Local Knowledge and Use of Pangolins by Culturally Diverse Communities in the Forest-Savannah Transition Area of Cameroon

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Source: Tropical Conservation Science, 14(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/19400829211028138

Research Article

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Tropical Conservation Science
Volume 14: 1–14

DOI: 10.1177/19400829211028138
journals.sagepub.com/home/trc
SAGE

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Abstract

Information about the presence and population status of pangolins, and the threats they face, remains limited in many parts of Cameroon, a country that is home to three species of pangolin and considered to be a global hub of pangolin trafficking. Local communities living in rural areas can provide valuable information on species presence, local uses of wildlife, and possible threats, that is useful for prioritising conservation actions. Using interview surveys in 20 villages surrounding Mbam and Djerem National Park, we investigated local peoples' knowledge of pangolin presence, perceptions of population trends, cultural importance, consumptive and non-consumptive uses, and hunting of pangolins. Our results showed that most people recognised the white-bellied and giant pangolins, but only 10% recognised the black-bellied pangolin. Ethnolinguistic group significantly affected the likelihood of respondents recognising and having seen a pangolin before. Giant pangolin populations were perceived to be declining, particularly by older respondents. We found evidence of local use of pangolins for meat, but few respondents reported uses of scales. Cultural significance was reported by few respondents, but when it was reported it mostly referred to giant pangolin. White-bellied pangolins are reportedly hunted using bare hands for local consumption most frequently, whilst giant pangolins were mainly hunted for local consumption and income generation using wire snares. Overall, our study shows the possible value of local knowledge for planning and prioritising conservation actions for pangolins. We highlight the urgent need to monitor pangolin populations, and assess the possible impacts to pangolins from threats such as hunting.

Keywords

bushmeat, Cameroon, hunting, local ecological knowledge, Manidae, wild meat

Human populations have continued to hunt and consume wildlife over thousands of years, and in many parts of the world nowadays, wildlife is also used in traditional medicines and the meat sold as a source of income (Coad et al., 2019). Yet, over 6000 threatened or near-threatened species are listed as having overexploitation as a threat globally (Maxwell et al., 2016). The extinction or local extirpation of wildlife (defaunation) negatively impacts ecosystem functioning and services (Young et al., 2016), which in turn risks imperilling the food security and livelihoods of the indigenous peoples

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Received 24 March 2021; Accepted 8 June 2021

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and local communities (IPLCs) which depend on these wildlife resources for their subsistence (Cawthorn & Hoffman, 2015).

In West and Central Africa, wild animals are still consumed for meat (referred to as wild meat or bushmeat), and are used in a variety of cultural practices and traditional medicines (Coad et al., 2019; Williams et al., 2014). Bushmeat is one of the main sources of animal protein and income for rural people, with an estimated 5 million tonnes harvested per year in the Congo Basin alone (Nasi et al., 2011). Consuming bushmeat is considered to be culturally important, and is highly valued by local people (Ichikawa et al., 2016). It is consumed in both urban and rural areas among all social classes, where it can be considered a symbol of power and prestige, and maintains a symbolic relationship in local culture through its consumption (Ichikawa et al., 2016; Ingram, 2020; Nasi et al., 2011).

Pangolins of the Order Pholidota are one of many groups of species found in West and Central Africa that are widely consumed for bushmeat (Ingram et al., 2018), and in some countries, traditional medicines (Soewu et al., 2020). Over the past decade research activity on pangolins has greatly increased, owing to the increased awareness of an international trade in pangolin scales to parts of Asia for use in traditional medicine (Harrington et al., 2018). The international trade in pangolins was banned when they were transferred to Appendix I of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES; 2017), and all African pangolins are classified as threatened on the IUCN Red List (International Union of Conservation Nature [IUCN], 2021). In terms of local use within African countries, research has shown that in West Africa, nearly all parts of the animal have been reported to be used in African traditional medicine, purported to treat a plethora of different spiritual and physical ailments including rheumatism, convulsions, asthma, and cardiovascular and dermatological problems (Akpona et al., 2008; Boakye et al., 2014; 2015; D'Cruze et al., 2020; Djagoun et al., 2012; Soewu & Adekanola, 2011; Soewu & Ayodele, 2009). Whilst research efforts on pangolins have increased, there is still limited information on pangolin ecology and local uses of pangolins, particularly in Central Africa.

