lion (*Panthera leo*), Leopard (*Panthera pardus*), and one of the largest concentrations of Hippopotamus (*Hippopotamus amphibius*) in Central Africa (Shaw et al. 2024; AWF 2025). Recognized as an Important Bird Area (IBA), the region is a critical stronghold for Critically Endangered vulture species. The climate is tropical, characterized by a distinct wet season from May to October and a dry season from November to April. Annual rainfall ranges from 900 to 1500 mm, with ambient temperatures typically fluctuating between 21 °C and 36 °C, though extreme heat events reaching 45 °C have been recorded in recent years.

## 2.2 Data Collection

### 2.2.1 Ethno-ornithology Surveys

Data were collected between January and April, during the dry season (2021, 2023, and 2024). We conducted exchanges using a semi-structured questionnaire. The villages were selected on the basis of security, proximity to the parks, and were chosen to encircle the Parks as far as possible. Approval to conduct the research came from the University of Dschang, in agreement with the Governor of the North Region. For each subdivision visited, we notified the local administration and the chiefs of different villages. Due to security challenges linked to terrorism in neighbouring countries, some villages were not visited during the survey. Villages were visited once. Around the protected areas, we prioritized discussions with focus groups based on the type of activity represented in the village. Around the slaughterhouses, we prioritized one-on-one exchanges with butcher leaders, veterinarians, and local residents living near slaughter areas. This method was chosen because it was suitable to the urban context where people are less wary of questions, but also less available to be grouped into discussion groups. Same pre-designed, open-ended questions were administered to each focus group near the protected area, as those submitted to individuals around the slaughter areas. We designed the questions to provide insights into the socio-demographic profiles of the respondents and vulture species and sighting frequency, time elapsed since last sighting and patterns in the abundance of vultures. Responses were gotten from participants on voluntary basis. Discussions were mostly in the local language, Ffulde, with the help of a local interpreter who translated responses to French. Questionnaires were anonymized to maintain confidentiality.

#### *Focus Groups Discussions (FGDs) \_near Benoue and Bouba Ndjida National Parks*

At least one focus group discussion was held in each

village near a National Park, and each discussion lasted less than an hour. Members of the group were mainly the men. Men in northern Cameroon spend more time than women outdoors, and engage in various activities. Group size varied from 5 to 12 individuals identified by chief or senior members of each village following a snowball sampling method (Morgan 1997 ; Noy 2008 ; Krueger and Casey, 2014). Informants represented different socioeconomic backgrounds (agriculturists, hunters, and pastoralists). Local translators were trained in facilitation to ensure that all participants could freely express their views (Patton, 1990). The strong support of community leaders for this research led to 100% participation in focus group discussions (Megaze et al., 2017).

During FGD the personal information (age, length of residence etc.) recorded for the socio-demographic profile represented that of the oldest member of the group, as we estimated that the older individuals are more likely to have greater knowledge about vultures and the responses obtained from a group would indeed be more applicable to the oldest member of that group. Questionnaires through FGDs gathered the maximum information and knowledge from locals about vultures (Smithson, 2000 ; Parker & Titter, 2006), because being in groups, they feel more confident to open up and provide accurate information (Tausch & Menold, 2016). Given the current high sensitivity surrounding vultures, we found it wise and effective to proceed with this method to reduce bias in responses and results (Mutanga et al., 2017). The FGDs participants represented the category of respondents near the National Parks. We conducted FGDs in the peripheral zones of Bouba Ndjida National Park (BNNP) and Benoue National Park (BNP), as the area is mainly rural and serves as resting and feeding sites for vultures, depending on the availability of carcasses. We conducted our research across 15 Hunting Zones of Interest (ZIC), representing 37 villages.

#### *Surveys at Butcheries*

We mainly targeted men because in the northern regions of Cameroon, slaughter areas (vultures feeding sites) are prohibited to women according to religion, even if a few women were included in the study as heads of Zootechnical centers in some subdivisions. We contacted workers through the heads of the Zoo technical centers (local representatives of the Ministry of Livestock, Fisheries, and Animal Industries\_ MINEPIA) at each site. So, we interviewed the main staff members of the MINEPIA who worked at the selected slaughter areas, the butchers' assistants and the head butchers. Thus, we interviewed workers in

13 cities grouping in 03 divisions, Benoue, Mayo Louti and Faro.

