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ABUNDANCE, DISTRIBUTION, AND THREATS AFFECTING HOODED VULTURES IN NORTH-CENTRAL NIGERIA

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ABSTRACT

Vulture populations have declined significantly across the world. Their population decline is largely associated with anthropogenic activities worldwide. The old-world vultures in Africa face threats ranging from poisoning, illegal hunting and trades in their body parts. Nigeria had seven species of vultures, but most of them have been hunted and extirpated across the country's ecological zones owing to belief systems and trades in their body parts. We carried out our study of the abundance, distribution, and threats affecting vultures across the state of Plateau in north-central Nigeria. We conducted field surveys of vultures using a stratified-random sampling approach involving 68 count locations distributed across 34 districts of the state, where threats (measured by utilization of vultures) as well as opportunities (poultry and slaughter-house operations) were recorded. We sighted more vultures in the higher Plateau, which has higher human population density and lower threat levels, than in areas of lower Plateau with lower human population density but higher threat levels. Vulture abundance likely reflects the influence of variation in the degree of threats against vultures, human populations and types of settlement. At lower Plateau, vultures experienced greater competition for food with humans, dogs, and pied crows Corvus albus. For this reason, we advocate increased public education to encourage improved coexistence between vultures and poultry and slaughterhouse operations. We also advocate for the establishment of "vulture restaurants" or artificial feeding points or safe havens specifically to benefit and sustain these invaluable species within the State.

Keywords: *Abundance; Plateau state, Nigeria; vulture trades; threats; traditional medicine*

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INTRODUCTION

Vultures provide important ecological services to the environment (Devault et al, 2016). Seven species occurred historically in Nigeria and in many parts of West Africa: White-headed; *Trigonoceps occipitalis*, Palm-nut; *Gypohierax angolensis*, Hooded; *Necrosyrtes monachus*, African white-backed; *Gyps africanus*, Lappet-faced; *Torgos tracheliotos*, Egyptian; *Neophron percnopterus*, and Ruppell's Griffon *Gyps ruepelli* (Borrow and Demey 2013). Currently, the populations of most of these species are at the verge of collapse in many parts of West Africa and Nigeria where they were formerly wide spread (Nosazeogie *et al.*, 2018; Convention on Migratory Species, 2011). Although many birds generally avoid areas with high threats and low food availability (Brandt and Cresswell 2007), in some parts of Africa, hooded vultures tend to occur in areas

of high human density, probably because of the availability of their food resources; being mainly carcasses in such areas (Mohamed *et al.* 2018) where they are persecuted.

West African vultures are under severe threat as they are been killed and used for traditional medicine whilst their food resources are in decline due to improved hygiene in slaughterhouses and direct and indirect persecution. Other threats include illegal poisoning, electrocution and loss of breeding sites and many other human-induced factors (Maxwell et al, 2019). For instance, logging resulting in loss of trees used for nesting and roosting is a known threat to hooded vultures in Africa (Mullié *et al*. 2017; Williams et al. 2021). The introduction of a closed system of slaughterhouses also threatens vulture populations that historically have relied on free access to search for food in such areas (Odino *et al*, 2014). However, relatively few studies have investigated the underlying causes of the vulture population declines in Africa (Tende and Ottosson 2008; Dunn 2010; Ogada *et al*. 2012, 2015; Ogada and Buij 2013; Berny *et al*. 2015).

Exacerbating their plight is the fact that hooded vultures have extremely low reproductive potential as they lay only one or two eggs in secretive areas with tall trees and dense foliage (Sarà and Vittorio 2003, Chris 2006). Despite careful nest-site selection, they still experience nest predation by species such as the Chacma baboon (*Papio ursinus*) and Martial Eagle (*Polemaetus bellicosus*) (Lindy *et al.* 2017). Poor or weak enforcement of laws protecting vultures is another contributing factor to the killing of vultures in different African communities, and this has led to the decline of vultures (Thomson and Andrew 2020, Williams *et al*. 2021).

In Nigeria, as in most African countries, monitoring of vulture populations is poor and there is no baseline data to enable researchers to identify and understand future trends. Information on population trends is from historic field observations that can be subjective leaving gaps in understanding the population dynamics and possible causes of mortality of vultures (Anderson, 2007). In some parts of Nigeria, particularly Plateau state, information on the status of vulture populations is lacking, as is knowledge of the scale of threats such as trading in vultures, their parts and other raptor parts for belief-base use and for native medicine. Our purpose was to determine the abundance and distribution of hooded vultures across Plateau State and identify threats that may be responsible for their decline in the state. Given the paucity of knowledge on the drivers of vulture population declines, this study provides essential data that could guide conservation ecologists and vulture specialists to develop a more practical mitigation measures towards saving vultures in the West African sub-region.