Cameroon is home to three species of pangolin, the giant pangolin (*Smutsia gigantea*), the white-bellied pangolin (*Phataginus tricuspis*), and the black-bellied pangolin (*Phataginus tetradactyla*) (Kingdon, 2015). Under the Cameroon national wildlife law, all three species of pangolin are listed as Class A, which prohibits the hunting, capture, killing and trade of pangolins and their derivatives in the country (MINFOF, 2020). Recently however, Cameroon was identified as a hub for illegal international trafficking of pangolins and their parts (Ingram et al., 2019). Despite national laws banning hunting and trade, evidence shows that pangolins are still hunted, traded and consumed in the country, where they are either consumed locally in rural areas as a source of protein, or are illegally traded as wild meat in open markets, along roadsides, and in restaurants, including in urban areas (Ichu, 2019; Last Great Ape Organization, 2018). Given the threats pangolins face in Cameroon, there is an urgency to design conservation plans for pangolins which integrate both robust ecological data and local knowledge (Challender et al., 2014). However, there is limited information on the population status and precise distribution of pangolins, the threats they face, or the role of pangolins in local culture and traditional medicine in Cameroon needed for such conservation plans. Records of pangolin presence from targeted surveys have mostly come from western and southern Cameroon (Ichu et al., 2017; Bruce et al., 2018). In the western parts of the country, giant pangolins are thought to have experienced declines (Abugiche, 2008; Laurent, 1992; Mouté, 2010; Ngoufo et al., 2014), likely due to historic and contemporary hunting for bushmeat using indiscriminate wire snares (Ingram et al., 2018). Pangolins remain particularly understudied in the Centre and Adamawa Regions (but see Difouo Fopa et al., 2020; Ichu et al., 2017), which is characterised by the forest-savannah mosaic transition area, an area of high biodiversity and diversity of ethnic groups and spoken languages (AfricaMap, 2020; Maisels et al., 2000).

Local knowledge, which includes local ecological knowledge (LEK) held by a specific group of people about their local ecosystem (Olsson & Folke, 2001), can play a central role in the effective design of strategies to conserve threatened species (Berkes et al., 2000; Huntington, 2011; Nash et al., 2016). Species conservation planning can be improved when local people sharing the same habitats with the species of interest directly participate in the design process, providing unique information based on their knowledge and lived experiences (Malmer et al., 2020; Nash et al., 2016). Local knowledge has also been acknowledged as a cost-effective means of collecting conservation-relevant data (e.g., species presence, perceived changes in environmental state, threats to biodiversity) across large geographic areas, particularly for species which have cultural or economic value (Archer et al., 2020; Zanvo et al., 2020).

Little is known about the occurrence of pangolins and possible threats to them in forest-savannah mosaic transition areas. Using the area surrounding Mbam and Djerem National Park (MDNP) in Cameroon as a case study, we explore three primary groups of research questions:

1. What is the extent to which local people have seen pangolins? Do local people perceive any trends in

pangolin populations, and which socio-demographic factors (e.g., age, gender, ethnicity, and education level) shape such perceptions? We hypothesise that, for example, older respondents might perceive giant pangolin population trends to be decreasing given the greater duration of their lived experience.
2. Do pangolins play a role in the culture of local communities in the study area? We hypothesise that the role pangolins play in local culture differs between ethnic groups which can have differing world views and histories.
3. What are the local uses of pangolins? Are pangolins hunted locally, and if so, what are the perceived reasons for hunting pangolins? Which socio-demographic factors shape reporting pangolin hunting? We hypothesise that pangolin hunting for bushmeat is common, given trends in other parts of rural Cameroon.

We believe this baseline information will be of significant use for developing management strategies for the conservation of these threatened species.

Methods

Study Area

The study was carried out in Mbam and Djerem National Park (MDNP; Figure 1), an area of 416,512 ha in central Cameroon lying between 5°30′ and 6°14′N, and 12°20′ and 13°15′E. Its climate has two seasons of almost equal length: the rainy season from mid-April to mid-October and the dry season from mid-October to mid-April. The relief is almost flat, but there is an altitudinal drop from 930 m to 650 m from the north to the south of the park. The park comprises a forest-savanna mosaic with an area of primary lowland rainforest within the southern section of the park. The fauna thus consists of species from both savannah and forest ecosystems with approximately 65 mammal species recorded (Kingdon, 2015; Maisels et al., 2000).

Approximately 25,000 people are distributed in 74 villages bordering the MDNP (Bureau Central des Recensements et des Etudes de Population, 2005), predominanly of the *Tikar, Gbaya, Vuté (Babouté), Baveuck, Peuhl, Bororo,* and *Képéré* ethnic groups (Ministère des Forêts et de la Faune [MINFOF], 2007). The human population density is generally considered to be low, and the people largely depend on farming or the exploitation of natural resources through fishing, gathering or hunting for their livelihood (MINFOF, 2007). Despite the fact that this park has the greatest habitat diversity of any protected area in Cameroon (Fotso et al., 2001), harboring many species of global conservation concern, the lack of alternative income generating activities locally and economic hardship results in extensive pressure on forest resources for local livelihoods (MINFOF, 2007).