### 2.3 Data Analysis

Chi-squared tests of equality and independence assessed differences in response proportions and evaluated associations between local vulture knowledge—including a binary dummy variable for Time Elapsed Since Last Sighting (TELS;  $\leq 1$  year vs.  $> 1$  year)—and socio-demographic factors. To explore vulture species distribution variations across divisions of residence, data were standardized using a  $\log(1+X)$  transformation before executing a Principal Component Analysis (PCA) ordination (Legendre & Legendre, 2012). A negative binomial regression was implemented to predict the reported number of recently sighted vultures, outperforming a Poisson model due to significant residual overdispersion ( $\theta=22$ ,  $p<0.001$ ). Six initial socio-demographic predictors were tested. Multicollinearity was controlled by calculating the Variance Inflation Factor (VIF), leading to the exclusion of highly collinear administrative variables ( $VIF>30$ ). Final variable selection followed a backward stepwise elimination approach optimized by the Akaike Information Criterion (AIC) to balance fit and parsimony (Burnham & Anderson, 2002), ultimately retaining two significant interaction terms. Data wrangling, visualization, and statistical modeling

were executed in R version 4.1.0 (R Core Team, 2021) utilizing the specialized packages *xlsx*, *dplyr*, *tidyr*, *gtsummary*, *glmmTMB*, *performance*, *sjPlot*, *ggplot2*, *ggstatsplot*, *rstatix*, *factoextra*, and *patchwork*.

## 3. Results

### 3.1 Socio-demographic Characteristics of Respondents

A total of 118 respondents (37 from focus groups near protected areas and 81 from interviews at abattoirs) from 67 villages were interviewed, comprising 55.9% natives ( $N = 66$ ) and 44.1% non-natives ( $N = 52$ ). Most participants were from Mayo-Rey Division (42.9%), followed by Benoué (34.8%) and Mayo-Louti (22.3%). Veterinary workers represented the largest occupational group (41.5%), followed by farmers (24.6%) and butchers (22.9%), while other professions accounted for 11% respondents, who consisted of hunters, pastoralists, traders, and gold workers. Regarding education, 41.5% had completed secondary school, 16.1% had completed primary school, 11.9% had completed university, and 30.6% had no formal education. The majority interviewed were male (96.6%). Residence duration was as follows: 1–20 years (50.0%), 21–50 years (24.6%), and 51–75 years (25.4%). Respondents' ages ranged from 28 to 80 years, with a mean of  $51.6 \pm 12$  years (Table 1).

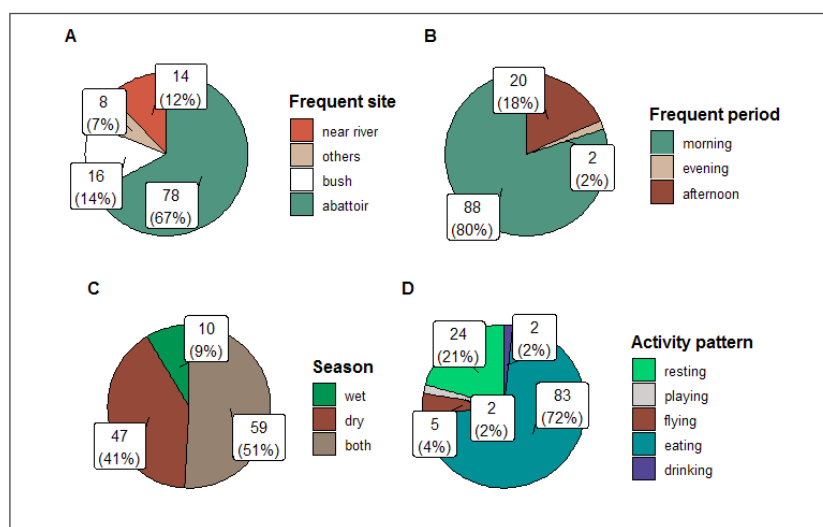
**Table 1.** Sociodemographic features of respondents.

