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Source: Tropical Conservation Science, 15(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/19400829221114845

Research Article

Tropical Conservation Science
Volume 15: 1–13

DOI: 10.1177/19400829221114845
journals.sagepub.com/home/trc
SAGE

Not Just an Issue in Forested Regions: Investigating the Consumption and Trade of Pangolins in a Forest-Savannah Mosaic Area of Cameroon

Alain D. T. Mouafo[1,2,3], Daniel J. Ingram[3,4,*], Valery A. Binda[2], Itoe Constantine N. Ngwayi[5], and Theodore B. Mayaka[1]

Abstract

Background and research aims: Cameroon hosts three species of pangolins and has recently been identified as a hub of pangolin trafficking. However, information on threats to pangolins needed to guide conservation efforts remains scarce, notably on consumption and trade patterns, and the prevalence of individuals trading pangolins. Local communities sharing the same habitats with pangolins can provide such information, which is useful to better target interventions.

Methods: Based on a snowball sampling approach and using interview surveys in 20 villages surrounding Mbam et Djerem National Park, we investigated the consumption of pangolins and its drivers, parts sold, selling prices, places sold and buyers, and employed the nominative technique to estimate the percentage of people within the surveyed population engaged in selling pangolins.

Results: Our results showed that both giant and white-bellied pangolins are locally consumed, mainly for their taste, and traded for meat and scales. Distance to the capital city Yaoundé, ethnolinguistic group, and education significantly affected the likelihood of consuming or trading white-bellied and giant pangolins. Selling and prices of giant pangolin meat and scales were significantly affected by distance to Yaoundé. The prevalence of people selling white-bellied and giant pangolins were higher in Tibati and Yoko compared to other municipalities.

Implications for conservation: Overall, our study provided information necessary for effective law enforcement and research-oriented decision-making for pangolin conservation. We recommend the establishment of consumption reduction campaigns focusing on taste preference, investigation of the impacts of the newly constructed national road on pangolin supply chains and trafficking, and increasing the involvement of local communities in the management process of Mbam et Djerem National Park.

Keywords

mammals, manidae, vertebrate, wild meat, nominative technique, central Africa

[1]Faculty of Science, Research Unit of Biology and Applied Ecology, Université de Dschang, Dschang, West Region, Cameroon
[2]Agriculture and Bio-conservation Organization for Youth Empowerment and Rural Development, Université de Dschang, Dschang, West Region, Cameroon
[3]% Zoological Society of London, IUCN SSC Pangolin Specialist Group, London, Regents Park, UK
[4]African Forest Ecology Group, School of Natural Sciences, University of Stirling, Stirling, UK
[5]Ministry of Forestry and Wildlife, Yaoundé, Cameroon

Received: 21 April 2022; accepted: 4 July 2022

***Current Address:** Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, CT2 7NR, UK
Correction (December 2022): Article updated online to correct the Funding statement.

Corresponding Author:
Alain D. T. Mouafo, Faculty of Science, Research Unit of Biology and Applied Ecology, Université de Dschang, P. O. Box 67, Dschang, West Region, Campost Building, 16 Dschang, Cameroon.
Email: alaindelon553@gmail.com

Introduction

The meat of wild animals, hereafter wild meat, is considered as the major source of protein for forest-dependent people living in rural areas in Central Africa, and for some, wild meat is a source of income (Bahuchet et al., 1999; Cawthorn & Hoffman, 2015; Coad et al., 2010; Froment et al., 1996; Ingram et al., 2021). One study using data published between 1987 and 1999 estimated that 4.9 million tonnes of wild meat are extracted from the Congo Basin alone to supply rural and urban consumers (Fa et al., 2002). This raises serious conservation concerns as overexploitation will lead to the extirpation of hunted animals, reducing ecosystem functioning and services, and disrupting trophic integrity (Abernethy et al., 2013; Maisels et al., 2001). Overhunting for wild meat thus poses a serious threat to biodiversity and people relying on nature for their income and livelihoods (Nasi et al., 2011).

In Central Africa, at least 177 species are exploited for wild meat (to varying degrees of legality), among which half may be threatened by overexploitation (Taylor et al., 2015). Among these species, mammals dominate the harvest accounting for over 60% of offtake (Abernethy et al., 2013). Wild meat consumption is widespread in Central Africa, and its trade is fueled in part by urban demand (Nguyen et al., 2021; Wilkie et al., 2005). While hunting activity is mostly conducted by people in rural areas, the consumption of wild meat is highly appreciated by urban citizens who are willing to pay large amounts of money to enjoy what is considered a delicacy (Foerster et al., 2012; Wilkie et al., 2005). For example, in Cameroon, respondents described wild meat as tasty, healthy, and luxurious, bonding them to their culture, and they were therefore willing to pay to consume it (Nguyen et al., 2021).

The illegal wildlife trade (IWT) is considered one of the major threats to wildlife; however, because of its hidden nature, it is likely to be underestimated ('t Sas-Rolfes et al., 2019; Arias et al., 2021). Regulation (e.g., national laws) has thus far been the major approach to controlling wildlife exploitation ('t Sas-Rolfes et al., 2019), but there is a great deal of uncertainty around the effectiveness of relying on laws alone, and significant data is still needed to develop more effective interventions that improve compliance (St. John et al., 2010). While this data can be collected through direct questioning and standard social science approaches, the secretive nature of IWT and the sensitivity of questions about illegal behavior limit these approaches and likely bias the data (Gavin et al., 2010; Keane et al., 2008). More specialized questioning techniques (SQTs) have been developed to minimize respondents feeling of risk associated with revealing sensitive, and potentially incriminating information (Lee, 1993). Among SQTs is the nominative technique (NT) which works by asking respondents to discuss the behavior of their social group, rather than their own behavior, thus allowing the respondent to keep their own behavior hidden (Miller, 1985). The NT was first developed and successfully employed in North America to investigate heroin use, but have since been adapted and successfully used in conservation (Davis et al., 2020, 2019; Miller, 1985; St John et al., 2010).

