Weak compliance with Nigeria's wildlife trade ban imposed to curb mpox spillovers

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Abstract

Zoonotic diseases pose global public health threats, prompting various interventions to limit their emergence and spread. One increasingly common response by governments has been to ban wildlife hunting, trade, and consumption. However, evidence of the effectiveness of wildlife trade bans remains limited. Here, we assess compliance with Nigeria's wildlife trade ban, enacted to curb the spread of mpox (formerly monkeypox), by analysing ~4.5 years of wild meat sales data from 19 vendors in southeastern Nigeria (988 vendor-months) alongside interviews with vendors and law enforcement officials. After matching by time of year, we found no significant differences before and after the ban in the number of vendors selling wild meat per week, the weekly mass of wild meat sold, or the weekly price per kilogram of wild meat, with the total weekly price of sales higher post-ban. These findings, supported by interview insights, indicate widespread non-compliance, questioning the ban's effectiveness. We argue that successful regulations require clear enforcement mechanisms, public engagement, and economic incentives to improve compliance. This study provides valuable insights for designing effective interventions to mitigate zoonotic spillovers.

Keywords

Zoonotic diseases; wild meat exploitation; mpox; monkeypox; wildlife trade ban; interrupted time-series analysis; Cross River National Park.

Background

Zoonotic diseases—infectious diseases that arise at the interface of humans, wildlife, and livestock and can be transmitted between these groups—pose significant global economic and public health risks [1,2]. Zoonotic pathogens account for up to 60% of emerging infectious diseases (EID) worldwide, with over 70% of EID originating from wildlife [2]. Zoonotic diseases are most likely to emerge in tropical forest regions undergoing land-use changes, in densely populated areas, and where mammalian species richness is high [3–5], making many sub-Saharan African countries hotspots for their emergence [3].

Wild animal meat (hereafter wild meat) provides food and livelihoods for many rural communities across sub-Saharan Africa [6]. Its consumption is driven by various factors, including cultural significance, availability, affordability, and perceived superiority in taste and health benefits compared to domestic meat [7–11]. In urban centres, wild meat consumption tends to increase with higher levels of wealth or socioeconomic status [12–14], and urban demand has been proposed as a driver of hunting activities in rural areas [15,16]. Nonetheless, wildlife exploitation is associated with biodiversity loss [17,18] and presents a pathway for zoonotic disease transmission from wildlife to humans. For example, serological data from Guinea revealed distinct immune responses to multiple Ebola virus (EBOV) antigens among wild meat hunters, with some hunters showing live EBOV neutralisation, suggesting exposure to EBOV or closely related filoviruses before the 2013-2016 West Africa Ebola epidemic [19].

Links between wild meat exploitation and zoonotic disease emergence have prompted several bans and calls for bans in response to zoonotic (or suspected zoonotic) disease outbreaks. Actions include prohibitions on wild meat hunting and consumption in several West African countries following the 2013–2016 Ebola virus disease epidemic [20], China's ban on terrestrial wild meat consumption during the COVID-19 pandemic [21] and the #EndTheTrade campaign during the COVID-19 outbreak targeting commercial trade of wild terrestrial animals—endorsed by over 100 local and global conservation organisations (https://endthetrade.com/). Despite the focus on bans, evidence of their effectiveness in reducing zoonotic disease outbreaks or people's compliance with them is sparse or relied heavily on qualitative data—previous research focused on how people perceived and responded to the messages used by government and public health agencies during zoonotic outbreaks [20].

Here we address this gap by studying compliance with Nigeria's ban on wildlife trade, which was imposed to curb the spread of mpox (formerly monkeypox). Enacted in June 2022 through an executive order by the Minister of Agriculture and Rural Development [22,23], Nigeria's wildlife trade ban aimed to reduce human interaction with wildlife hosts—primarily rodents. These are the main reservoir hosts of mpox [24] and account for 41% of hunted wild meat species by number and 27% by mass in Southeast Nigeria [25]. The ban states "Following the recent confirmation of Monkeypox (MP) resurgence in Nigeria on May 29, 2022, involving 21 persons, by the Nigerian Centre for Disease Control (NCDC), where it was said to have led to the death of one person with co-morbidity, the Federal Ministry of Agriculture & Rural Development (FMARD), through the Department of Veterinary & Pest Control Services, is collaborating with NCDC and stakeholders in the One Health Team to ensure the situation is contained and brought under control. Hunters and dealers of bush meat must desist from the practice forthwith to prevent any possibility of spillover of the pathogen in Nigeria. Transport of wild animals and their products within and across the borders should be suspended and restricted."[22]. Prior to the ban, wild meat hunting, trade, and consumption in Nigeria were only prohibited for species protected under the

Endangered Species Act and for animals taken from protected areas without a permit [26]. The ban remains in effect as of January 2025.

Mpox transmission occurs through contact with infected animals (mostly bites and scratches), persons or objects, causing painful rashes, swollen lymph nodes, and fever [27]. The multiple resurgences of mpox over the last five decades occurred mostly in Africa until 2022, when mpox spread globally (16,000 reported human infections and five deaths across 75 countries and territories), prompting the World Health Organization (WHO) to declare the outbreak a Public Health Emergency of International Concern [28]. This legally binding emergency status, based on the International Health Regulations framework that supports member states to address acute public health risks with cross-border potential [29], was lifted in May 2023. However, it was reinstated in August 2024 after mpox was linked to over 500 deaths worldwide [30].

Our study aims to inform effective and equitable strategies that strengthen conservation efforts and public health policies. Using interrupted time-series analysis [31], we first analyse trends in wild meat sales from two markets (19 vendors), with our data spanning ~ 2 years before and 2.5 years after the ban, and then use qualitative data from vendors and law enforcement agents to contextualise our findings.

Methods

We used three interrelated datasets to investigate the impact of the mpox ban in Nigeria:

1. A quantitative wild meat trade dataset gathered in real-time (pre- and post-ban) from 19 vendors in two markets in Cross River State (September 2020-December 2024; hereafter market survey data).