Characteristics	Levels	N=118
Division	Mayo rey	48 (42.9%)
	Benoue	39 (34.8%)
	Mayo louti	25 (22.3%)
Ethnicity	Natives	66 (55.9%)
	Non-natives	52 (44.1%)
Main occupation	Veterinary	49 (41.5%)
	Agriculture	29 (24.6%)
	Butchery	27 (22.9%)
	Others	13 (11.0%)
Level of education	Secondary	49 (41.5%)
	No formal education	36 (30.5%)
	Primary	19 (16.1%)
	University	14 (11.9%)
Gender	Male	114 (96.6%)
	Female	4 (3.4%)
Length of residence	1 to 20 years	59 (50.0%)
	21 to 50 years	29 (24.6%)
	51_75	30 (25.4%)
Age	50 (51.6,12) 28.0/80	
<i>n (%)</i> ; Median (Mean, SD) Minimum/Maximum		

### 3.2 Vulture Species and Sighting Frequency

During the survey, all respondents had seen at least a vulture in their life. Frequent sighting was significantly higher ( $X^2 = 13.79, df = 1, P < 0.001$ , also see Figure 2A) in abattoirs (67.2%) than elsewhere (32.8%). The proportion of respondents who reported sighting them in the morning (80%) was significantly higher ( $X^2 = 39.6, df = 1, P < 0.001$ , also see Figure 2B) than for those who said they sighted at the other time of the day (20%, afternoon/evening). Both

season sighting was reported by half of the respondents (50.9%,  $N=59$ ), but significantly ( $X^2 = 24.0, df = 1, P < 0.001$ , also see Figure 2C) more in the dry (40.5%,  $N=47$ ) than in the wet season (8.6%,  $N=10$ ). According to the respondents, most sighting in the dry season was due to more food availability (15 respondents) and clearer visibility in the vegetation (10 respondents). The vultures were sighted mostly eating (71.6%,  $N=83$ ) or resting (20.7%,  $N=24$ ), and in few cases they were flying (4.3%,  $N=5$ ), drinking (1.7%,  $N=2$ ) or playing (1.7%,  $N=2$ ) (Figure 2D).



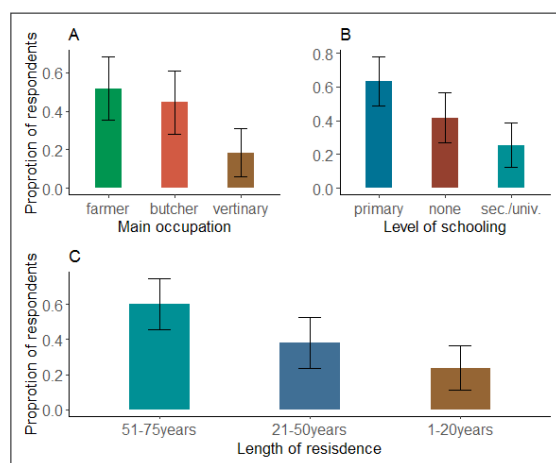
**Figure 2.** Respondent's opinion on the site and period of frequent sightings of vultures, sighting season and frequent activity pattern of vultures.

A total of seven species were reported seen by the local community: Hooded-vulture (HV, 57.5% of responses), white-backed vultures (WBV, 33.3% of responses), Lappet face vulture (LFV, 3.9% of responses), white-headed vultures (WHV, 2.6% of responses), Palmnut vulture (PV, 1.3% of responses), Egyptian vulture (EV, 1.3% of responses) and Ruppell's vulture (RV, 1.3% of responses). Knowledge of species richness varies as follows: most respondents reported having sighted only one (49.2%) or two (35.6%) species (richness) of vultures, while a few said to have sighted three (5.1%) or four species (1%).