Pangolins (Order: Pholidota) are amongst the species widely used for wild meat (Ingram et al., 2018; Nguyen et al., 2021), and in some places, they are also used in traditional African medicines in the region (Soewu et al., 2020). Pangolins are highly favored in both rural and urban areas, and trade in pangolins for wild meat is well established across the rural-urban gradient (Cowlishaw et al., 2005a; Ingram et al., 2019; Mambeya et al., 2018). It is estimated that 400 thousand pangolins are hunted yearly in the forests of Central Africa for wild meat, and the prices of both the giant (*Smutsia gigantea*) and white-bellied (*Phataginus tricuspis*) pangolins have increased in urban markets over time (Ingram et al., 2018, 2019). In urbans areas, arboreal pangolins can fetch approximately 11–18 USD, while a whole giant pangolin can go for >160 USD (Harvey-Carroll et al., 2022; Ichu, 2019). Furthermore, pangolin scales are also trafficked to parts of Asia, where the scales are used in some traditional medicine (Emogor et al., 2021; Sexton et al., 2021; Wang et al., 2020). Trade in pangolins remains unabated despite being listed as Integrally Protected in most range states, being listed on Appendix I of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES), and being recognized as threatened (Vulnerable, Endangered, or Critically Endangered) on the IUCN Red List (CITES, 2017; IUCN, 2021). Attention to the plight of pangolins and action for their conservation is increasing in recent years because of concerns over their continuing population declines (Harrington et al., 2018; Heighton & Gaubert, 2021).

Cameroon is home to three species of pangolins which are traded, the white-bellied pangolin (WBP; *Phataginus tricuspis*), the giant pangolin (*Smutsia gigantea,* GP) and the black-bellied pangolin (*Phataginus tetradactyla*, BBP) (Kingdon, 2015). Here, they are fully protected by Order No. 056/MINFOF of 15th April, 2020; in spite of this, pangolins are still exploited in the country and sold openly without any fear of prosecution (Ichu, 2019; MINFOF, 2020; Mouafo et al., 2021). The country has recently been identified as a hub of pangolin trafficking internationally (Ingram et al., 2019; MINFOF, 2020), showing the extent of exploitation. For example, between 2006 and 2018, at least 45 seizures of pangolin parts were seized throughout Cameroon, most of them being scales (Ingram et al., 2019), and in 2020, despite restrictions due to the Covid-19 pandemic, more than 500 kg of pangolin scales were seized throughout the country (LAGA, 2020). While staggering in quantity, these seizures are likely to underestimate total volumes trafficked given the limited efforts employed to detect and monitor activities. Since exploitation of pangolins is ongoing, and has become an illegal activity over recent years, applying SQTs could be beneficial to assist law enforcers in targeting enforcement actions and developing robust compliance procedures.

Although pangolins are known to be widely exploited, patterns and drivers remain unclear and there is limited information available on the factors influencing consumption and trade especially from important forest-savannah mosaic transition areas in Cameroon. To address this knowledge gap, we worked with communities surrounding Mbam et Djerem National Park (MDNP) to address the following groups of research questions:

- Do people sell and/or consume pangolins and/or their body parts? What are the reasons driving these practices? Which factors (distance to the national park, distance to market towns and the capital city, sex, ethnicity, and municipality) shape such behaviors? We hypothesize that pangolins are consumed because they are considered as a delicacy and sold as a source of income which may be affected by proximity to markets.
- Which parts of pangolins are sold? To whom and where are they sold? What are the different prices? Do spatial factors (e.g., distance to the park and market town) affect the reported prices? We hypothesize, for example, that reported prices may increase as distance from the village to the capital city decreases.
- What is the prevalence of people in the study area engaged in the trading of pangolins? We hypothesize that a large proportion of the study population is engaged in the trading of pangolins as many people may not be aware of the protection status of pangolins.

We believe the baseline information provided by this study will be useful to improve understanding of pangolin consumption and trade as well as their drivers, in order to better target conservation actions, for example, behavior change campaigns. Furthermore, our study will highlight the importance of using SQTs such as NT to estimate the prevalence of people within a population engaged in pangolin trade to inform conservation planning and interventions.

Methods

Study Area

Mbam et Djerem National Park (MDNP; Figure 1) was created in 2000 and covers an area of 4165.2 km^2 in central Cameroon. It is approximately 260 km from Cameroon's capital Yaoundé lying between 5°30′ and 6°14′*N*, and 12°20′ and 13°15′E (Bobo et al., 2006; MINFOF, 2007). MDNP has a climate comprising two seasons of almost equal length, the rainy season which goes from mid-April to mid-October, and the dry season from mid-October to mid-April. MDNP comprises a forest-savanna mosaic with an area of primary lowland rainforest within the southern section of the park (Maisels, 2004; White, 1993). The relief is almost flat, with an altitudinal drop from 930 m to 650 m from the north to the south of the park. The average annual rainfall is 1900 mm with the mean annual temperature of 24°C (Bobo et al., 2006; MINFOF, 2007).

Approximately 30,000 people are distributed around the park within four municipalities (Yoko, Tibati, Ngaoundal, and Bétaré Oya) and 75 villages, comprising predominanly the *Tikar, Gbaya, Vuté (Babouté), Baveuck, Peuhl, Bororo,*