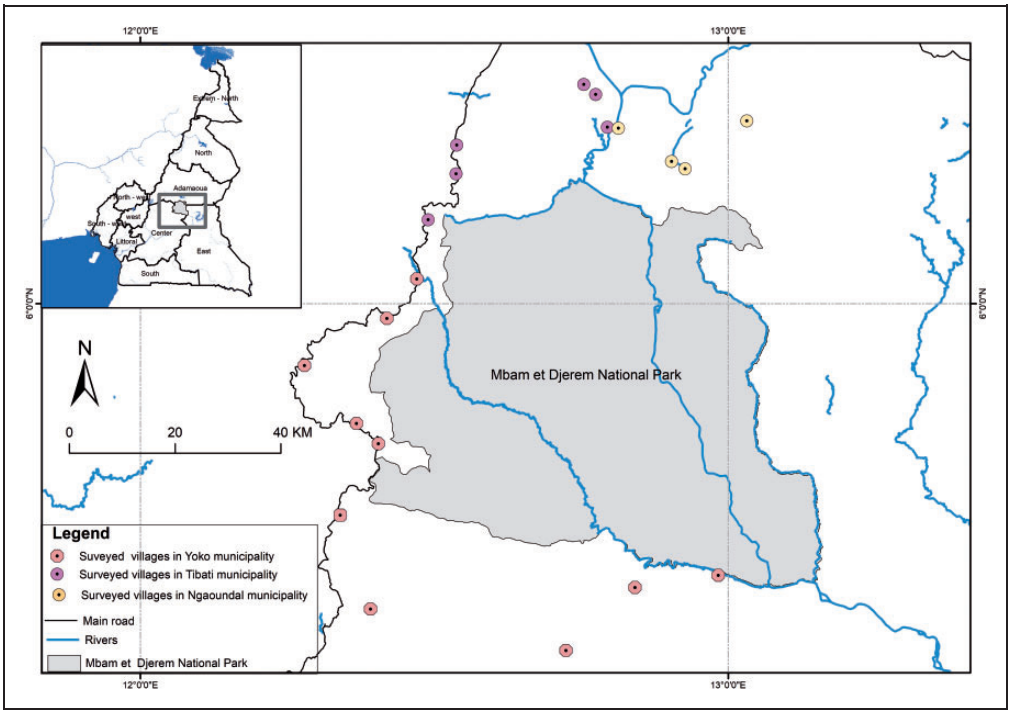

Figure 1. The locations of the surveyed villages around Mbam et Djerem National Park, central Cameroon. Village symbol colour shows the municipality of the village, inset shows the location of the study area in Cameroon.

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, 2011). The questionnaire contained sections addressing: (i) respondent information, (ii) wildlife knowledge, (iii) cultural significance and traditional medicine, and (iv) hunting (described below). The survey instrument was prepared in English and translated into French and crosschecked against the original English to ensure accuracy. The questionnaire was pre-tested in Yoko municipality and final adjustments were made accordingly. We obtained the full list of villages in each municipality from the MDNP management office and using a stratified random sampling design, we selected 10 villages in Yoko municipality, 6 villages in Tibati municipality and 4 villages in Ngaoundal municipality, three of the four municipalities bordering the national park; the number of villages was allocated based on the area of the national park within each municipality. The stratified random sampling was 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 conducted interviews with $\geq$10 people per village (Guest et al., 2006; White et al., 2005). Two weeks before the beginning of the survey, letters describing the purpose of our study were sent to the village chiefs. Once we arrived in villages, we approached the chiefs to inform them of our intentions and to ask permission for our activities. The chiefs of the villages then introduced us to the youth president of the village to act as our local guide. The local guide helped us in selecting experienced community members following the chain-referral method (also called 'snowball sampling') which is useful when researchers are seeking a particular hidden population to interview (Newing, 2011). 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 at the end of each interview. Prior to each interview, verbal and written consent was obtained from all respondents and they were informed the interview was anonymous and that they could interrupt it at any time without issue. Local people below the age of 18 were not interviewed and only one respondent was interviewed per household to ensure independance of responses.

The interviews were conducted in the villages throughout the month of February 2020 by two teams of two persons, a local guide and the pricipal investigator. 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. The questionnaire was divided into five parts and comprised of open-ended as well as structured questions (see Supplemental Material 1). In the first part we documented information about the gender, age, ethnic group, education level, occupation and time spent living in the sampled villages of all respondents. In the second part, the respondents were shown color photographs of six mammals (Aardvark, *Orycteropus afer*; giant pangolin, *Smutsia gigantea*; blue duiker, *Philantomba monticola*; white-bellied pangolin, *Phataginus tricuspis*; African brush-tailed porcupine porcupine, *Atherurus africanus*; black-bellied pangolin, *Phataginus tetradactyla*), and for each species, respondents were asked questions on whether they recognised the species, its local name, the last time the species was seen and how they percieved the population trend of the species. The incorporation of a wide range of species in the interviews was intended to reduce the attention of the questionnaire on pangolins, and therefore to increase the probability of the respondents declaring potentially sensitive information regarding pangolins (Nash et al., 2016; Turvey et al., 2015). The remaining parts of the questionnaire concerned the cultural importance, traditional medicine and hunting practices used among local people living around MDNP.