2. Post-ban interviews with 27 wild meat vendors from ten markets in different locations across Cross River (August-November 2024; hereafter vendor interview).

3. Post-ban interviews with 11 law enforcement officials from the National Environmental Standards and Regulations Enforcement Agency (NESREA) in Abuja and seven of Nigeria's 36 administrative states (November 2024-January 2025; hereafter NESREA interview). See Figure 1 for study locations and data collection timelines.

We obtained written consent from all respondents before data collection. For vendors, we first secured permission from their community leaders before visiting the markets, while the agency's headquarters in Abuja approved interviewing the NESREA staff. All respondents were at least 18 years old, and we emphasised their right to withdraw from the study at any time. Ethical approval was obtained from Cambridge University's Psychology Research Ethics Committee (PRE.2020.095/PRE.2021.071 and PRE.2024.061).

Market Survey Data

We surveyed markets in two southeast Nigerian communities using a questionnaire developed by the WILDMEAT project (https://www.wildmeat.org/). We defined a community as a group of approximately 500-2000 people in the same area and with a traditionally appointed or elected leadership. The market communities border the Oban Division of Cross River National Park (CRNP) and were selected for an ongoing study assessing the effectiveness of an intervention to reduce pangolin decline. Market A is located in a community approximately 35 km from Calabar (via road), the capital of Cross River State. Market B, north of Market A, is approximately 150 km from Calabar and along Katsina Ala highway (we use pseudonyms to maintain anonymity). Market A operates only on Saturdays (6-9 am), with vendors here mostly selling in bulk to buyers from Calabar. This bulk sale, coupled with potentially high demand from urban centres, means the likelihood of all carcasses being purchased on a single day is very high, reducing the chances of double-counting. In contrast, market B operates daily (except Sundays), with vendors having distinct stalls where they also sell other items, such as drinks and foodstuffs. To minimise the risk of double-counting in market B, we visited the market daily but collected data only when vendors had wild meat that had not been previously recorded. To ensure accuracy, we asked vendors if they had new carcasses, which they helped identify.

To recruit respondents, we invited people selling wild meat in these markets to participate in our study. Fifteen vendors from market A and ten from B consented—only one vendor available during our visit declined to participate, citing law enforcement concerns (Note that the 19 vendors included in this study are those whose data met our matching criteria; see Analysing Market Survey Data section). We first recorded the number of vendors selling wild meat on each market visit. With each vendor given a unique ID, we then recorded the following information per carcass displayed for sale: a) species, b) part (entire, half, quarter, or piece—referring to units smaller than a quarter), c) quantity of each part, d) state (fresh—including live—or smoked), and d) asking price (hereafter price). Due to the busyness of the markets, it was unfeasible to weigh all carcasses, so we instead used another questionnaire, which did not require capturing everything being sold to record carcass mass (also noting the species, part, and state). However, we did not obtain mass measurements for all combinations of species, states, and body parts. In such cases, we used substitute values based on taxonomic similarity and average adult body size. For example, we used the body mass of the blue duiker (*Philantomba monticola*) as a proxy for bay duiker (*Cephalophus dorsalis*). Data collection was conducted by trained research assistants residing in the communities.

Vendor Interviews

To understand vendors' perceptions of the ban and trends from the market survey data, we interviewed 27 vendors across ten locations in Cross River (four urban centres and six communities). Ten of the vendors were part of our market survey. We used systematic random sampling to identify eight of the locations and purposefully selected the remaining locations: markets A and B. To select the eight locations, we separately stratified the Oban and Okwangwo divisions of the CRNP (into four strata each), randomly selected one community per stratum, and chose alternative locations where no market exists in a selected community. We included Calabar and other urban areas in the poll to enhance urban representation.

During community visits, we first identified wild meat markets and other areas where wild meat is sold exclusively in bulk (that is, not wild meat restaurants) before following our ethics protocol to recruit vendors (four vendors invited to participate declined to be interviewed).

Using a pre-determined set of questions, we then gathered data on people's understanding and views on restrictions on trading wild meat, paying attention to Nigeria's mpox ban in 2022. Our interview, which lasted about 45 minutes, covered their knowledge of the ban, the impacts of the ban on their livelihood, alternative livelihood opportunities (if any) that they considered due to the ban, their compliance with the ban and challenges with compliance. To assess their knowledge of mpox relative to other mostly zoonotic viruses, vendors responded 'Yes' or 'No' to whether they had heard of any of: a) Coronavirus, b) Ebola virus, c) Lassa virus and d) mpox (monkeypox). Our last question on whether they think selling wild animals exposes them to diseases from the animals was asked using a 3-point Likert scale (Agree, Disagree, and Not Sure; interview questions are in Table S1).

NESREA Interviews

To assess efforts in ensuring compliance with the ban, including awareness-raising and enforcement actions, we interviewed NESREA staff working in different parts of the country, including Cross River. NESREA provided us with the contact details of eleven staff members in the Wildlife Unit, all of whom provided consent and were interviewed. NESREA is a parastatal of the Federal Ministry of Environment, charged with enforcing Nigeria's environmental laws, guidelines, policies, and standards, as well as environmental treaties in Nigeria (except issues relating to oil and gas).

Interviews lasted 30-60 minutes and first asked about respondents' knowledge of mpox and the Nigerian government's response to the mpox outbreak in 2022 before inquiring about the ban: its status, timeline, and the agency's awareness-raising and enforcement efforts. We also asked whether respondents noticed any changes in wildlife trade since the 2022 mpox outbreak, the challenges they face in enforcing the ban, how they handle cases of non-compliance, and their perceived effectiveness of the ban. All respondents were interviewed separately, and interviews occurred online (see Table S2 for the complete interview questions).