### 3.3 Time Elapsed Since Last Sighting

Of the seven species of vultures reported to have been seen by the respondents, three of which were recently seen, that is, less than a year: HV (22.2% of responses,  $N=26$ ), WBV (13.7% of responses,  $N=13$ ), and EV, though by only one respondent. While the time elapsed since last sighting (TELS) of vultures was collapsed into recent ( $\leq 1$  yr ago) and late or long ago ( $> 1$  yr ago), there was significantly ( $X^2 = 8.68, df = 1, P = 0.003$ ) ( $X^2 = 8.68, df = 1, P = 0.003$ ) less people with the former (36.4%,  $N=43$ ) TELS than the latter (63.3%,

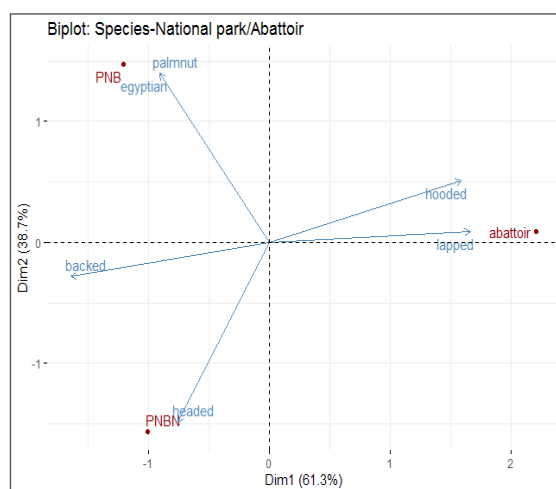
$N=75$ ). We found that the proportion of recent sightings (as opposed to late sightings) respondents was also significantly associated with three sociodemographic factors as shown in Figure 3: the main occupation ( $X^2 = 12.63, df = 3, P = 0.005$ ), length of residence ( $X^2 = 11.33, df = 2, P = 0.003$ ) and the level of education ( $X^2 = 9.60, df = 2, P = 0.008$ ) of the respondent. Pairwise proportion test revealed that the significance: for the main occupation was due to the combination "farmer vs veterinary worker", with farmers (51.7%) more likely ( $P_{adj} = 0.005$ ) to report shorter or recent TELS of vultures compared to veterinary workers (18.4%); for the length of residence was due to the combination "1-20 year vs 51-75 year of residence", with people with shorter duration (1-20 years, 23.7%) in the area less likely ( $P_{adj} = 0.005$ ) to report recent TELS of vultures than those who have lived for long (51-75 years, 60%); for the level of schooling was due to the combination "primary vs secondary/university level", with primary level of schooling respondents (63.2%) more likely ( $P_{adj} = 0.006$ ) ( $P_{adj} = 0.006$ ) to report recent TELS of vultures than those with secondary/university-level schooling (25.4%).



**Figure 3.** Relationship between the proportion of reported less than a year (recent) sighting (as opposed to older or >1year sighting) of vultures in the area in association to the main occupation (A), the level of education (B) and the length of residence (C) of the respondent in the area. Other occupation categories were excluded for small sample even after collapsing them, while the secondary and university level class were collapsed into sec./univ. (secondary/university) for statistics purpose.

Ordination analysis demonstrated some variations in the recent reported species across different respondent's localities (Figure 4). Counts of the Hooded vulture (HV) and the Lappet face vulture (FV) were highest in abattoirs. Most Palmnut and Egyptian vultures were

reported near the Benoue National Park (PNB), while headed vultures were most associated to the Bouba Ndjida National Park (PNBN) surrounding. The Zhite backed vulture was most common to both the PNB and the PNBN surroundings.



**Figure 4.** PCA-Biplot of the species sighted by the respondent in relation to their residential locality (PNB=Benoue National Park, PNBN= Bouba Ndjida National Park, and abattoir). The Ruppel vulture is explicitly absent since it was not reported in the last sightings.