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, some levels within categorical variables were grouped to ensure adequate sample size within each level and to increase interpretability. Nine sparsely distributed ethnic groups were recorded in the study area. We classified ethnic groups 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*). Educational levels were grouped into None, Primary, and Secondary+ which includes respondents who have undertaken education from secondary to university level. Given the variety of different types of occupation recorded (16), we grouped occupations into those where work was predominantly conducted outside (e.g., farmers, hunters, fishermen), and those that were not (e.g., carpenters, traders, butchers).

Binomial generalized linear models (GLM) with a logit link function were built for dependent variables having two outcomes such as whether the respondent recognised the species or had seen it before (Yes/No).

When the dependent variable was an ordered categorical variable, such as when the respondent had last seen the species (week, month, year, more than a year), and their perceived population trends (decreasing, stable, increasing), we used Ordinal Logistic Regression analysis to test potential predictors, using the *Ordinal* R package (Christensen, 2019). When our dependent variable was nominal with more than two unordered levels (e.g., the place where a pangolin was last seen), we used Multinomial Logistic Regression (MLR) in the *MASS* R package (Venables & Ripley, 2002). Independent variables tested were: age, distance from the village to the nearest entrance to MDNP, sex, ethnolinguistic group, primary occupation, and educational level.

We first tested whether independent variables in the model were correlated (multicollinearity). Once model assumptions were met, we ran increasingly more simple models and tested model fit by conducting Likelihood Ratio Tests (LRT) between nested models. Significant variables obtained through this process were then used to construct and run a reduced model. To verify if the final model met the proportional odds assumptions, we used a Brant test (Brant, 1990). Differences between factor levels were compared by estimated marginal means using Tukey post-hoc tests in the R package *emmeans* (Lenth et al., 2018). Statistical significance was set at the 5% probability level and all statistical analyses were carried out in R 4.0.2 (R Core Team, 2020).

Table 1. Demographics of the Respondents Interviewed in Villages Surrounding Mbam et Djerem National Park, Cameroon.

Demographics	Municipality[1] Yoko (n = 124)	Tibati (n = 78)	Ngaoundal (n = 38)
Gender			
Male	104	67	38
Female	20	11	0
Age			
Range	18–78	18–78	18–82
Mean	39.6	40.1	41.7
Median	39	38.5	38.5
Education			
None	9	17	15
Primary	69	29	17
Secondary	45	32	6
University	1	0	0
Occupation			
Farmer	82	47	28
Others[2]	22	31	10
Ethnicity			
Vute	89	8	1
Gbaya	8	46	22
Others[3]	27	24	15

[1]Number of villages within each municipality: 10 in Yoko, 6 in Tibati and 4 in Ngaoundal.
[2]Other occupations recorded: fisherman, carpenter, driver, student, trader, teacher, shepherd, butcher, couturier, electrician, forester, household, hunter, mason, and waiter.
[3]Other ethnic groups recorded: *Mbororo, Tikar, Baveuck, Mbvoum, Mbakaou, Foulbe, Hausa, Peulh*.

Results

We interviewed 240 people distributed between three municipalities (Table 1). More than eighty-seven percent (n = 209) of respondents were male while 12.91% (n = 31) were female. Interviewees ranged from 18 to 82 years old (mean= 40.1, median= 39). 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), with other minorities representing 11.2% (n = 27). The more frequently recorded occupation was farming, representing 65.4% (n = 157) in the three municipalities. Primary school level education was the most common level attained (47.9%; n = 115), whilst only one respondent had been to University.

Pangolin Recognition

Most respondents recognised the white-bellied pangolin (WBP; 82.9%, 199 of 240), but very few respondents recognized the black-bellied pangolin (BBP; 10%, N = 24; Figure 2A). We found that including ethnolinguistic group in a GLM of whether or not respondents recognised WBP significantly improved model fit ($\chi 2 = 8.773$, df = 3, $p < .032$; also see Supplemental Material 2). People from the Adamawa-Ubangi ethnolinguistic group were significantly more likely to recognise the WBP compared to those from the Atlantic group (GLM: odds ratio $6.59 \pm \text{CI}\ 1.79 - 24.26$, $p = .001$; Figure 3A). Those from the Atlantic group were also significantly less likely to recognise the WBP than those from the Bantoid group (GLM: odds ratio $0.11 \pm \text{CI}\ 0.03 - 0.39$, $p < .001$).

Most respondents also recognised the giant pangolin (GP; 91.7%, N = 220; Figure 2A) which differed significantly between ethnolinguistic groups ($\chi 2 = 9.245$, df = 3, $p = .026$). People from the Adamawa-Ubangi ethnolinguistic group were significantly more likely to recognize the GP than those from the Atlantic group (GLM: odds ratio $10.38 \pm \text{CI}\ 1.10 - 97.71$, $p = .037$; Figure 3B).