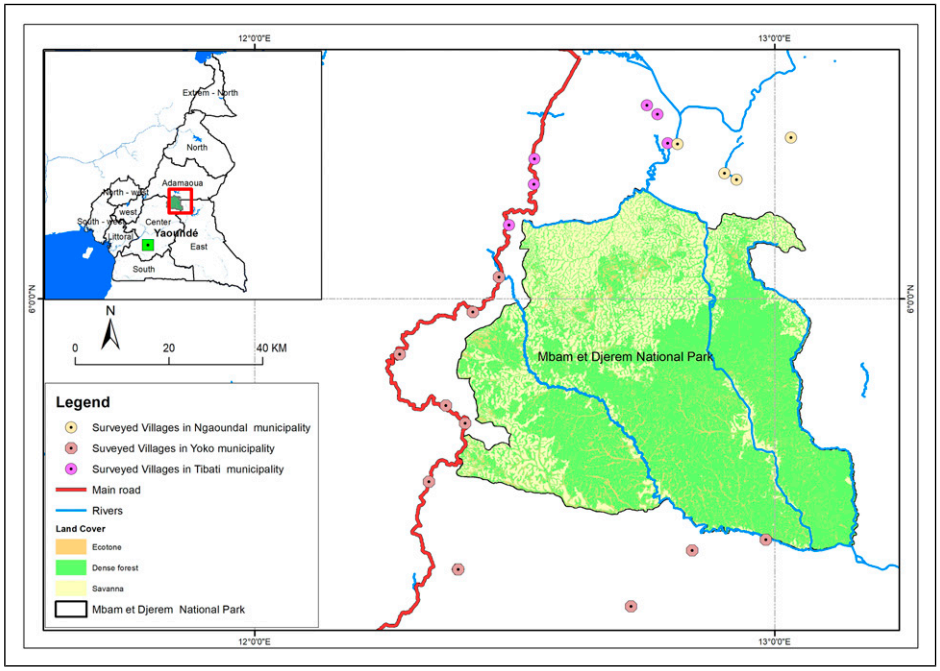

Figure 1. The locations of the surveyed villages around Mbam et Djerem national park, central Cameroon. Village symbol color shows the municipality of the village, while the inset shows the location of the study area in Cameroon (source: Mouafo et al., 2021).

and *Képéré* ethnic groups (MINFOF, 2007; RGPH, 2005). The human population density is generally considered to be low and is concentrated around the Mbakaou dam and the railways linking Belabo to Ngaoundéré with a station in Ngaoundal (MINFOF, 2007). The local people depend on the exploitation of natural resources for their livelihoods and the main activities include crop farming, cattle breeding, fishing, and hunting (Morgan et al., 2011).

Sampling Methods

To assess local knowledge and uses of pangolins in the study area, we used a semi-structured interview questionnaire comprised of both open and closed-ended questions (Newing, 2010) delivered in the same communities as Mouafo et al. (2021). The questionnaire contained sections addressing: (i) respondent information, (ii) wildlife knowledge, (iii) cultural significance and traditional medicine, (iv) hunting, (v) consumption, and (vi) trade (Supplemental Material 1). Methods and selection of villages are described in details in Mouafo et al. (2021). The survey instrument was prepared in English and translated into French and crosschecked against the original English to ensure accuracy. Each interview lasted between 20 and 30 minutes and was mainly conducted in French or in the local language (e.g., Fufulde) and translated back to French by the local guide. Based on a random stratified sampling approach and the area of the national park within each municipality, we selected 10 villages in Yoko municipality, 6 villages in Tibati municipality, and 4 villages in Ngaoundal municipality. The stratified random sampling was used to ensure that our data would be representative of the wider patterns of local knowledge in the study area. To capture possible variation in responses to questions, we interviewed at least 10 people per village (Guest et al., 2006). We conducted interviews throughout the month of February 2020 using two teams of two interviewers, including a local guide, the principal investigator and his field assistant.

Two weeks before the beginning of the survey, we sent letters describing the purpose of our study to the village chiefs and upon arrival, we sought their permission for our research. We relied on the youth president of each village to act as our local guide, and selected respondents based on their hunting experience and then used the chain-referral method (also called "snowball sampling"). Snowball sampling has been shown useful when seeking a particular hidden population for interview (Newing, 2010). The first respondent was selected by the local guide while subsequent respondents were recruited by asking respondents to direct the team to people they thought could have good knowledge about the wildlife and local uses of wildlife in the area. Prior to each interview, we obtained verbal and written consent from all respondents and they were informed the interview was anonymous and that they could end their participation at any time. All the respondents were over the age of 18 and we only interviewed one respondent per household to ensure independence of responses.

To estimate the percentage of people within the surveyed population who have sold pangolins or their parts, we used the NT. A correction is then applied for duplication as multiple respondents may report the same person and the prevalence of people conducting a given behavior can be estimated (Miller, 1985). NT has increasingly been used in conservation (Arias et al., 2021; Davis et al., 2019, 2020bib Davis et al 2020bib Davis et al 2019; St John et al., 2012) because it reduces social-desirability bias, non-response bias and sampling variance (Miller, 1985). Respondents were asked how many of their close friends have for certain sold/traded pangolins. If the answer was more than one, the respondent was finally asked to nominate one of them and give the number of people other than themselves, they believe knows the nominated friend has conducted the activity.

This research was approved by the University of Dschang and the methods were approved by the Ethics Committee at the University of Stirling. All required authorizations for field work were obtained from the Ministry of Forestry and Wildlife through the Conservator of MDNP.

Data Analysis

Prior to carrying out inferential analyses, ethnic groups and educational levels were grouped to ensure adequate sample size within each level and to increase interpretability (see Mouafo et al., 2021). We recorded nine sparsely distributed ethnic groups and classified them into their broader ethnolinguistic groups as follows: the Bantoid and Bantu (*Baveuck*, *Tikar*, and *Vute*), the Atlantic (*Foulbe, Mbororo, and Peulh*), the Adamawa-Ubangi (*Gbaya, Mbvoum*), and the Afro-Asiatic (*Hausa*). We calculated Euclidian distances from each village to the nearest park boundary, to the local wild meat market town (Yoko) and to Yaoundé using ArcGIS 10.5 (ESRI, Redlands, CA, USA).

As GP meat was mostly sold in pieces, we obtained total carcass value by multiplying the unit price of a piece by the total number of slices obtained per carcass (generally 4 pieces). We used descriptive statistics to describe patterns and trends in the data. We then used inferential statistics to test for relationships between dependent and independent variables.

We built binomial generalized linear models (GLM) with a logit link function for dependent variables having two outcomes, such as whether the respondent had consumed or sold meat and/or scales of pangolins (Yes/No). When the dependent variable was numerical, such as meat and scales prices, we used GLM with loglik function using either Poisson or quasi-Poisson distributions as determined by the dispersion of data. We tested the following independent variables: Euclidian distances from the village to the nearest MDNP boundary, to the local wild meat market town and to

Yaoundé, and ethnolinguistic group, gender, municipality, and educational level.