**2.3. Patterns in the abundance of vultures**

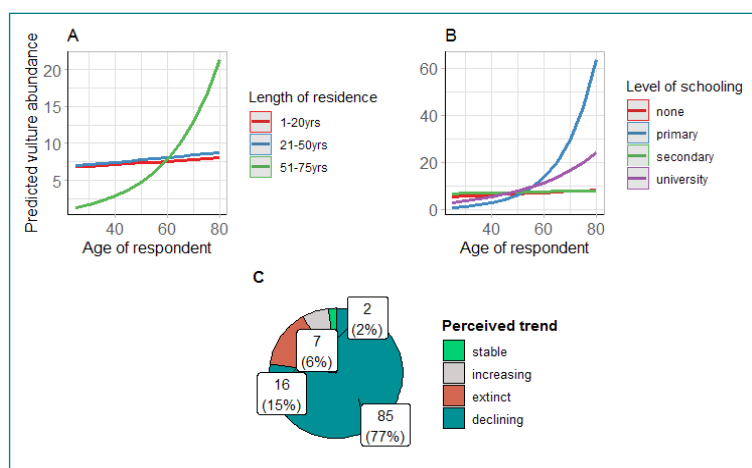
Both interaction terms between respondent age and two socio-demographic factors were statistically significant in predicting vulture abundance. The effect of increasing age of the respondent on the average number of vultures reported was higher ( $\beta_1 = 0.05$ , 95% CI: 0.00-0.10,  $Z = 2.12$ ,  $p = 0.034$ , Figure 5A, Table 2) among long-term residents (51–75 yrs) than among short-term residents (the reference group, 1–20 yrs). The positive interaction suggests that for respondents with 51–75 years of residence, each one-year increase in age was associated with about a 5% higher expected vulture count compared with similarly aged respondents with 1–20 years of residence.

Similarly, age had a greater positive effect ( $\beta_1 = 0.05$ ,

95% CI: 0.01-0.09,  $Z = 2.68$ ,  $p = 0.007$  Figure 5B, Table 2) on reported vulture counts for respondents with primary education level than for those with no level of education (the reference level). Hence these interactions imply that older respondents who are long-term residents or who have primary education reported relatively higher vulture abundance. Respondents were also asked to tell how they perceived the trend in vulture numbers during the past years (Figure 5C). Most of them significantly ( $X^2 = 37.09$ ,  $df = 1$ ,  $P < 0.001$ ) saw this trend as decreasing (77% of respondents,  $N=85$ ), while a few reported it was increasing (6.4% of respondents,  $N=7$ ) or was constant (1.8% of respondents,  $N=2$ ). Sixteen respondents (14.5%) perceived that vultures were extinct in the area.

**Table 2.** Parameter estimates of the negative binomial regression model to explain the variation of vulture abundance in association to the age, the length of residence and level of schooling of the respondent.

Predictors	Estimates	95% CI	Z-value	p-value
(Intercept)	1.99	0.32 – 3.65	2.34	0.019
Age of respondent	-0.00	-0.03 – 0.03	-0.23	0.821
Length of residence [21-50yrs]	-0.34	-2.54 – 1.87	-0.30	0.766
<b>Length of residence [51-75yrs]</b>	<b>-3.12</b>	<b>-5.92 – -0.32</b>	<b>-2.18</b>	<b>0.029</b>
Level of education [primary]	-2.23	-4.50 – 0.03	-1.93	0.054
Level of education [secondary]	0.06	-1.82 – 1.95	0.07	0.948
Level of education [university]	-1.90	-5.33 – 1.53	-1.09	0.277
Age : Length of residence [21-50yrs]	0.01	-0.04 – 0.05	0.38	0.702
<b>Age : Length of residence [51-75yrs]</b>	<b>0.05</b>	<b>0.00 – 0.10</b>	<b>2.12</b>	<b>0.034</b>
<b>Age : Level of education [primary]</b>	<b>0.05</b>	<b>0.01 – 0.09</b>	<b>2.68</b>	<b>0.007</b>
Age : Level of education [secondary]	0.00	-0.03 – 0.04	0.09	0.929
Age : Level of education [university]	0.04	-0.03 – 0.11	1.13	0.257
<i>N</i> =102; <i>marginal R</i> <sup>2</sup> =0.45				

**Figure 5.** Predicted average size of vultures sighted recently by the respondents in association with the combined effect of the age of the respondent and his/her length of residence in the area (A) or his/her level of schooling (B). Respondent's opinion on the population trend of vultures (C).