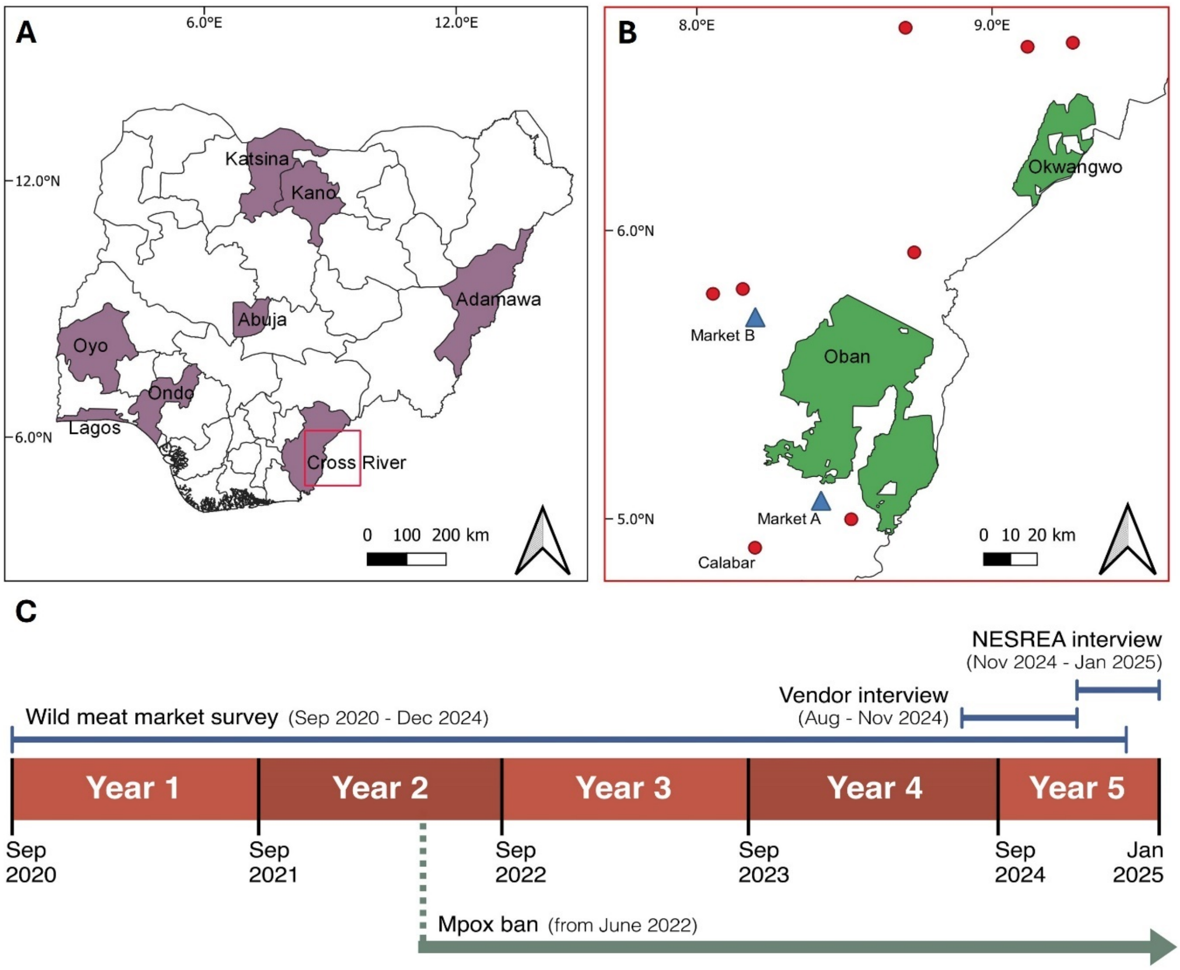

Figure 1. Map of the study locations indicating the Nigerian states where our respondents reside (that is, vendors and/or NESREA; A) and approximate locations of the markets and communities where we surveyed and interviewed vendors (B; note that we highlighted Calabar because it is a city, which we used as a reference point for the markets). Panel C shows the timeline for the data strands relative to the duration of the ban. Image credit (panel C): Airi (Iris) Ryu.

Analysing Market Survey Data

To assess compliance with Nigeria's wild meat sales ban, we used the interrupted time-series approach [31] to fit four mixed-effects models, each with a different response variable: (1) the weekly number of vendors selling wild meat per market (that is, one data point per week from each market; vendor model), (2) the weekly mass of wild meat sold per taxonomic order per vendor and per market (each data point corresponds to a specific taxon sold by an individual vendor in a given market and week; mass model), (3) the weekly total price per taxon per vendor per market (data structure as in mass model; price model), and (4) the weekly price per kilogram of carcass sold per vendor per market (price per kilogram model). The first model evaluates changes in market participation due to the ban, with the mass and price models focusing on shifts in the scale of trade and economic turnover. The price per kilogram model allows us to assess whether vendors compensated for reduced sales volume (e.g., fewer vendors or lower mass sold) by increasing prices.

Before deriving the response variables, we generated our main predictor variable, "period", which had two levels: pre-ban (before 6 June 2022) and post-ban (after the ban). Further, since the dataset spanned multiple years, we matched the records per calendar week (we aggregated the daily records in Market B accordingly) while accounting for period, year, and season, such that pre-ban weeks were matched by date with corresponding post-ban weeks. For instance, the week of 19 September, when data collection began in 2020, corresponded to Week 38, so data from this week in 2020-2021 were categorised as 'pre-ban' and as 'post-ban' in 2022-2023 (our post-ban period began the week after the ban: 13 June 2022). Note that here we followed the International Organization for Standardization (ISO) system where weeks span Mondays to Sundays, with the first week of the year always containing 4 January and some years having 53 instead of 52 weeks (we used weeks 1-52 to ensure consistency).

In the vendor model, the response variable for Market A was the weekly count of vendors in our study selling wild meat and in Market B, where data collection occurred more frequently, the number of unique vendors each week. We excluded weeks without pre- and post-ban records, and to account for variations in the number of records per period, we divided the number of vendors by the number of records per ISO week per period. In the mass and price model, for each vendor and week, we multiplied the median mass of each species—including the median mass of the different parts—and carcass-specific price by the number of units and then divided these variables by the total number of records for each ISO week per period. We adjusted the price to 2024 monetary values using the yearly median consumer price index (CPI; we only found reliable CPI values for January to September 2024 and we used the median to represent 2024; 1,2). We calculated inflation rates relative to 2024 by dividing the 2024 CPI by the CPI of previous years, then adjusted the stated prices by multiplying them by the inflation rate for the corresponding year of data collection. Finally, to ensure comparability across periods, we excluded weeks where a particular vendor did not have corresponding data in pre- and post-ban. The response variable for the price per kilogram model was derived by dividing each vendor's weekly price by their total mass, with subsequent data processing conducted in the same manner as the mass and price models (Figure 2).