We first tested whether independent variables in the model were correlated (multicollinearity). This was done for both categorical and numerical variables. For categorical variables, the R package "*GoodmanKruskal*" was used to test the association between all the categorical independent variables to be included in the model (Pearson, 2020). To test the relationship between numerical and categorical independent variables, for example, distance to Yaoundé and municipality, we first ran a simple linear model between the two variables and then used the square root of the coefficient of determination (R-squared) as a proxy of correlation coefficient between the two variables (Vogt & Johnson, 2011). We set the correlation coefficient between independent variables to <0.5 and when an association was found between two variables, one of them was removed from the model. Once model assumptions were met, we ran increasingly more simple models and tested model fit by conducting Likelihood Ratio Tests (LRT) between nested models. We then used the significance obtained through this process to construct and run a reduced, final model. To verify if the final model met the proportional odds assumptions, we used a Brant test (Brant, 1990). For data resulting from the NT, we calculated prevalence estimates of people who have sold pangolins using the following formula.

$$T_X = \sum_{j=i}^{n} \frac{Aj}{1 + Bj}$$

Where T_X represents the estimated number of individuals in a sample size n performing the sensitive behavior. A_j represents the number of rule breakers that the respondent j knows, and Bj represents the number of friends, other than j, that are aware of the "nominated friend's sensitive behavior." For this analysis, we excluded interviewees from the calculation if they stated to have more than 10 close friends as these respondents likely did not have the same definition of "close" as the other respondents.

We set the statistical significance at the 5% probability level for all tests and implemented all statistical analyses in R 4.0.2 (R Core Team, 2020).

Results

We interviewed 240 people in three municipalities and the demographic composition was similar to that presented in Mouafo et al. (2021). More than 87 percent (N = 209) of respondents were male. Ages of interviewees ranged between 18 and 82 years old (mean= 40.1, median= 39) and the dominant ethnic group was *Vute* with 40.8% (N = 98), followed by *Gbaya (*31.7%; N = 76), *Baveuck* (9.2%; N = 22), *Mbororo* (7.1%; N = 17), and other minorities representing 11.2% (N = 27). Farming represented the most frequently recorded occupation representing 65.4% (N = 157) of respondents. The most common educational level attained was primary school (47.9%; N = 115), with only one respondent reporting university experience.

Pangolin Consumption

A large majority of respondents recognized WBP was consumed within their respective villages (WBP; 81%; 192 of 237; Figure 2(a)). Educational level (LRT: $\chi 2 = 41.280$, df = 2, $p < 0.001$) and ethnolinguistic group (LRT: $\chi 2 = 13.376$, df = 3, $p = 0.003$) were the significant independent variables contributing to model fit. Respondents who attended primary (GLM: odds ratio 4.91 ± CI 1.69–14.31, $p = 0.003$), and secondary school or higher (GLM: odds ratio 5.04 ± CI 1.67–

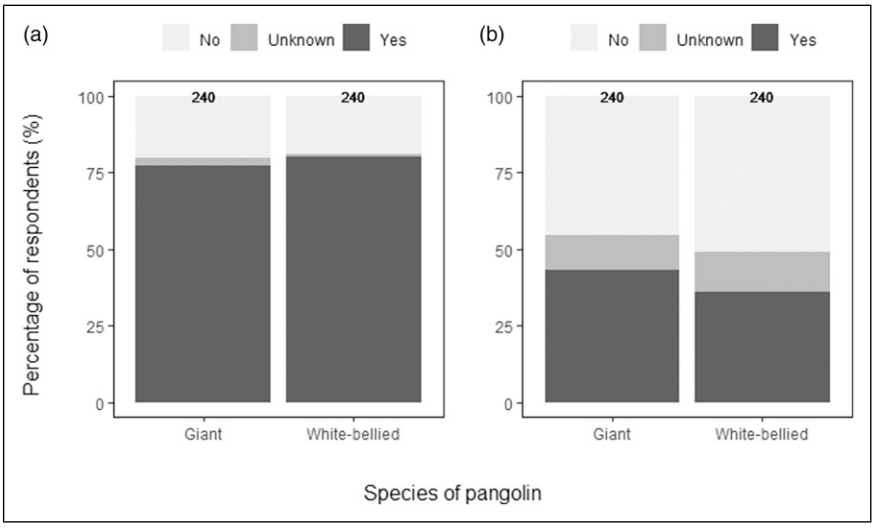

Figure 2. The percentage of respondents who (a) recognized each species of pangolin to be consumed and (b) recognized each species of pangolin to be sold around MDNP. Numbers inside graphs show the number of respondents included in each bar.

15.61, p = 0.004) were more likely to have reported WBP meat consumption compared to those who have not been to school at all. Respondents belonging to the Bantoid ethnolinguistic group were more likely to have reported WBP consumption within their villages compared to those from Atlantic and Afro-Asiatic ethnolinguistic groups (GLM: odds ratio 2.56 ± CI 1.06–6.52, p = 0.04).

Most of the respondents recognized GP meat was consumed within their respective villages (GP; 79.06%; 185 of 234; Figure 2(a). This significantly differed with ethnolinguistic group (LRT: $\chi 2 = 43$, df = 3, $p < 0.001$). Compared to respondents belonging to Afro-Asiatic and Bantoid ethnolinguistic groups, Atlantic ethnolinguistic group respondents were less likely to have reported GP meat consumption within their respective villages (GLM: odds ratio 0.06 ± CI 0.02–0.19, $p < 0.001$).

Reasons for Pangolin Meat Consumption

Of the respondents who reported WBP consumption, 86.67% reported that it was due to taste (N = 169), while 7.7% stated both its taste and lack of suitable alternatives (N = 15), 3.07% because no other protein alternatives were available (N = 6). More than two percent recognized WBP was not consumed due to protection laws.