## 4. Discussion

### 4.1 Community Composition and Distribution of Vulture

#### 4.1.1 Vulture Species Richness from Local Ecological Knowledge

Ethnobiological data reveal a vulture community heavily dominated by the Hooded Vulture (*Necrosyrtes monachus*, 57.5%) and the African White-backed Vulture (*Gyps africanus*, 33.3%). Together, these species account for over 90% of all reports. Conversely, apex wilderness scavengers like the Lappet-faced (*Torgos tracheliotos*, 3.9%), White-headed (*Trigonoceps occipitalis*, 2.6%), Rüppell's (*Gyps rueppellii*, 1.3%), and migratory Egyptian Vulture (*Neophron percnopterus*, 1.3%) are rarely encountered. This structure and restricted Local Ecological Knowledge (LEK) with 84.7% of respondents recognizing only one or two species

mirrors the uneven impacts of the African Vulture Crisis across Central African savannas.

The Hooded vulture's dominance is driven by its extreme commensalism, foraging in urban dumps, markets, and municipal slaughterhouses across northern Cameroon's Sudanian-Sahelian belt, where human settlements provide predictable organic waste (Ogada & Buij, 2011; Henriques et al., 2018; Daboné et al., 2022). In contrast, the tree-nesting White-backed vulture is highly sensitive to human disturbance, preferring open scrublands within protected boundaries like the Bénoué and Boubandjida National Parks (Kendall et al., 2023). Its lower reporting frequency highlights how wild-dependent vultures are increasingly pushed into isolated ecological strongholds by agricultural expansion. The exceptionally low sightings of Lappet-faced, White-headed, and Rüppell's vultures align with documented regional population collapses across West Africa

(Ogada et al., 2012, 2016; Rushworth et al., 2018), signaling severe localized range contractions.

#### **4.1.2 Local Ecological Knowledge on Vulture Distribution**

Vulture sightings were significantly higher at abattoirs (67.2%) than in other landscapes (32.8%), driven by predictable slaughterhouse waste availability amidst wild carrion scarcity (Ogada & Buij, 2011 ; Gangoso et al., 2013). While abattoirs are primary feeding sites outside protected areas, they could act as dangerous ecological traps in environment of high human pressure, exposing commensal Hooded Vultures to intentional or accidental poisoning (Ogada & Buij, 2011 ; Gangoso et al., 2013). Conversely, wilderness-dependent White-backed and Rüppell's vultures restrict themselves to National Parks, completely avoiding human infrastructure (Scholte, 1998). Their scarcity far from abattoirs suggests a severe range contraction, leaving human-dominated landscapes almost entirely occupied by highly localized, commensal populations.

### **4.2 Ecological Dynamics of Vulture Sightings**

#### **4.2.1 Seasonal pattern of vulture sightings Seasonal Dynamics of Vulture Detection : Integrating Local Ecological Knowledge with Environmental Drivers**

Data revealed a distinct seasonal pattern : 50.9% of respondents observed vultures year-round, while 40.5% reported sightings strictly during the dry season, compared to just 8.6% in the wet season. Locals attribute this dry-season peak to greater food availability and increased visibility of structural (vegetation) features This dry-season spike aligns with ecological data showing that environmental stress leads to natural peaks in ungulate mortality (Ogada et al., 2015 ; Kibuule, 2016), while bushfires and land clearing uncover hidden carcasses (Thiollay, 2006a). Conversely, dense wet-season grass and closed woody canopies create a homogeneous matrix that blocks lines-of-sight, significantly delaying carcass detection by obligate visual scavengers (Bornah et al., 2024; Malan et al., 2024; Blanche, 2026).

#### **4.2.2 Scavenger Time-Budgets and Anthropogenic Food Subsidies: The Role of Abattoirs in Vulture Aggregation**

Vultures spend most of their time feeding (71.6%) and resting (20.7%), allocating minimal time to flight (4.3%), drinking (1.7%), or social behavior (1.7%). The high percentage of feeding observations is directly tied to local abattoirs offering continuous organic waste, where vultures aggregate to exploit food subsidies as wild ungulates decline outside protected zones (Ogada

& Buij, 2011; Henriques et al., 2018; Daboné et al., 2024). This reflects a high observation probability at slaughter areas rather than a true baseline time-budget. Conversely, resting birds are rarely observed because they gather in low-pressure, unexposed areas to avoid human disturbance and conserve energy (Henriques et al., 2018). Ultimately, these trends demonstrate clear niche partitioning. Conservation cannot rely on a single strategy; Parks boundaries must protect wilderness-dependent species, while strict hygiene protocols at abattoirs are required to safely support commensal populations without poisoning risks (Santangeli et al., 2024).