Pangolin Sightings

A large proportion of respondents stated to have seen WBP (78.3%, N = 188), and GP (85.8%, N = 206) at least once in their lives, but very few claimed to have seen a BBP (9.2%, N = 22). Ethnolinguistic group influenced the probability of having seen the WBP ($\chi 2 = 9.688$, df = 3, $p = .021$; Figure 3C), and the GP

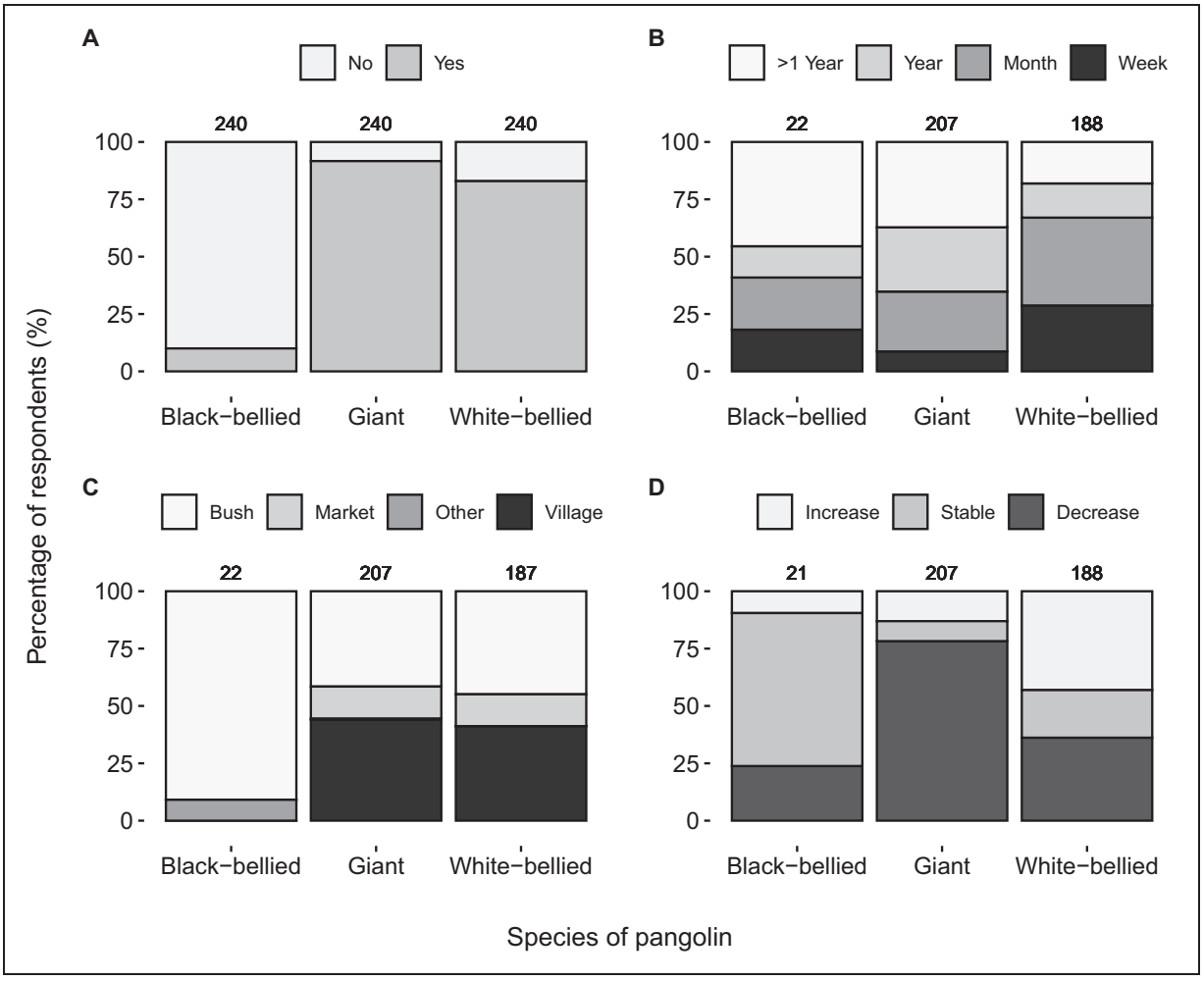

Figure 2. The percentage of respondents who: (A) recognized each of the three species of pangolin; (B) had last seen each species within a given time-period; (C) had last seen each species of pangolin in a given location; and (D) perceived different population trends of the three species of pangolin. Numbers inside graphs show the number of respondents included in each bar.

($\chi 2 = 7.919$, df = 3, $p = .048$; Figure 3D). Respondents from the Adamawa-Ubangi ethnolinguistic group were significantly more likely to have seen a WBP than those from the Atlantic group (GLM: odds ratio $7.00 \pm$ CI $1.95 - 25.14$, $p < .001$). Similarly, respondents from the Atlantic group were significantly less likely to have seen a WBP than respondents from the Bantoid group (GLM: odds ratio $0.12 \pm$ CI $0.04 - 0.42$, $p < .001$). The odds of having reported seeing a GP was also significantly higher if the respondent was from the Adamawa-Ubangi group, compared to the Atlantic group (GLM: odds ratio $5.12 \pm$ CI $1.06 - 24.83$, $p = .039$).