More than 70% of respondents reported people in their village were consuming GP because of its taste (72.07%, N = 160), while 12.16% stated both the taste and because of the lack of suitable alternatives (N = 27), and less than one percent have no particular reason for consuming (0.46%; N = 1). More than 15 percent (15.31%, N = 34) of the respondents were not consuming GP meat because of the law protecting pangolins.

Pangolin Trade, Parts Sold, Buyers, and Places Sold

Less than half of our respondents reported that the WBP (WBP; 41.35%; 86 of 208; Figure 2(b)), and the GP (GP; 48.83%; 104 of 213; Figure 2(b)) were sold. WBP (LRT: $\chi 2$ = 18.45, df = 1, $p < 0.001$) and GP (LRT: $\chi 2 = 16.47$, df = 1, $p <$ 0.001) sales differed significantly with distance to the capital city Yaoundé. The likelihoods of selling WBP (GLM: odds ratio 0.992 ± CI 0.988–0.996, $p < 0.001$) and GP (GLM: odds ratio 0.993 ± CI 0.989–0.996, $p < 0.001$) meat significantly increased the closer the village was to Yaoundé.

WBP was reported to be sold with both meat and scales by the majority of respondents (73.5%; N = 86 of 117), while 25.64% (N = 30) reported just meat was sold, and finally, only one respondent mentioned just scales to be sold, the meat being eaten locally. All respondents reported that WBP meat was sold privately in the village (100%; N = 85), with buyers being mostly local residents (97.7%; N = 83 of 85) and sometimes outside residents (2.3%; N = 2 of 85).

Of the respondents who reported GP trade, 45.83% (N = 55 of 120) mentioned that just meat was sold, while 53.33% (N = 64 of 120) reported both meat and scales to be sold, and finally, less than one percent of the respondents reported just scales being sold (0.84%, N = 1 of 120), the meat being eaten locally. All respondents reported that GP meat was exclusively sold in private and not in the market (100%; N = 100) and was mostly bought by village residents (97.03%; N = 98 of 101) and sometimes by outsiders (2.97%; N = 3 of 101).

Scale Trade

Very few respondents claimed WBP scales were sold (11.2%; N = 13 of 116) while the large majority stated that WBP scales were not sold (88.5%: N = 103 of 116). This differed significantly with municipality (LRT: $\chi 2$ = 5.9, df = 1, p = 0.015). Respondents from the Yoko municipality were more than five times more likely to claim that WBP scales were sold compared to those from Ngaoundal municipality (GLM: odds ratio 5.2 ± CI 1.36–25.97, p = 0.002).

In total, 34.93% (N = 51 of 146) of the respondents reported GP scales to be sold. Distance to Yaoundé significantly affected the likelihood of respondents reporting GP scales being sold (LRT: $\chi 2 = 26.45$, df = 1, p<0.001), where GP scales being sold significantly increased the closer the village was to Yaoundé (GLM: odds ratio 0.985 ± CI 0.979–0.991, $p < 0.001$).

Pangolin Meat and Scales Prices

Less than half of our respondents reported prices of WBP during this study (36.25%; N = 87 of 240). The prices of the whole carcass with scales ranged between XAF 1000 (USD 2) and XAF 5000 (USD 10), the highest being in the Yoko municipality (median = XAF 2000; USD 4; N = 87 of 240; Figure 3(a)). Distance to Yaoundé significantly affected reported WBP meat prices (LRT: $\chi 2 = 864.84$, df = 1, p = 0.018). WBP meat price significantly increased closer to Yaoundé (GLM: odds ratio 0.999 ± CI 0.998–0.999, p = 0.018; Figure 4(a)).

Less than half of our respondents reported the price of GP meat (43.75%; N = 105 of 240), with none of them reporting GP carcasses being sold with scales. The reported prices of a whole carcass of GP without scales ranged between XAF 10,000 (USD 20) and XAF 35,000 (USD 70), the highest being found in the Yoko municipality (median= XAF 15,000; USD 30; N = 105; Figure 3(a)). This differed significantly with distance to the capital city Yaoundé (LRT: $\chi 2$ = 45,787, df = 1, $p < 0.001$), where the reported price of a whole carcass of GP without scales significantly increased closer to Yaoundé (GLM: odds ratio 0.997 ± CI 0.997–0.999, $p < 0.001$; Figure 4(b)).

Very few respondents reported scales' prices of WBP during this study (5.41%; N = 13). The reported prices per kilogram ranged between XAF 400 (USD 0.8) and XAF 800 (USD 1.6), the highest being found in Yoko municipality (median= XAF 600; USD 1.2; N = 13; Figure 3(b)). We found no significant predictors for the WBP scales price.

Less than one quarter of respondents reported GP scale prices during this study (21.25%; N = 51 of 240), ranging between XAF 2500 (USD 5) and XAF 70,000 (USD 140) per kilogram, the highest being reported in Yoko municipality (median = XAF 17,500; USD 35 per kilogram; N = 51; Figure

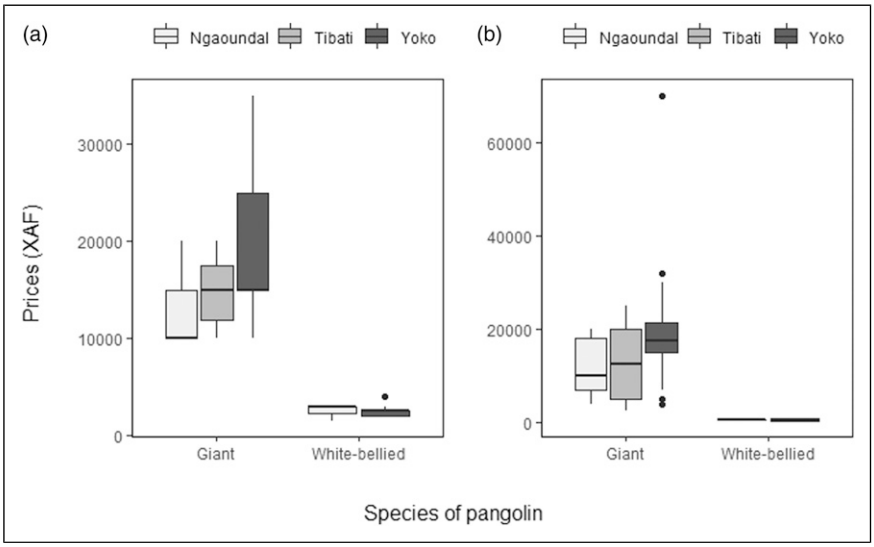

Figure 3. The prices of (a) meat of each species of pangolin; (b) scales of each species of pangolin in each of the surveyed municipalities around MDNP.