MATERIALS AND METHODS

Study Area

We conducted our study in the Plateau state in the middle belt of Nigeria (9º10′N 9º45′E), at approximately 1,238 m above mean sea level (amsl). Plateau state comprises 17 Local Government Areas (LGAs) divided into northern, central and southern zones. For the purpose of this study, we divided the state into a high-altitude region (>700 m amsl) and a low-altitude region (<700 m amsl). The high-altitude region encompassed the northern zone and part of the central zone; and featured high human population density in concentrated settlements and less vegetation (City Population, 2016). The low-altitude region encompassed the southern zone and two LGAs in the central zone; and featured low human population density in dispersed settlements and relatively dense vegetation. Mean annual rainfall in Plateau ranges from 131.2–146.0 cm, with average temperatures ranging from 18–22°C (Adzandeh *et al.* 2015).

Data Collection

We surveyed hooded vultures between 29 May and 5 August 2017, covering all LGAs in Plateau state. We selected survey locations by randomly choosing two districts in each LGA and then identifying two suitable observation sites (one poultry site and one abattoir or slaughterhouse) in each of those districts, which resulted in 68 observation points across the state. To help identify suitable sites, we gathered information from local people about where vultures tend to congregate.

We conducted two 30-min surveys at each of the 68 sites, either in the morning (1000–1100 HRS) or afternoon (1300–1600 HRS). During

all surveys, encountered birds were identified with the aid of a pair of binoculars. All vultures seen perched or flying were recorded. The count with the highest number of individual hooded vultures between the two counts was recorded and used in the final analyses.

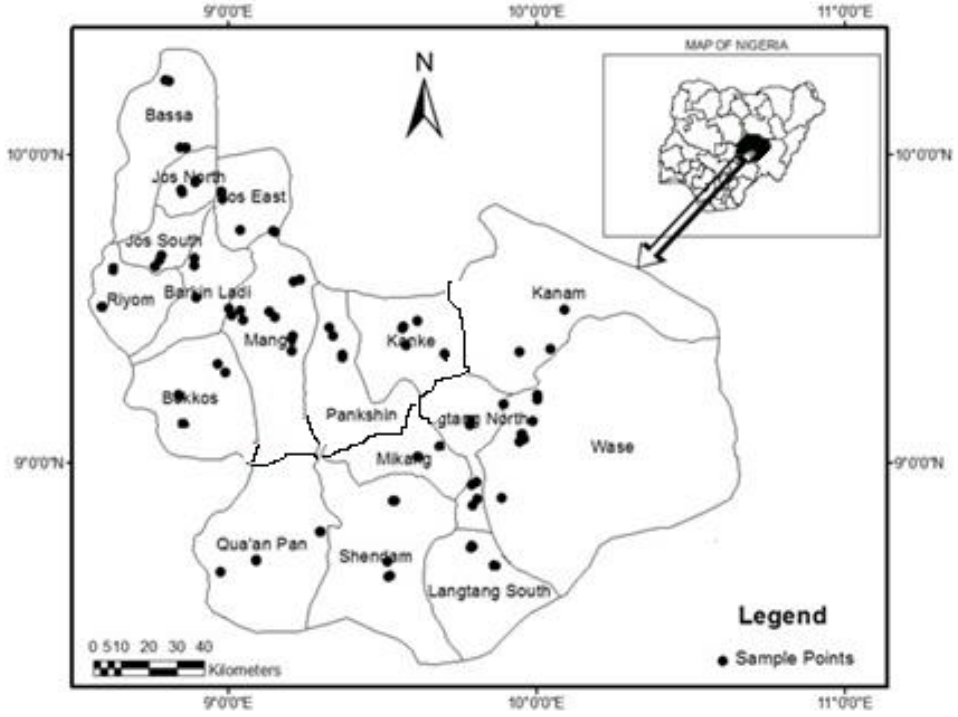

Figure 1: Hooded vulture survey sites with sampling stations distributed across each Local Government Area of Plateau state, Nigeria.