Of those reporting to have seen a white-bellied pangolin before, 38.3% claimed to have seen the species within the last week, 18.1% within the last month, 28.7% within the last year and 14.9% more than a year ago (Figure 2B). We found that including respondent age improved model fit of when a respondent reported last seeing a WBP ($\chi 2 = 8.180$, df = 1, $p = .004$; Figure 4), but we found no effect of distance to protected area entrance or respondent sex. The likelihood of having seen a white-bellied pangolin more recently significantly decreased with respondent age (OLR: odds ratio = 1.027, 95% CI = 1.008 – 1.046). We could not test for effects of ethnicity given that few of the Atlantic and Afro-Asiatic people we sampled had seen a WBP. Of those who had reportedly seen a giant pangolin, more than twelve percent of respondents (12.6%, N = 26) reported seeing one within the last week, 26.1% within the last month, and 28.2% (N = 58) within the last year (Figure 2B). We found no statistically significant predictors of when a GP was last seen.

Of the respondents who provided an answer when asked where they had seen a white-bellied pangolin for the last time (N = 188), the highest proportion claimed to have seen the species in the bush (44.7%, N = 84), followed by the village (41%, N = 77), and finally in

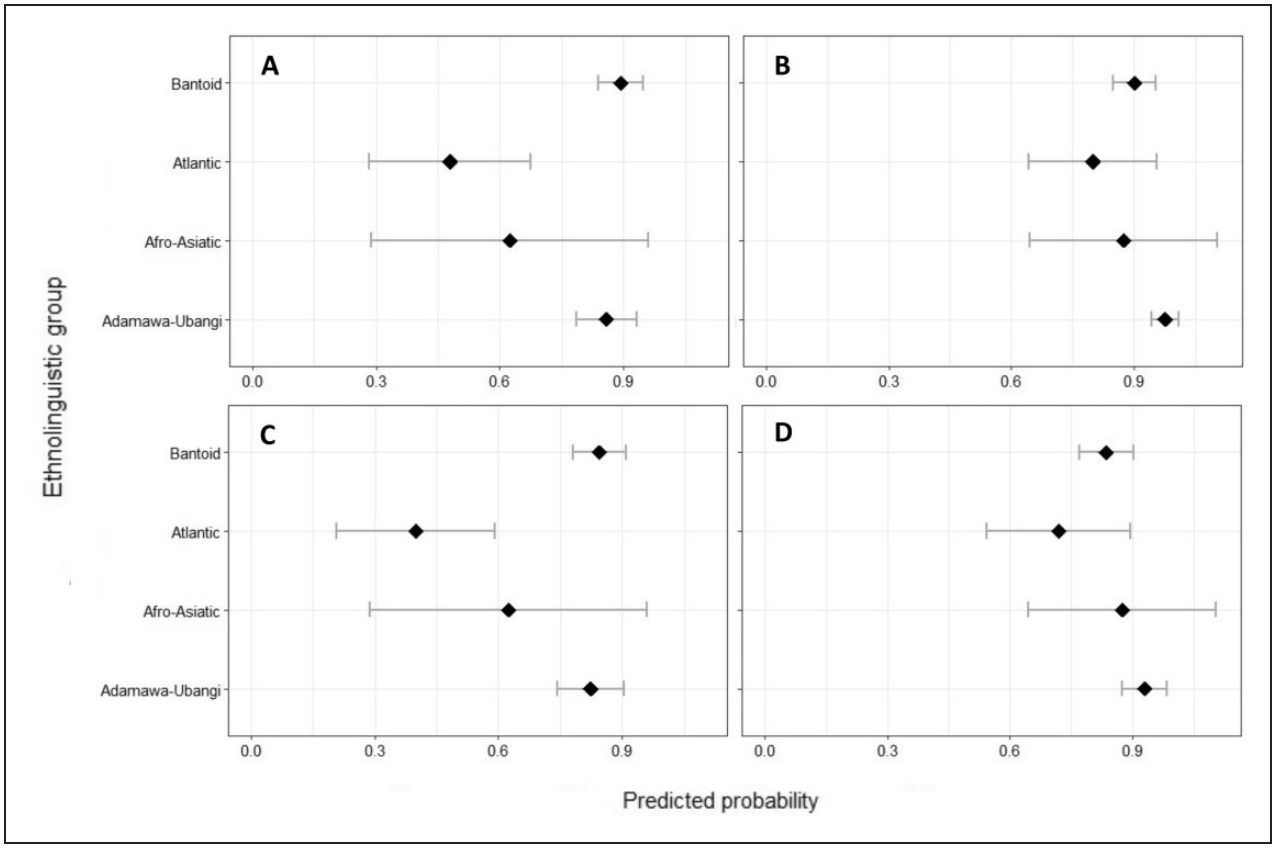

Figure 3. Predicted probabilities of recognising a while-bellied pangolin (A) and giant pangolin (B) in relation to ethnolinguistic group. Panels (C) and (D) show the predicted probabilities of respondents from different ethnolinguistic groups having seen a white-bellied and giant pangolin, respectively.