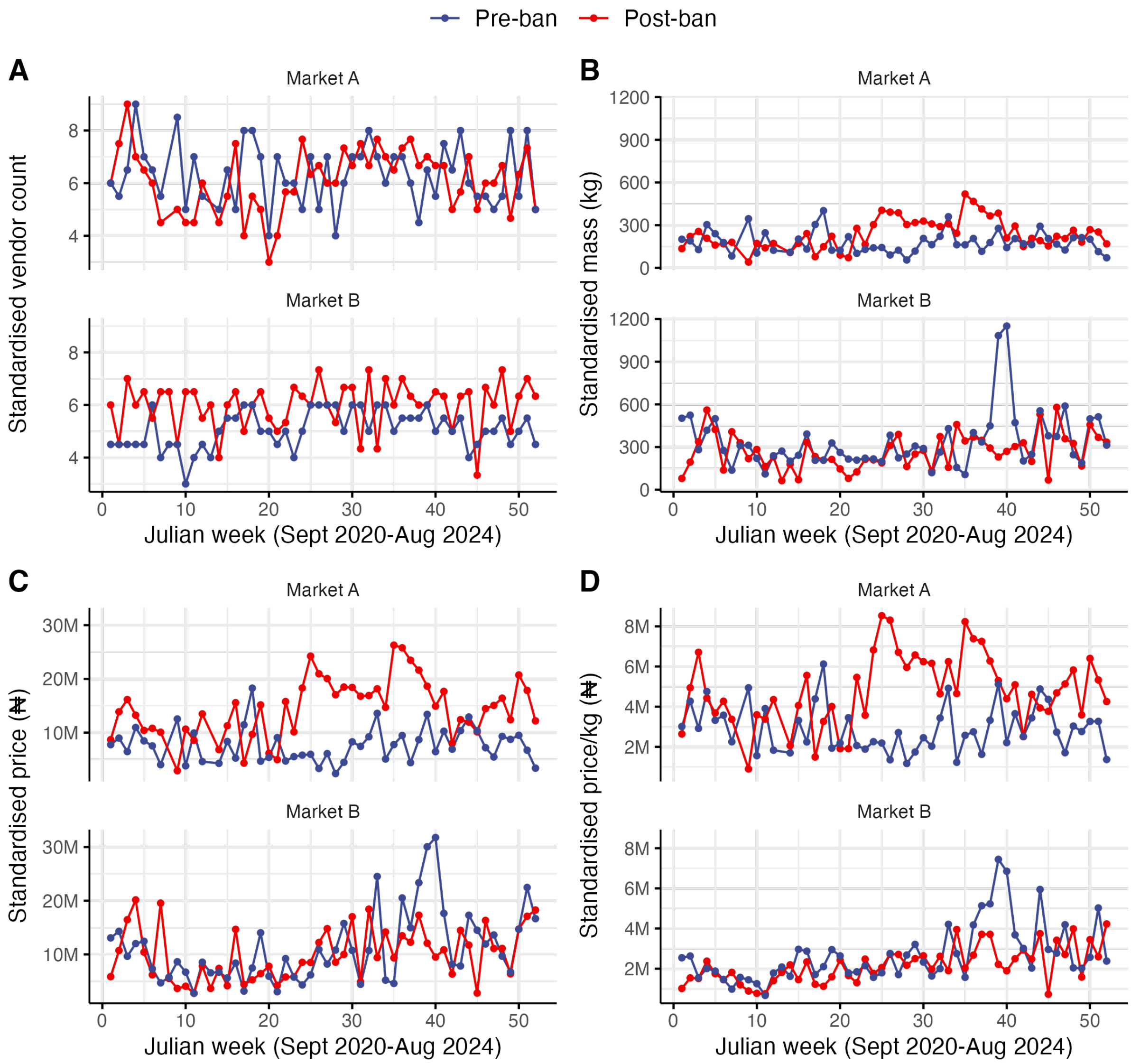

Figure 2. Weekly trend in the number of vendors selling wild meat (A) and the mass (B), price (C), and the price per kilogram (D) of wild meat displayed on sale from September 2020 to December 2024. The figure summarises the data from 19 vendors with data matched per week across pre-ban (before 6 June 2022) and post-ban (after 6 June 2022) periods.

We log-transformed the response variables to enhance model fit and fitted all models assuming a Gaussian distribution (recall the number of vendors was transformed to a rate, as we divided it by the number of records per ISO week per period). The fixed predictors in the vendor model were period (categorical: pre- and post-ban), season (categorical: dry and wet), year (categorical: 2020–2024), market (categorical: A and B), and lagged vendor count (representing the number of vendors recorded in the previous week; numeric). To account for the multiple records from the same week across multiple years, we included week (Week 1–52) as a random effect in the model. The other models were similar but included an additional fixed effect (taxonomic order, categorical) and random effect (vendor identity), with a lagged covariate of the response variable. We could not include an interaction term between period and taxonomic order to evaluate whether the ban's impact varied across different taxonomic groups due to high collinearity.

Note that the lagged covariates in the final three models were based on each vendor's previous week's prices (see model specification in Equations S1-S4 in the Supplementary Material). The wet and dry seasons span April-October and November-March, respectively [34], with season included to account for potential seasonal variations. Year was included to control for interannual differences in market conditions, such as changes in purchasing power and law enforcement [31]. Specifying market and taxonomic order in the models allowed us to assess differences between the markets as well as any taxon-specific effects that could influence the outcomes, with the lagged variables incorporated to control for possible temporal autocorrelation.