Threat Indices

We investigated the areas where vultures were sighted for observable threats, including evidence of vulture meat and body parts in markets, traps, dealers in vulture parts and vulture markets, and the presence of other animals that might compete with vultures for food. We ascertained threats against vultures using a unified classification of threats and actions (Task *et al.* 2006; Salafsky *et al*. 2009). We assigned an equivalent score of 1 to each distinct observation in a given jurisdiction of vulture parts, a vulture dealer, or a vulture market (Adam 2016). For example, if we found four vulture markets in a Local government Area (LGA) it received a market threat score of 4. Similarly, if we observed three vulture dealers in an LGA, we assigned a dealer threat score of 3. Some LGAs lacked a focal vulture market, but individuals with vulture parts in their possession were evident; the parts threat score reflected the number of vulture parts observed. An LGA's cumulative threat ranking then represented the sum of the parts, dealer, and market ratings.

Data Analysis

We used a Generalized linear model (GLM) with Poison family specification to evaluate how vulture counts varied between high and low altitude regions of the state and at abattoir versus poultry sites. Poisson was used because of the nature of the count data. We produced a map to illustrate variations in the combined-total vulture counts recorded in different LGAs using Q-GIS (version 1.7.4) and used t-test to compare the abundance of hooded in the two different altitudinal (high and low) areas of the Plateau state. General Linear Model (GLM) (Poison) was used to relate and determine the relative variations of the effects of identified threats on hooded vultures within the two study categories (lower and higher Plateau state). Hooded vulture abundance was modeled as a function of three threat indicator explanatory variables namely (presence of vulture markets, number of vulture dealers and sighting of

vulture parts) and with site type and altitude as main predictors in a backward stepwise approach. The interaction terms "site type * human population" was added and the best model selected using Akaike Information Criterion (AIC). All statistical l analyses were conducted using the R statistical package (R Core Team 2019).

RESULTS

Abundance of Vultures

We recorded 276 hooded vultures during the entire study period comprising 238 adults and 39 juveniles, which occurred in groups ranging from 2–52 individuals (Figure. 2). Based on the highest number of individuals counted at each site during two visits, we recorded approximately 276 individual vultures in Plateau state during the surveys. Most of the vulture sightings were at abattoir or slaughterhouses and dumping sites for poultry wastes, with eighty six percent (86%) of the sightings were in the high or upper Plateau survey region, which has higher population density than the lower Platea state, which also has more vulture traders and vulture parts' selling points than the upper Plateau.

We found that number of hooded vulture counts varied significantly vary with human population density (t=2.5, p <0.018) (Fig. 3). Similarly, we counted significantly more hooded vultures in both abattoir and poultry sites where human population was estimated to be high and vice versa with significantly higher numbers at poultry sites than abattoirs (Fig. 3). Threat scores were higher at the Lower Plateau area than at the Upper Plateau study areas (Fig. 4). The presence of vulture dealers, vulture parts and vulture markets were found to negatively influence hooded vulture abundance (p <0.001).

Modeling hooded vulture abundance with threats

We found evident that the identified threats have significantly influenced the abundance of hooded vultures in the study area ($F_{3, 135}$) = 20.93, p < 0.001) (Table 1). Site type: abattoir (t = - 6.86, p <0.001) and altitude: lower Plateau (t= -8.54, p <0.001) had significantly negative influences on number of hooded vultures counts the interaction between sites and human population density (t = 4.83, p < 0.001) (Table 1) played significant roles in the abundance of vultures' significance It was found that