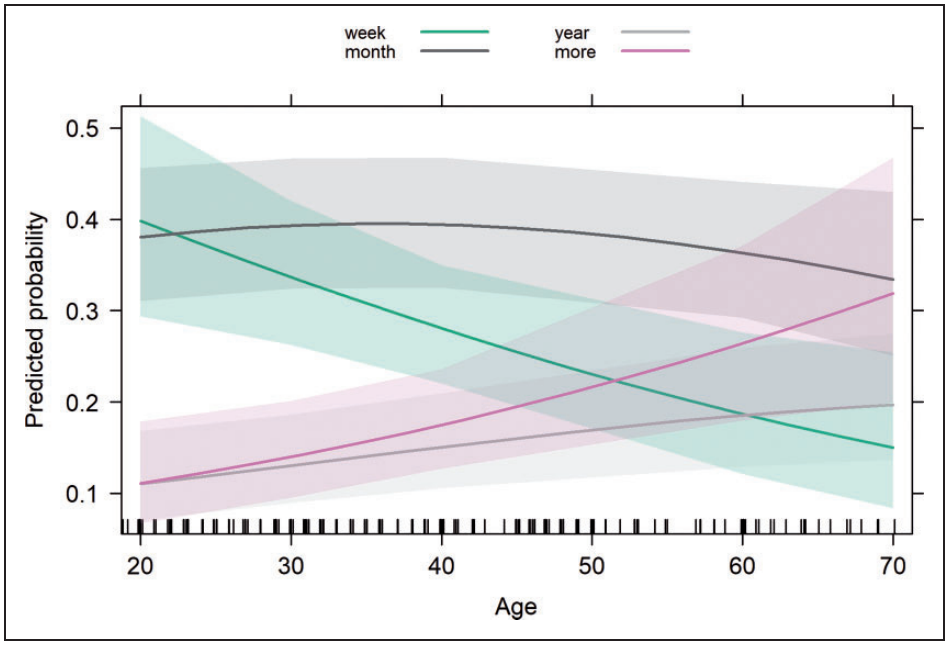

Figure 4. The Relationship Between Respondent Age and the Predicted Probabilities of When a White-Bellied Pangolin Was Last Seen.

the market (13.80%, N = 26; Figure 2C). Multinomial logistic regression showed that respondent sex was significantly associated with the place where white-bellied pangolin was last seen ($\chi2 = 11.317$, df = 2, $p = .003$). Being male significantly reduced the likelihood to have last seen WBP in the market (OR = 0.20, 95% CI = 0.04 – 0.98, $p = .05$) or village (OR = 0.15, 95% CI = 0.04 – 0.55, $p = .004$). Of the respondents who reported having seen a GP (N = 207), most claimed to have seen the GP in the village (45.4%; N = 94), followed by in the bush (41.5%; N = 86), and market (14%; N = 29; Figure 2C). We found no significant predictors for the location where a GP was last seen.

Pangolin Population Trends

Of the 188 respondents who perceived a trend in the WBP population, 68 (36.2%) declared it as decreasing, 39 as stable (20.7%) and 81 (43.1%) as increasing (Figure 2D). The perception of a trend associated strongly with the last time the respondent stated to have seen a WBP ($\chi2 = 24.451$, df = 3, $p < .001$). Respondents who had last seen a WBP more than a year ago were more likely to consider the population to be decreasing, when compared to those who reported to have seen the species within the past week (OLR: odds ratio = 2.110, 95% CI = 0.891 – 3.328, $p < .001$), month (OR = 1.673, CI = 0.525 – 2.820, $p = .001$), and year (OR = 1.911, CI = 0.526 – 3.297, $p = .002$).

Of the respondents who provided perceptions on giant pangolin population trends in the study area (N = 207), the vast majority (77.8%, N = 161) perceived it to be decreasing, with fewer people perceiving the trend to be stable (8.7%; N = 18) and increasing (13.0%, N = 27; Figure 2D). Including respondent age as a predictor for perceived giant pangolin population trends improved model fit ($\chi2 = 7.246$, df = 1, $p = .007$), whereby older respondents were more likely to consider the giant pangolin population trend as decreasing (OR = 1.040, 95% CI = 0.943 – 0.991, $p = .01$).

Cultural Importance and Local Perceptions

Few respondents reported cultural significance associated with pangolins and among those, none were reported specifically in relation to black-bellied pangolins. Cultural significance was mostly linked to the whole animal or its meat. Two male respondents from the *Vute* ethnic group (Bantoid) considered giant pangolin to be a totem animal, whilst two older *Gbaya* men (aged 65+) reported it to be a '*sacred animal*', meaning it was culturally forbidden for those people to hunt or eat the meat of GP otherwise it was believed that disastrous consequences (sometimes leading to the death of the person concerned) would occur. One *Baveuck* (Bantoid) man (aged 50+) stated that the GP meat is reserved for chiefs. Two *Gbaya* men (aged 45+), and one young *Gbaya* women reported that the pangolin meat was considered as a food taboo for women to whom it was forbidden. One older male respondent (aged 60+) from the *Hausa* ethnic group stated that GP meat was eaten within a group with the aim to improve social cohesion and improve sharing among members of a community.