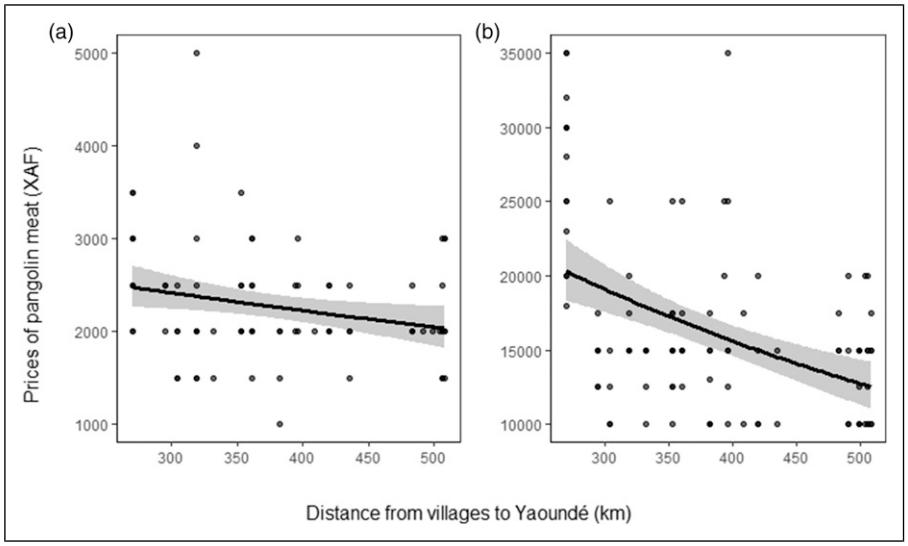

Figure 4. The relationships between distance to the capital city Yaoundé and (a) the selling prices of a whole carcass of white-bellied pangolin with or without scales, and (b) the selling prices of a whole unscaled carcass of giant pangolin in the surveyed villages.

3(b)). GP scales price differed significantly with distance to Yaoundé (LRT: $\chi 2 = 26{,}132$, df = 1, $p = 0.032$), where prices were higher closer to the capital (GLM: odds ratio 0.997 ± CI 0.995–0.999, $p = 0.04$).

Prevalence Estimates of People Who Have Sold Pangolin Parts (Using the Nominative Technique)

Pangolin parts were recognized to be sold in the three municipalities surveyed. The prevalence of people in our studied villages who have sold WBP parts were estimated at 21.33% (SE: 0.06, CI: 21.21–21.45%) in Yoko, 25.16% in Tibati (SE: 0.095, CI: 25.35–25.97%), and 16.33% in Ngaoundal (SE: 0.108, CI: 16.11–16.55%) municipalities (Figure 5).

For the GP, the prevalence of people who have sold its parts was estimated at 37.37% in Yoko (SE: 0.05, CI: 37.32–37.42%), 32.9% in Tibati (SE: 0.08, CI: 32.74–33.06%), and finally 22.33% in Ngaoundal (SE: 0.13, CI: 22.06–22.6%) municipalities (Figure 5).

Discussion

This study aimed to explore the consumption and trade of pangolins and their body parts within 20 communities around

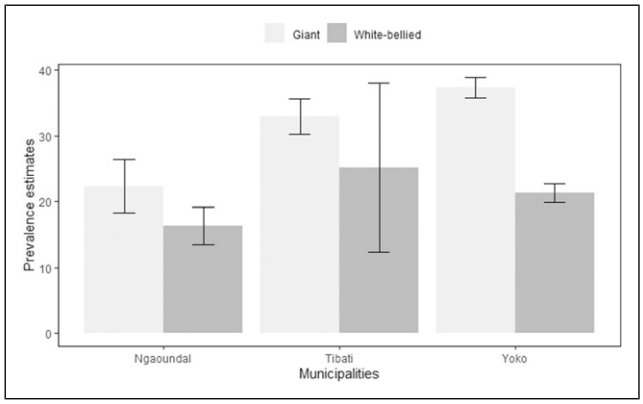

Figure 5. Prevalence estimates of people selling giant and white-bellied pangolins parts in each of the surveyed municipalities around MDNP.

Figure 6. Photos of (a) an unscaled adult giant pangolin carcass ready to be butchered before cooking in a respondent house and (b) a freshly sourced whole carcass of white-bellied pangolin in a restaurant in one of our surveyed villages. Photo credit: Alain Delon.

MDNP, an important site for pangolin conservation in Cameroon. Our questionnaire survey enabled us to gain a greater understanding of pangolin consumption, the reasons for consumption and the trade of pangolin parts and their prices. The nominative technique allowed us to estimate the prevalence of respondents carrying out the behavior of selling pangolins and their parts around MDNP. Our results showed that understanding consumption and trade of wildlife as well as the use of SQT to estimate prevalence of such behaviors can be very useful tools to prioritize behavior change intervention sites and better design interventions to improve compliance (Davis et al., 2019; St John et al., 2010).