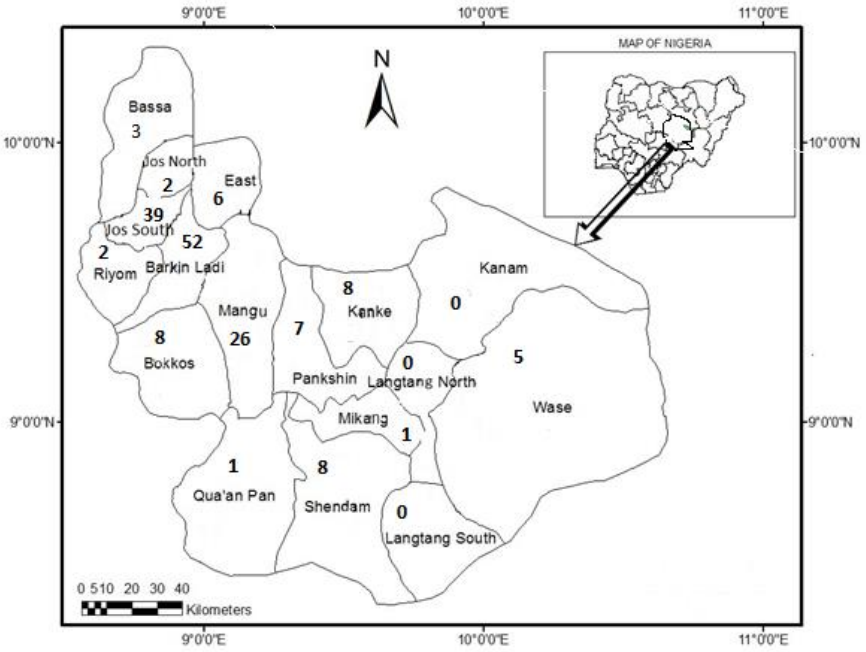

Figure 2: Combined total numbers of vulture sightings recorded during two surveys in May and August 2017 at four study sites in each Local Government Area of Plateau state, Nigeria.

Table 1: Difference in counts of vultures (combined total from two surveys in May and August 2017) at poultry waste and abattoir study sites in lower (<700 amsl) and higher (>700 m amsl) altitude regions of Plateau state, Nigeria.

Coefficient	Estimate	SE	*t*	*P*
Intercept	1.5612	0.07856	19.87	<0.001
Site Type: Abattoir	0.6039	0.13966	-6.86	<0.001
Altitude: Lower	-1.0986	0.31158	-8.54	<0.001
Site Type * Human Population	-0.1823	0.38783	4.83	<0.001

Notes: null deviance = 1013.86; residual deviance = 823.21; Pseudo-R^2 (explained deviance) = 0.19.

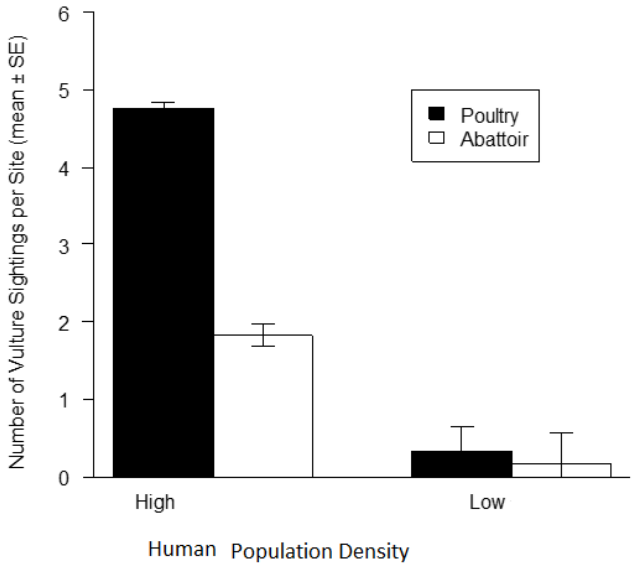

Figure 3: Average vulture counts from two surveys conducted during May and August 2017 at study sites located near poultry farms and abattoirs in two areas with varying human population density in Plateau state, Nigeria.

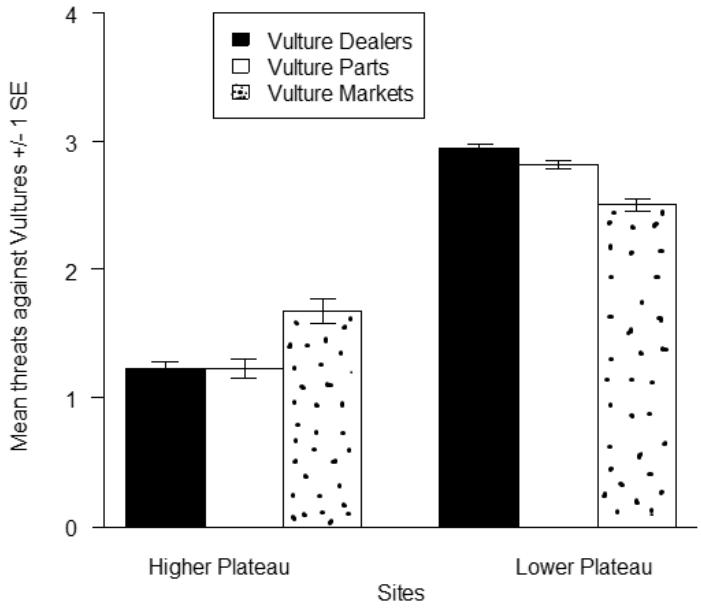

Figure 4: Average vulture threat rankings in three categories recorded in May and August 2017 across 68 study sites in the lower (<700 m asl) higher (>700 m asl) Plateau regions of Plateau state, Nigeria.