Based on insights from vendors via our interview, we truncated the data to three and six months on both sides of the ban to investigate trends in wild meat sales immediately after the ban. Using two Gaussian-based models—one for each subset of the data—we used each taxon's weekly mass per vendor per market as the response variable against period, season, market, order, and lagged mass, with a random effects specified for week and vendor identity (Equations S1-S2. All analyses were conducted using R v 4.2.2 [35], with *lme4* [36] and *emmeans* [37] used to fit the models and conduct post hoc tests, respectively. We assessed model fit using p*erformance* package [38] (distribution of raw data and model fit are presented in Figures S1-S12).

Results

Trends in Wild Meat Sales

In our market survey, across the 19 vendors, we recorded sales of 28 identified species (26 mammals and two reptiles) and other unidentified carcasses categorised at higher taxonomic levels (Figure 3). Together, they accounted for at least 80,060 kg of meat (76% wet and 24% dry), valued at approximately ₦422,000,000 (~US$281,300 at $1=₦1,500). Of the total mass, 30,740 kg (₦142,900,000) was sold before the ban, while 50,200 kg (₦279,100,000) was recorded post-ban. When standardised (that is, restricted to vendors and times of year recorded both pre- and post-ban; see Methods), the total mass was approximately 16,050 kg, estimated at ₦81,200,000 (pre-ban=7,600 kg valued at approximately ₦35,600,000 and post-ban=8,450 kg at ₦45,600,000).

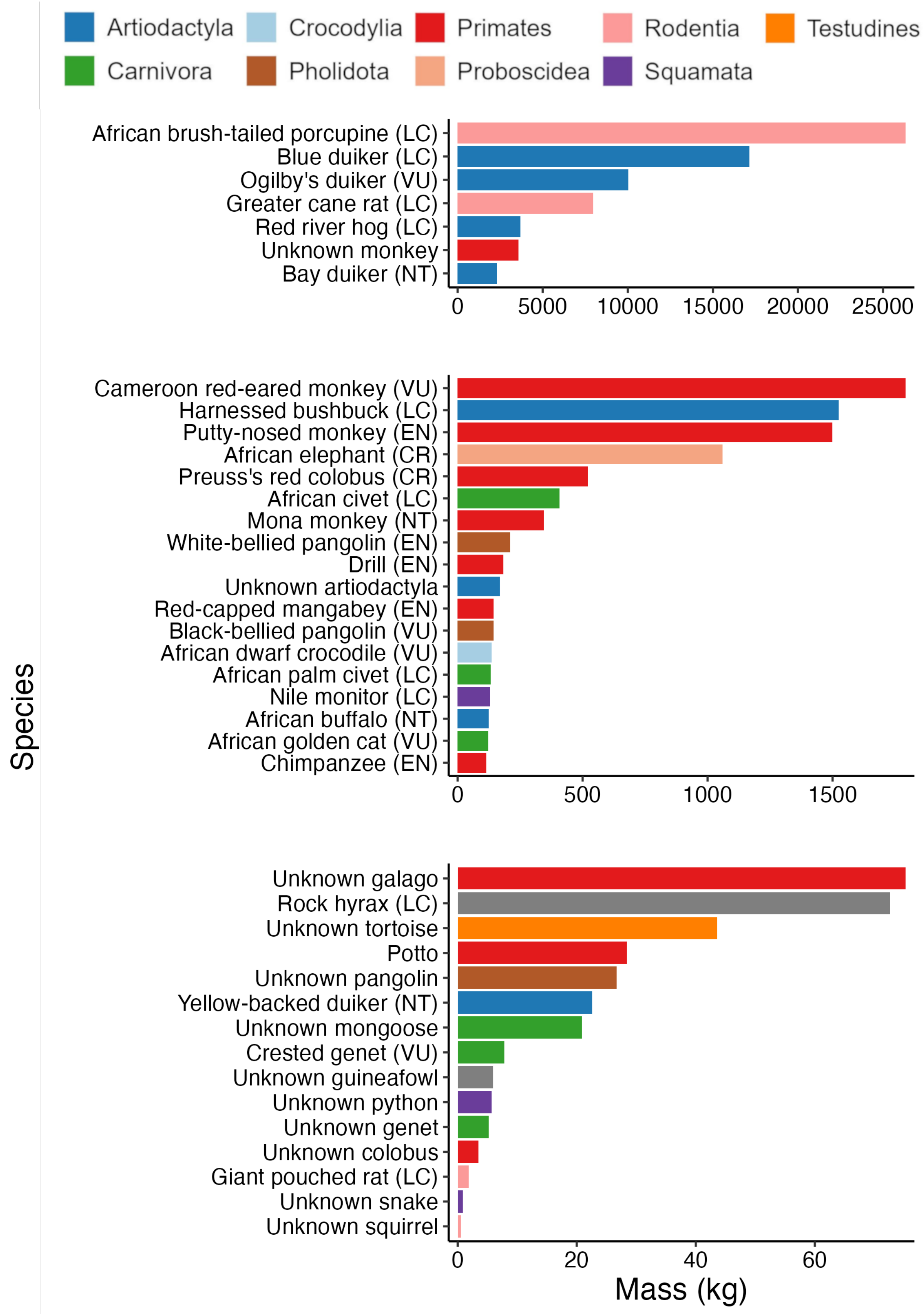

Figure 3. Carcass mass recorded from 19 vendors in two southeastern Nigerian markets, categorised by species (or species groups), from September 2020 to December 2024. Bars are colour-coded by taxonomic order. Note a) the x-axis range varies across panels, and b) that the figure represents the total

mass, not only those matched per week for each vendor (see Methods). IUCN categories are in brackets: LC=Least Concern, NT=Near Threatened, VU=Vulnerable, EN=Endangered, and CR=Critically Endangered.