### **4.3 Population Trends and Factors Influencing the Time Elapsed Since the Last Vulture Sighting**

#### **4.3.1 Perception of Vulture Trend by Locals**

An alarming 91.5% of respondents recognize a severe ecological collapse, with 77% perceiving a decrease and 14.5% believing they are completely extinct locally. This provides powerful, ground-truthed validation of the broader «African Vulture Crisis,» where avian scavengers have faced population crashes exceeding 80–90% due to sentinel poisoning, the traditional medicine trade, and habitat degradation (Ogada et al., 2016). Believing vultures are locally extinct indicates populations have fallen well below the «ecological detection threshold,» suggesting severe localized extirpation (Turvey et al., 2010). Conversely, the minor fraction perceiving an increase (6.4%) or constant trend (1.8%) is likely skewed by the artificial crowding of remaining populations around open abattoirs or newly established dumpsites, creating a temporary illusion of abundance (Phiri et al., 2022).

#### **4.3.2 Time Elapsed Since Last Sighting (TELS) and Factors Influencing**

Using TELS as a temporal proxy indicated a profound disparity between historical memory and recent encounters: 63.3% of respondents reported last seeing a vulture over a year ago (some stretching back to 1985–1990), while only 36.4% reported recent sightings. This provides robust evidence of local population collapses and rapid defaunation, stripping pastoral lands of crucial carcass disposal ecosystem services. Recent sightings (36.4%) likely represent ephemeral encounters with transient individuals or localized attraction to slaughterhouses and protected areas.

#### **Socio-Demographic Stratification of Local Ecological Knowledge (LEK)**

Our statistical analysis demonstrates that LEK varies significantly across groups, heavily influenced by

occupation, length of residence, and education (Gavin et al., 2015 ; Berkström et al., 2019). This stratification occurs because daily landscape proximity and generational baselines dictate an individual's capacity to recall wildlife declines (Newing, 2010). Farmers (51.7%) reported significantly shorter Times Since Last Sighting (TELS) than veterinary workers (18.4%), as farmers spend extended working hours in open, rural habitats where vultures forage, increasing visual encounters (Morales-Reyes et al., 2017 ; García-Alfonso et al., 2019). Meanwhile, clinic-bound veterinary workers are limited to narrow sites.

Additionally, long-term residents (51–75 years) reported significantly more recent sightings (60%) than newer residents of 1–20 years (23.7%), providing a deeply anchored, reliable temporal framework for data (Timilsina, 2025). Counterintuitively, primary-educated respondents (63.2%) noted vastly more recent sightings than formally highly educated cohorts (25.4%). Primary-educated individuals remain tightly integrated into land-based livelihoods, developing robust, practical LEK through daily environmental monitoring, whereas highly educated groups are often disconnected from landscape realities (Gavin et al., 2015). Consequently, LEK is highly stratified by human-landscape interactions (Timilsina, 2025), meaning conservation planning must actively partner with long-term, primary-educated farmers as the true "eyes on the ground."

#### *Generational LEK and Shifting Baseline Syndrome*

A compounding interaction exists between age and generational residency. For long-term resident (51–75 years of residence), each one-year increase in age is associated with an ~5% higher expected vulture count compared to similarly aged, short-term peers (1–20 years of residence). Older, lifelong residents possess an ecological memory of pristine historical baselines prior to the accelerated African vulture crisis (Ogada et al., 2016). This interaction provides clear empirical evidence of Shifting Baseline Syndrome (SBS), where initial encounters in youth or upon arrival establish an individual's cognitive standard for what is «normal» (Soga & Gaston, 2018). Short-term newcomers establish baselines after severe declines have already occurred, thereby lacking the reference points to conceptualize past abundances regardless of age. Conversely, older, long-term residents serve as historical archives for past communal roosts, nesting sites, and migrations (Berkes et al., 2000; Fernández-Llamazares et al., 2015). To avoid underestimating past abundance and setting deflated recovery targets, conservation biologists must explicitly seek out

these older, lifelong residents (Papworth et al., 2009; Turvey et al., 2010; Soga & Gaston, 2018).