DISCUSSION

Vultures, like other birds, are sensitive to threats in the environment and, thus, usually avoid areas with high threats and low food availability (Brandt and Cresswell 2007, Ogada et al. 2012). We found that hooded vultures were more abundant at regions of higher Plateau (>700 m asl) where threats scores were lower with higher human populations than at lower Plateau (< 700 amsl) where threats were higher and with lower human population density. This could reflect regional differences in human population density as the regions of higher Plateau has higher human population density than the lower Plateau. It also has more nucleated settlements than the lower Plateau. Henriques et al. (2018) found that the abundance of hooded vultures and human density were positively correlated in Guinea-Bissau. In our study, Barkin Ladi LGA had the highest number of vulture sightings (52), because a poultry-waste dumpsite near the main town regularly attracted vultures that visited to feed on carcasses. Gbogbo and Awotwe-Pratt (2008) also reported hooded vulture concentrations near dumpsites and landfills, as well as in other areas where human activities provided other food resources. We also recorded relatively high number of vultures (39) in the Jos South LGA (in the towns of Bukuru, Rayfield, and Vom), again primarily at a dumpsite near a poultry farm.

In contrast, lower abundance of hooded vulture abundance on the lower Plateau likely reflected lower human density and attendant lower food availability, but also likely a greater threat from vulture hunters and traditional medicine practitioners. The region has the highest number of people trading in the vulture parts in open markets. The lowland areas of Plateau lie adjacent to the far northern states of Bauchi, Taraba, and Nasarawa. In this region, trades in vulture parts are considered an honorable occupation and vulture hunters often travel far in search of opportunities. Some of the vulture dealers we interviewed came from northern Nigeria and had links to other vulture traders in neighboring countries such as Niger, Benin Republic, Chad, and Cameroun. We found body parts of hooded vultures, palm-nut Vultures, and white-headed vultures on display in some of the markets in this area (Plate 1). More so, our market survey revealed at least six vulture dealers in Quanpan town alone.

We found that hooded vultures were significantly more abundant at poultry-waste dumpsites than in or around abattoirs. Most of the slaughterhouses were closed and roofed during the surveys (e.g., as in the main abattoirs in Jos, Mangu, Dangi, and Shendam), which prevented vultures from accessing and feeding on discarded meat scraps. Odino et al. (2014) also found that the introduction of a network of closed-system slaughterhouses threatened hooded vulture populations in Africa. Another reason why vultures' numbers were low at abattoirs may be because they attract vulture hunters more often than do poultry-waste sites, as we noted during our surveys. In addition, unlike at most poultry-waste sites, both people and dogs deplete the food resources available at abattoirs, as they seek to glean edible meat scraps discarded by the slaughterhouse (Plate 2). We often observed dogs chasing vultures away from abattoirs after human scavengers departed.

Other threats to vultures that we confirmed in Nigeria during our study included logging in Kanke LGA and keeping live vultures in captivity for traditional practices in Langtang–South LGA. Mullié *et al.* (2017) in earlier study noted that logging of tall trees had adverse population consequences for hooded vultures that used these trees for roosting and nesting.

CONCLUSION

In our estimation, traditional medicine, the presence of vulture markets, and an increasing number of vulture dealers likely constitute a major threat and a primary cause of vulture population declines in Plateau, Nigeria. We noted that hooded vultures appear to have shifted to using poultry-waste sites more than abattoirs. Educational and awareness campaigns are urgently needed around Plateau in communities with poultry-waste sites and abattoirs about how humans can better co-exist with vultures and help sustain populations of these sensitive and declining species. Positive outreach efforts and law enforcement are crucially needed to help discourage people from hunting vulture and stop the trade in

vulture parts for traditional food and medicinal practices. It would be prudent to devise alternative ways for that may provide the native people who depended on traditional medicine because of their belief systems whiles advancing efforts to educate them about availability of scientific underlying causes of certain diseases and the efficacy of orthodox treatments.

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Appendix

Plate 1: Vulture dealer with wing of white-headed v(*Trigonoceps Occipitalis*) in Namu, Quanpan LGA of Plateau State, Nigeria.

Plate 2: Dogs and other animals at slaughter slabs and poultry wastes dump sites at compete with vultures for carcasses.

Plate 3: **Hooded vultures (*Necrosyrtes monachus*) sighted during this study the across Plateau State**