Our vendor model revealed no statistical difference in the weekly number of vendors selling wild meat before and after the ban (Figure 4A; β=-0.07, SE=0.08, p=0.39). Similarly, none of the yearly comparisons (2021–2024) showed significant differences in vendor counts (see coefficients in Table S3), nor was there a difference in vendor count between the dry and wet seasons (β=-0.001, SE=0.05, p=0.98). However, vendor count was significantly lower in Market B (β= -0.09, SE=0.04, p=0.02), with a significant positive relationship observed between the number of vendors in the previous week (lagged covariate) and that of the following week (β = 0.15, SE = 0.02, p < 0.0001; model overall r^2=30%, fixed effects r^2=24%; full details in Table S3). The mass model also showed no statistical difference in wild meat mass sold before and after the ban (β=-0.10, SE=0.07, p=0.16; Figure 4B). Furthermore, weekly mass sold per vendor was significantly higher for Artiodactyla than most other taxonomic orders, with the largest differences observed relative to Pholidota (Table S4). Similarly, Pholidota consistently had significantly lower weekly mass compared to most other orders, including Primates, Rodentia, Carnivora, and Crocodylia (all p < 0.001). Other orders were generally not significantly different from one another (with few exceptions; Table S4). Yearly comparisons were statistically significant in some cases (Table S4), but no difference was observed between the wet and dry seasons (β=-0.03, SE=0.05, p=0.79). Unlike the vendor model, mass sold was significantly higher in Market B (β=0.35, SE=0.09, p=0.002). Finally, the lagged weekly mass exhibited a significant positive relationship with mass sold (β=0.09, SE=0.02, p<0.0001; model overall r^2=33%, fixed effects r^2=29%; full details in Table S4).

In contrast to the vendor and mass models, the price model showed that vendors took more money (expressed in 2024 Naira) from selling wild meat after the ban than before it (Figure 4C; β=0.17, SE=0.07, p=0.01). While there were differences in the weekly price of wild meat in certain years (see full pairwise comparisons in Table S5), the weekly price did not differ across the wet and dry seasons (β=0.008, SE=0.05, p=0.87). Weekly price was significantly higher in Market B (β=0.32, SE=0.09, p=0.004), and several taxonomic orders showed relatively higher weekly price, with Artiodactyla having significantly higher prices than all other orders (Table S5). Again, the lagged price variable showed a significant positive association with weekly price (β=0.09, SE=0.02, p<0.0001; model overall r^2=36%, fixed effects r^2=32%; full details in Table S5). Our fourth main model revealed no significant difference in price per kilogram between the pre- and post-ban periods (Figure 4D; β=0.02, SE=0.06, p=0.73). Here, the weekly prices differed between some year combinations (Table S6). Market B had a significantly lower price per kilogram (β=-0.42, SE=0.10, p=0.001), while there was no difference between the seasons (β=0.003, SE=0.05, p=0.95). The taxonomic orders exhibited a similar pattern in weekly price per kilogram as observed in the price model, with Artiodactyla showing significantly higher values than all other orders (Table S6). Furthermore, the lagged price per kilogram variable again showed a significant positive relationship with weekly price per kilogram (β=0.11, SE=0.01, p<0.0001; model overall r^2=34%, fixed effects r^2=29%; full details in Table S6).

Lastly, the supplementary models using truncated data (three and six months after the ban) showed an increase in the weekly mass sold after the ban (Tables S7-S8).