#### *Age-Education Dynamics and Community Perceptions of Vulture*

Advancing age exerts a stronger positive effect on reported vulture counts for primary-educated respondents than for those with no schooling. While higher education distances individuals from nature, primary education provides basic literacy and numerical skills that enhance a respondent's cognitive capacity to systematically structure, recall, and quantify observations over time (Gavin et al., 2015). Coupled with lifelong environmental exposure, primary-educated elders become highly precise ecological chroniclers. With nearly 92% of the community already recognizing the vulture crisis, conservation campaigns do not need to prove declines exist. Instead, managers should leverage the highly structured historical memory of older, primary-educated cohorts to map exactly when and where populations collapsed, enabling targeted habitat restoration and species reintroduction (Soga & Gaston, 2018).

## **5. Conclusion**

Local Ecological Knowledge collected around abattoirs and protected-area peripheries in northern Cameroon reveals a stark picture: vultures are perceived to have declined substantially, with sightings increasingly concentrated at anthropogenic food sources and wild-dependent species largely confined to protected refugia. LEK provides actionable, cost-effective intelligence to prioritize monitoring, rapid response, and community-centered interventions, especially in contexts where formal ecological surveys are constrained by logistics or security. To halt and reverse local declines, conservation strategies must combine targeted field validation, poisoning mitigation, abattoir management, and community partnership, leveraging the ecological memory of long-term residents as both a data source and a conservation asset. Immediate implementation of the recommendations above will maximize the likelihood of stabilizing remaining populations and restoring functional scavenger communities in northern Cameroon.

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### Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Author Contributions

Study design : IBK, TAI, SAT ; Field work implementation: IBK ; Data Analysis : JPKD ; Writing : IBK, SAT, TAI ; MDC, JPKD and SNN

### Ethics Declarations

#### Ethics Approval and Consent to Participate

In addition, in accordance with the British Sociological Association's Statement of Ethical Practice (2017), informed consent was obtained verbally by each survey participant prior to the interview, participants were informed of their right to participate voluntarily or to refuse.

#### Consent for Publication

All participants in this study gave oral consent, and all data are anonymized.

#### Competing Interests

The authors declare that they have no competing interests.

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**Supplementary Material.** Table of villages surveyed in the North region.

Division	Subdivision	villages
Mayo rey	Tcholliré	Doudja; Bandjoukri; Youkout; Mbaou; Taboun; Dougon; Mbissiri; Gouga; Koum; Ouro kessoum; Tham; Gaba; Guidjiba; Mayo salah; Djaba; Leunda; Gamba; Karba ; Tchollire. centre; Saktje and Banda
	Rey Bouba	Landou; Guatouguel; Rey Bouba Centre; Béré and Dami
	Madingring	Mayo-Djarendi; Kouloumbou; Mandi-ouro; Mandi-mayo; Gor; Bongo; Telbe1; Gambou and Madingring.abattoir
	Touboro	Touboro.Centre
Benoue	Garoua 1	Garoua_HRG ,Garoua.abattoir; Garoua1.delegation
	Garoua 2	Garoua2.abattoir, sabongari.lainde
	Garoua 3	Djalingo and Sanguere.paul
	Tcheboa	Ngong.market
	Pitoea	Pitoea abattoir
	Demsa	Gashiga
	Bibemi	Adoumri
	Mayo hourna	Nakong kodogou, Nakong and Barndake
Mayo louti	Lagdo	Lagdo.centre ; Lagdo.abattoir and Gouna.abattoir
	Guider	BebereII; Guider.abattoir; Gada.korgou; Mbailla; Douroum and Mousgoy
Faro	Figuil Mayo Oulo	Karewa and Figuil.market Mayo Oulo.centre ; Dourbeye and Bossoum
	Poli	Poli.abattoir; Waté and Pintchoumba
	Beka	Beka centre