Pangolin Consumption and Reasons for Consumption

A large majority of our respondents reported pangolins to be consumed around MDNP. This was confirmed when the first author found an unscaled giant pangolin carcass ready to be butchered before cooking in the house of one of the respondents (Figure 6(a)) and a carcass of WBP freshly bought from a hunter in Yoko municipality (Figure 6(b)). Pangolin meat is considered a delicacy and is available, being openly sold in markets of some cities of Cameroon. Alternatively, some consumers acquire the meat through private transactions in the village or by catching them in traps set around their farms (Ichu, 2019; Mouafo et al., 2021; Nguyen et al., 2021). Respondents with primary, secondary, or higher educational levels were more likely to report WBP meat consumption as compared to those with no education. Despite not being in the same geographical areas, these results corroborate the finding of other authors who found more educated respondents were more likely to consume pangolin meat (Olmedo et al., 2021; Sandalj et al., 2016). We observed in the field that being literate is generally associated with prestige and as pangolin meat is considered a luxury meat, it may be offered to literate residents in exchange of some services such as writing a letter or following a case at public services in the city. The fact that more Bantoid and Afro-Asiatic respondents reported both GP and WBP meat consumption compared to other linguistic groups may be linked to their culture of hunting and the strong association of wild meat in their diets (Chausson et al., 2019; MINFOF, 2007).

The main reason for consuming both WBP and GP meat was its taste, thus corroborating other studies that found that pangolin meat is preferred by respondents because of its taste (Ichu, 2019; Nguyen et al., 2021). This also support the notion that pangolin meat is considered a delicacy (Shairp et al., 2016; Soewu et al., 2020; Soewu & Sodeinde, 2015). Respondents highlighted low income as a reason for pangolin consumption as well as other wild meat. This may be linked to the availability and affordability of wild meat (including pangolin) compared to domestic meat which is expensive and not always readily available for poor households (Abugiche, 2008; Chausson et al., 2019; MINFOF, 2007).

Pangolin Trade, Parts Sold, Buyers, and Places Sold

Trade of both WBP and GP was reported by less than half of the respondents. These results could be explained by the reluctance of some respondents to report pangolin trade if they are aware it is an illegal behavior. The clear notion that meat of both WBP and GP is considered a delicacy among local people may mean it is equally likely to be consumed or traded. The closer to Yaoundé, the likelihood of reporting selling both WBP and GP increased. This could be explained by the availability of pangolin meat in remote areas leading to reduced trade, the bad state of roads, and the regular checkpoints installed around MDNP which may discourage from selling products in city,

forcing them to rely principally on middlemen for their selling.

We found WBP to be mostly sold with both meat and scales, and sometimes alive, similarly to other studies (Harvey-Carroll et al., 2022; Jansen et al., 2020; Soewu et al., 2020). This was later confirmed in the field as we observed many living WBP being sold along the road to Yaoundé. Informal discussion with local people revealed WBP scales were rarely included in trafficking, being discarded or burnt. As reported by one respondent, middlemen are not interested in buying WBP scales and those doing so will buy them at a very cheap price, thus discouraging hunters from spending time collecting WBP scales. However, caution needs to be taken as WBP scales are still present in most of the seizures within the country. Thus, long term studies should be carried out in within these communities to better understand this phenomenon.

Respondents claimed scales and meat of GP were sold separately. A trend also reported elsewhere (Challender et al., 2020; Harvey-Carroll et al., 2022; Mambeya et al., 2018; Soewu et al., 2020; Swiacká, 2019), and may be because the giant pangolin has been fully protected since 2006, and may be more conspicuous to law enforcement given its large size. As reported by some of the respondents, middlemen are more interested in GP scales than meat. Between 2017 and 2019, middlemen used to order GP scales, driving local people to actively seek GP. In addition, the price of a single kilogram of GP scales was reported to be sometimes more than twice the price of a whole GP carcass without scales.

GP was recognized to be sold exclusively in private with buyers being both villagers and sometimes outsiders while WBP was sold both openly and privately. These results are similar to those of Harvey-Carroll et al. (2022), who found only one GP available on the market, albeit outside their survey period. Our results also corroborate other authors' findings who reported open sales of WBP in both Cameroon and Congo (Harvey-Carroll et al., 2022; Swiacká, 2019). Open sales of WBP in our study area may be explained by the strong possibility that most of the respondents were not yet aware of the fully protected status of WBP which came into force in 2020 (MINFOF, 2020), compared to GP whose fully protected status has been running since 2006 (MINFOF, 2007). The privacy of selling both WBP and GP is similar with the findings of Martin et al. (2020) in Cameroon who reported Baka Pygmies to sell their wild meat (including pangolins) to both local residents and outsiders, which was also recognized for local communities in northern Congo (Swiacká, 2019). Respondents recognizing pangolin meat to be sold privately may be an indicator of the increase in the level of awareness about the illegality of trafficking pangolin and their parts. Another explanation might be that middlemen will order wild meat, including pangolins, from local hunters or may travel from the city to come and buy in the villages, but in the case of no immediate buyers, hunters will prefer to immediately sell their catches to an interested villager instead of waiting for the middleman as the meat may spoil. From our observation from the field, it is important to highlight that sometimes, some local villagers will act as middlemen, collecting wild meat from hunters, waiting to have a large quantity before calling a bulk buyer from the city.

Scales Trade

Scales trade of both WBP and GP was reported by few respondents, with more respondents indicating trade of GP scales. The same was reported by Swiacká (2019) and confirms the observation of Mouafo et al. (2021), who noticed a recent drop in scales prices around MDNP due to lack of buyers and increased surveillance, reducing interest in pangolin scales trafficking in MDNP. However, this should be viewed cautiously as respondents might be reluctant to report pangolin scale trade due to the illegality.

Respondents from the Yoko municipality were more than 5 times more likely to report WBP scale trade. This could be due to their proximity with the town of Yoko which is a gathering point for travel to Yaoundé (approximately 260 km), making it a better and more direct road to big cities, and easy access to cars rendering the transportation and sale of products easier. The Yoko municipality is inhabited primarily by Bantoid ethnolinguistic group respondents, which are often recognized to be hunters, dependent on selling wild meat to fulfill their livelihoods (MINFOF, 2007).