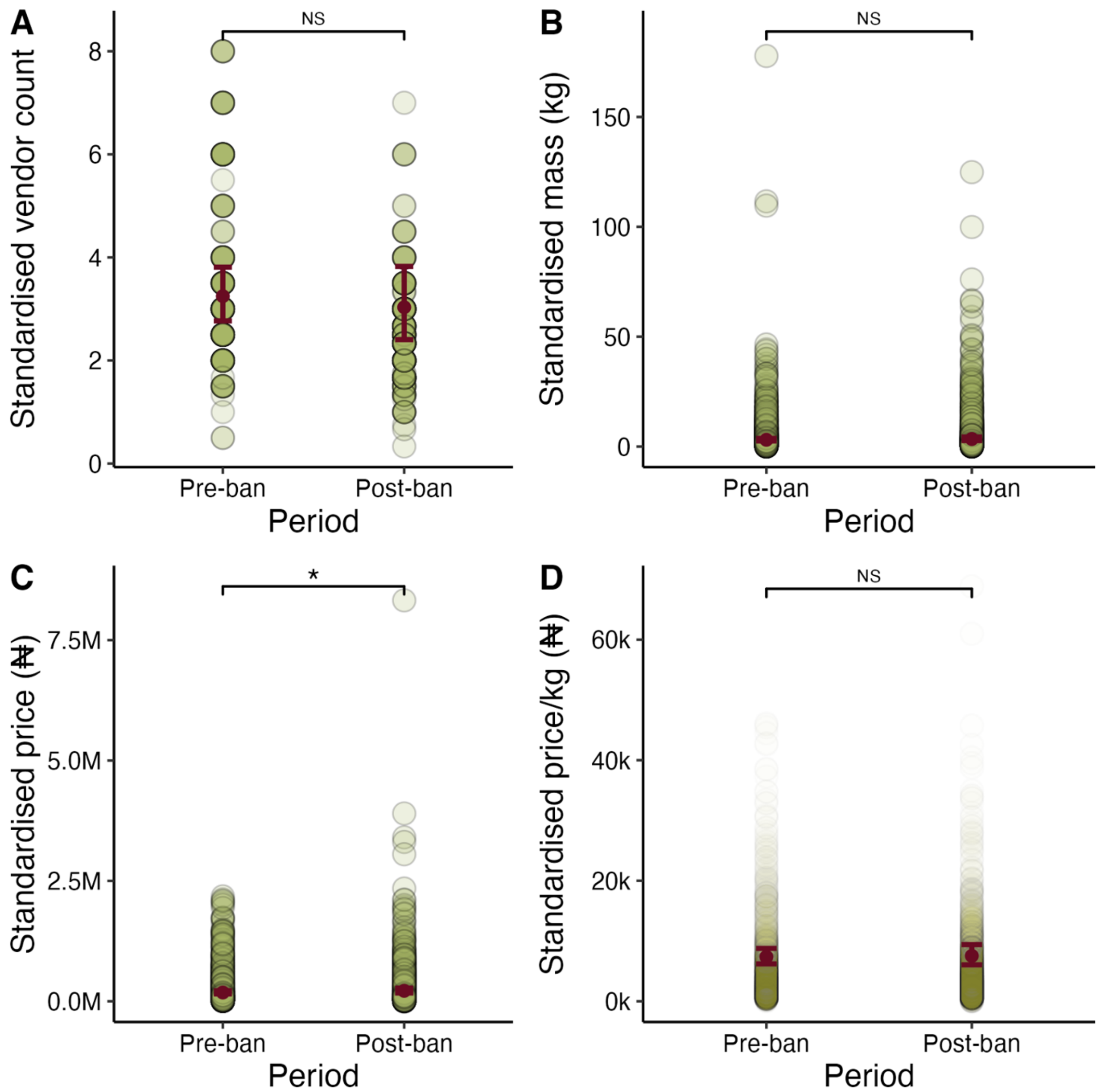

Figure 4. Comparisons before and after the ban in the weekly number of vendors selling wild meat (A), and the weekly mass (B), price (C), and price per kilogram (D) of wild meat sold. Red circles represent model means, with error bars indicating the 95% confidence intervals of the predictions. Blue circles display the distribution of the data used in the respective models. The horizontal bar in each panel displays the results of our mixed-effects model (NS = non-significant; * = significant at $p < 0.05$). The panels summarise data from 19 wild meat vendors in southeast Nigeria, covering the periods from September 2020 to 12 June 2022 (pre-ban) and 13 June 2022 to 31 December 2024 (post-ban).

Vendors' Perceptions of the Ban

Most vendors reported that there were restrictions on selling wild meat in Nigeria. 48% of vendors were aware of the ban. Of these (n=13), nine vendors said that the ban was motivated by disease outbreaks (although two respondents referred to the links between wild animals and disease outbreaks as fake news), four vendors reported that it was implemented to protect wild animals. Regarding the ban's impact, 11 vendors said that their overall sales dropped after the ban, mainly because people feared contracting zoonotic diseases: 6 stopped selling for a couple of months, while the remainder did not observe any changes in wild meat sales due to the ban. Overall, vendors did not appear to have considered an alternative livelihood, although they expressed interest in farming, poultry, and running a grocery kiosk. Compliance was generally low. Only about one-third of vendors were reportedly compliant for some months when the ban was first enacted, primarily because of declines in demand for wild meat.

When asked about the challenges they faced in complying with the ban, almost all respondents pointed to the lack of an alternative source of income and the lack of financial support from the government that would allow them to meet their households' needs. These points were again stressed in their responses to our question on changes or support that would help them comply with the ban. Here they decried the lack of employment opportunities and emphasised the need for skills and funds (including via loans) to start other businesses. On the enforcement of the ban, most vendors reported that they have never experienced inspections or enforcement activities since the ban was enacted. The vendors (n=5) who reported having had such visits said it occurred sparingly and was either by army officers or government personnel concerned about taxes or food hygiene.

Five vendors thought banning wild meat sales to curtail zoonotic disease spread was necessary, all citing the need to protect public health. Other vendors thought the measure was unnecessary, as they thought wild meat was disease-free or, at worst, carried fewer pathogens compared to domestic meat. They also told us that there is still growing demand from the public to consume wild meat and that, without alternative income sources, the ban will cause additional economic hardship. One vendor added that it would be practical to achieve if the ban concerned certain species that have been identified to cause diseases. Lastly, vendors demonstrated high awareness of the viruses we inquired about, with 100% being aware of coronavirus, Ebola, and Lassa and 90% for mpox. Responses to whether they believed trading in wild meat could expose them to zoonotic diseases were mixed: nine agreed, ten disagreed, and eight were unsure.

Law Enforcement Efforts

All 11 NESREA respondents described mpox as an infectious zoonotic disease (although one staff member only learnt about the disease when contacted for the study), and most (n=9) were aware of Nigeria's mpox outbreak in 2022. Those aware of the 2022 outbreak recalled the ban on wild meat trade pronounced by the Minister of Agriculture and Rural Development, adding that the ban is still in effect (those unaware of it attributed it to poor communication between the headquarters and the state offices). These nine respondents reported that, given mpox's links with wildlife and because certain wildlife species can be legally traded and consumed in Nigeria, the ban aimed to reduce human exposure to wild meat, hence curbing the spread of the virus. Nonetheless, these nine respondents reported that NESREA did not change its activities due to the ban, although the ban and the possibility of contracting mpox were highlighted in their periodic awareness-raising and sensitisation campaigns with hunters and wild meat vendors.

Respondents referred to the ban as a "directive," "proscription," "statement," or "executive order" and noted that while enforceable, it cannot lead to prosecutions as it has not been passed into law and lacks penalty guidelines. They were unaware of any arrests or prosecutions of wild meat vendors for violating the ban, as NESREA's focus on wildlife trade enforcement appears to target international trafficking of CITES-listed species, mainly in urban areas. The lack of legal action was attributed to the non-specificity of the ban, which appears to apply to all wild animals and to the absence of alternative livelihoods for vendors who cease trading wild meat. When asked about arrests or prosecutions of local vendors trading species listed in Nigeria's Endangered Species Act, respondents reported no knowledge of such cases but reported that their enforcement efforts primarily involved public sensitisation in urban areas, with the frequency of these visits ranging from weekly to quarterly.

Regarding observed changes in wildlife trade, respondents revealed that vendors are increasingly concealing illegal species rather than displaying them openly. The respondents identified several major challenges in carrying out their duties, including a) fear of being harmed through diabolical means (e.g., voodoo), b) the absence of alternative livelihoods, as wild meat is a critical source of income for many, so that stopping wild meat sales without viable economic alternatives could have devastating consequences, c) the lack of NESREA's presence at land borders and ports due to insufficient funding and logistical constraints, d) the inability of some staff members to accurately identify endangered wildlife species, and e) the agency's disproportionate focus on awareness-raising initiatives at the expense of enforcing existing laws.

Discussion

Our analysis of wild meat sales in southeastern Nigeria before and after the mpox-induced wildlife trade ban revealed that wild meat vendors did not comply with the ban. Specifically, compared to the period before the ban, we found that the standardised number of vendors selling wild meat per week, the weekly mass of wild meat sold, and the weekly price per kilogram were similar after the ban, while the weekly price of wild meat was higher post-ban. Although a few vendors reported complying with the ban for a few months when it was announced, our supplementary analysis of the market survey data—restricted to six months on both sides of the ban---did not show a reduction in the mass of wild meat sold. Instead, it revealed an increase in the weekly mass sold during this period. These findings were corroborated by interviews with vendors and law enforcement officials who reported minimal compliance with and minimal enforcement of the ban, respectively. Taken together, our results suggest that the ban was ineffective in reducing vendors' interaction with potential mpox hosts, thereby failing as a strategy to curb future mpox outbreaks.

We propose that the low compliance with the ban stemmed from two main factors. First, there was minimal follow-up by NESREA—the agency responsible for ensuring compliance with conservation-related regulations—in terms of raising awareness and enforcing the ban where necessary, with NESREA's efforts mainly targeting urban areas. Vendors told us that they experienced little to no inspections or other forms of enforcement efforts during the ban. This was in line with insights from NESREA staff, who reported that their activities remained unchanged following the ban, indicating that the agency did not prioritise activities that would promote compliance. Our interviews with NESREA suggest that this lack of prioritisation was due to the ban's broad and non-specific nature (that is, no clear definition of the species it covered) and legislative flaws. The ban lacked clear penalty guidelines, making it unenforceable through arrests or prosecutions. Second, the lack of an incentive to stop wild meat sales or viable economic alternatives meant many vendors continued trading. Only a third of the 27 vendors we interviewed perceived wildlife trade as a potential health risk, and about the same fraction reportedly stopped trading wild meat for a few months, although this was because of reduced consumer demand rather than active enforcement. Since wild meat exploitation serves as a crucial source of income in many sub-Saharan African communities, including in Nigeria [25,39], compliance with such restrictions without alternative livelihood provisions is likely to have a negative effect on the income and wellbeing of local populations [40].

Despite the limited compliance with the mpox ban, the ban underscores the Nigerian government's recognition of the critical link between wildlife exploitation and public health, an approach grounded in the One Health framework. One Health highlights the interconnectedness of human, animal, and environmental health, emphasising that addressing zoonotic diseases requires a holistic, integrated response [41]. When properly implemented, One Health initiatives, which have gained significant attention over recent decades, offer substantial potential in preventing future outbreaks by targeting the root causes of zoonotic spillovers [42,43]. While these initiatives require considerable financial investment, they represent a proactive and cost-effective strategy for managing zoonotic diseases, ultimately helping to mitigate the risk of widespread health crises [1,44].

The strength of this study lies in our use of longitudinal market survey data gathered in real-time, spanning at least two years before and after the ban, as well as the integration of interviews from key stakeholders. The vendor and NESREA interviews enabled us to contextualise our statistical analysis, which would otherwise have been difficult to interpret. Nonetheless, our data has several limitations. Our sample sizes of markets and vendors are relatively small. But the positive association between vendor behaviours in the previous week and their activities the following week, observed across the four models, suggests that our data are robust enough to detect significant differences between periods, should they exist. Our vendor data was geographically restricted. However, interviews with NESREA staff from various regions, whose responses aligned with those from Cross River, suggest that our findings are likely representative of the broader context across the country. Last, although our self-reported data may be subject to desirability bias, where respondents provide inaccurate reports to be viewed favourably [45], we believe this bias was minimal in our study, as vendors admitted to trading protected species and violating the ban, and NESREA reported that their activities remained largely unchanged after the ban.

Conclusions and Recommendations for Future Bans

From a conservation perspective, bans on wildlife trade are often blunt instruments that fail to address the complexities of human-wildlife interactions [40]—trade bans have even been enacted to reduce threats to taxa not threatened by trade [46]. Moreover, although wildlife exploitation restrictions can help reduce exploitation pressures [47], they might displace threats to other taxa [48] or drive trade underground, making it harder to monitor and regulate [20,46].

We have demonstrated that mere pronouncements of wildlife trade bans without simultaneous attention paid to social and legal considerations will likely yield low compliance [49]. Therefore, future bans must consider these factors and adopt an inclusive approach [50]. We propose the following practical steps. First, governments and organisations promoting the regulation of wildlife trade to increase sustainability should first conduct public consultations and offer economic incentives to encourage adherence and support sustainable compliance [51]. Second, there should be sustained public engagement with culturally appropriate messaging [20,52] that is tailored to the specific context, taking into account how target audiences understand conservation issues and their perspectives on wild meat consumption [12]. Similarly, targeted and evidence-based regulations should be designed in consultation with a broad stakeholder group and actively enforced. Third, relevant government ministries could benefit from working closely with protected area managers to plan and implement interventions in and around protected areas. Similarly, there is a need to invest in ensuring compliance with existing domestic wildlife laws, as such efforts could bolster government actions and public compliance during periods of crisis. To operationalise these steps, NESREA and similar agencies in other countries could benefit from stronger institutional support, including increased funding, more explicit enforcement mandates, and improved coordination with relevant agencies [53].

Data Accessibility

The study data will be uploaded to an online repository upon acceptance of the paper.

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Author Contribution

Conceptualisation: CAE, AB, DJI, LC

Data curation: DO, OI

Methodology: CAE, AB, LC

Investigation: CAE

Visualisation: CAE

Funding acquisition: CAE, DJI, LC

Project administration: CAE, LC

Supervision: AB, LC

Writing—original draft: CAE

Writing—review & editing: AB, DJI, OI, II, DO, LC

Competing Interests

Charles A. Emogor is the founder of Pangolin Protection Network (aka Pangolino; https://pangolino.org/), a conservation non-profit promoting community based interventions to reduce wildlife decline in Nigeria.

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