For GP, as we get closer to Yaoundé, the likelihood of reporting GP scale sales significantly increased. Due to reduced accessibility to some of our villages because of the bad state of roads, which consequently increases transportation fees, middlemen may find it difficult to reach remote villages, preferring to source scales in more accessible ones. More accessible communities may also be more aware of the value of pangolin scales in the illegal trade. However, a national road is being constructed near MDNP and may facilitate access to more remote areas; thus, increased surveillance mechanisms may be needed. It will also be important to investigate if scales are stockpiled, waiting for buyers or good prices as reported by Mouafo et al. (2021).

Pangolin Meat and Scale Prices

Prices reported for meat of both GP and WBP were similar or higher than those reported in Gabon and Congo (Mambeya et al., 2018; Swiacká, 2019), higher than those reported in Benin for WBP (Akpona et al., 2008), but lower than those of Ichu (2019) and Ingram et al. (2019) in Cameroon and Equatorial Guinea. These differences in the latter two studies could be as a result of a market based survey, where the meat had already passed through middlemen before reaching the market and the expenditures engaged in the supply chain were added to the final price, and consequently increasing the final price. For the lower prices recorded for our study, the explanation could be the availability of meat in the surveyed

villages, tending to decrease the commercial value of wild meat in remote areas (Mavah et al., 2018; Wilkie et al., 2005).

Prices of WBP scales reported during this study were less than 2 USD/kg. These prices are less than those reported elsewhere in Cameroon and Benin (D'Cruze et al., 2020; Ichu, 2019). This confirms the lack of interest in WBP scales observed in the field, respondents reporting sometimes mixing these with GP in order to have a chance to sell. In addition, the important difference with the price reported by Ichu (2019) highlights how along the supply chain middlemen could make large profits compared to initial collectors. For GP, scales prices were similar or less than those reported elsewhere (Ichu, 2019; Swiacká, 2019). Despite this, recent observations from the field highlighted that the lack of buyers, conservation awareness, and increased surveillance, all drove the price per kilogram of GP scales down to less than XAF 5000 (USD 10) compared to the prices at the time of this study.

As distance to Yaoundé decreased, reported prices of both meat and scales for both species increased, which may be an indicator of trade. As reported in other studies (Brashares et al., 2011; Cowlishaw et al., 2005b; Macdonald et al., 2011; Mavah et al., 2018; Torres et al., 2021; van der Hoeven et al., 2007), distance to urban cities is a key factor affecting wild meat prices as middlemen will reduce buying price in accordance with the difficulties encountered in getting the products.

Prevalence Estimates of Selling Pangolin Parts Using the Nominative Technique

The prevalence of people who have sold pangolin parts we obtained was relatively high within the three municipalities of our study area. This is reasonable, given that as people in our study area mostly depend on forest resources such as wild meat (including pangolins) to fulfill their daily needs, they would naturally have higher prevalence estimates (Davis et al., 2019). However, we note that a large proportion of our sample were men, and we cannot ascertain whether this would influence our prevalence estimates. Compared to other municipalities, we obtained lower prevalence in Ngaoundal municipality, where many inhabitants are Muslim. However, during informal discussions with rangers, it was reported that most of the middlemen involved in pangolin scales trafficking were Muslims. Finally, the presence of a railway station in Ngaoundal might explain the prevalence observed, which, despite being the lowest observed during this study was relatively high as they can easily smuggle their products to Yaoundé with minimal checks, as reported by Edderai and Dame (2006). This opens the way to future research aiming to investigate the role of transportation by train in trafficking of pangolin parts.

Conservation Implications and Recommendations

Much remains to be done to fill the knowledge gaps preventing effective pangolin conservation planning and management. Despite the limitations of this study, our results clearly showed that at least two pangolin species are consumed and traded by communities surrounding MDNP, with the Black-bellied pangolin being the least known in the study area (Mouafo et al., 2021). Meat and scales are consumed and traded due to their good taste and the high economic value, respectively. These parts are mainly sold privately and the prevalence of people who have sold pangolin parts was relatively high. This study provides preliminary information useful for informing effective law enforcement and research-oriented decision-making in protecting pangolins. We provided a better understanding of pangolin uses in MDNP and showed that SQTs are useful tools that conservationists, researchers, and managers might take advantage of to estimate the prevalence of sensitive behaviors if properly implemented. We recommend that more research is carried out in and around MDNP, specifically to better understand:

1) pangolin supply chains and trafficking pathways around MDNP;
2) the roles of the recently constructed national road and the Ngaoundal railway station in pangolin trafficking;
3) the use of SQTs to investigate the prevalence of people that consume and hunt pangolins;
4) whether there are any locally acceptable alternatives to pangolin meat;
5) the profiles (demographic and psychographic) of the different groups of individuals involved in pangolin trade (hunters, middlemen, consumers).

We additionally recommend the following actions to reduce hunting pressure on pangolins: (1) plan and establish consumption reduction campaigns focusing on taste preference, (2) plan regular outreach campaigns about pangolins and increase law enforcement, (3) provide suitable wild meat and livelihood alternatives to local communities to mitigate their impacts on pangolins in MDNP, and (4) increase the involvement of local communities in the management process of MDNP.

Acknowledgments

We thank the Cameroon's Ministry of Forests and Wildlife, Mbam et Djerem National Park staff and Agriculture and Bio-Conservation Organization for Youth Empowerment and Rural Development (ABOYERD) for permission to conduct this study and assistance during field work. We acknowledge Edgar Désiré Ambassa Ongono, Tsetagho Guilain, Iya Paul, Kengne Paulin, Tegang Pagning Romaric, and the village chiefs and local communities for their collaboration. We thank Matthew Shirley for kindly agreeing to review an early draft of this manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by Mohamed Bin Zahed Species Conservation Fund (Grant ID: 190520489), Chicago Board of Trade Chicago Zoological Society, the Small-Scale Initiatives Program managed by IUCN France and Idea Wild. DJI was supported in part by funding from the United States Fish and Wildlife Service (USFWS).

ORCID iDs

Alain D. T. Mouafo https://orcid.org/0000-0002-5053-4938
Valery A. Binda https://orcid.org/0000-0002-0909-7318
Theodore B. Mayaka https://orcid.org/0000-0002-9781-6182

Supplemental Material

Supplementary material for this article is available on the online.

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