Respondents did not recall that pangolins featured in any local stories, but there were several perceptions about GP and WBP but not BBP. The most common perception was an association with luck. Sixteen male respondents, 94% of who were *Vute and Baveuck* (both Bantoid, and representing 15% of all Bantoid men surveyed) located across seven villages considered GP as bad luck, with some stating that seeing a GP during day time in the village or forest was a sign of future mourning in the family or village of the observer. However, one *Mbvoum* man, and one *Gbaya* man reported that seeing GP and WBP respectively were good luck. One person reported that pangolin abundance during some period of the year was a sign that a celebration (e.g., a marriage or community feast) was going to take place in the village. Two respondents reported that both GP and WBP were considered as delicacy meat.

Local Uses of Pangolin Scales

Local uses were mentioned for pangolin scales in the study area with 5% (N = 12) of respondents reporting uses for GP and WBP scales. Two *Baveuck* (Bantoid) women reported that the scales of the WBP, mixed with ground nut seeds had the power to increase harvest, or that by simply throwing them in different corners of the farm improved yam and cassava production. Three male and three female *Vute* (Bantoid) respondents stated that scales of GP mixed with seeds of melon and/or elephant faeces and throwing the mixture at different corners of the farm before sowing will increase harvest, while two respondents reported that GP scales were used in the past as a traditional bullet-proofing during times of war. Finally, two *Vute* respondents stated that pangolin scales were used for the preparation of medicine to purportedly cure hepatitis or as an antipoison.

Pangolin Hunting

The majority of respondents who recognised WBP, reported it to be hunted by people in the study area (82.9%, N = 165 of 199). Including education level in our GLM of WBP hunting improved model fit ($\chi2 = 17.366$, df = 2, $p < .001$); the model was fit using only the responses of people who recognised the WBP.

Respondents with no education were less likely to report WBP hunting than those with primary (GLM: odds ratio $0.159 \pm$ CI $0.048 - 0.529$, $p = .001$) and secondary+ level education (odds ratio $0.094 \pm$ CI $0.022 - 0.401$, $p < .001$).

More than half of the respondents who recognised GP claimed that the species was hunted by people in the study area (60.9%, N = 134 of 220). Thirty-two percent of respondents (N = 71) claimed people did not hunt GP, whilst 15 people did not know. In our model of GP hunting, including education level ($\chi 2 = 21.238$, df = 2, $p < .001$) and employment activity ($\chi 2 = 5.729$, df = 1, $p = .017$) improved model fit (which excluded people who did not recognise the GP). People with no education had significantly lower odds of reporting GP hunting than those with primary (GLM: odds ratio $0.262 \pm$ CI $0.098 - 0.700$, $p = .004$) and secondary+ level education (odds ratio $0.126 \pm$ CI $0.041 - 0.383$, $p < .001$). People who did not primarily work outside were significantly less likely to report that people in the village hunted GP compared to those who worked outside (odds ratio $0.403 \pm$ CI $0.191 - 0.850$, $p = .017$).

When asked whether WBP were specifically hunted, most respondents stated that they were not (70.9%, N = 141 of 199), whilst the remaining respondents (29.1%) reported that they did not know. Most of the respondents reported that people hunted WBP for local consumption (71.9%, N = 143), whilst 8.0% stated that it was for local consumption and income generation, 6.0% said that people had no alternatives to hunting, and the remainder did not know. Respondents most frequently reported that giant pangolin were either not specifically targeted by hunters in the village (37.7%) or that they did not know (35.9%), whilst 26.4% said that GP were specifically targetted. The most frequently reported reason for GP hunting was for local consumption and to generate income (42.7%), followed by for meat only (13.2%), that there were no alternatives to hunting (9.1%), or for income only (2.7%), whilst the remainder did not know. Of those who recognised the BBP, 41.7% stated that the species was hunted. The only reason stated for hunting BBP was for meat (29.2%), and nobody said the species was specifically hunted by people.

Many hunting methods were reported to be used for hunting pangolins during our survey, and respondents were allowed to state more than one method. Of those who recognised WBP, the hunting methods reported were by hand (50.7%), snare (39.7%), club (11.6%), and cutlass (8.5%). For GP, the hunting methods reported were snare (70.9%), cutlass (28.2%), gun (15.0%), hand (4.5%), and club (2.7%). Finally, most people who recognised the BBP did not know the hunting method (58.3%), whilst the remainder reported snare use (37.5%) or by hand (16.7%).

Discussion

This study aimed to investigate the local knowledge and uses of pangolins within communities around MDNP, an area of ecological and cultural importance. Our LEK-based approach permitted an overview of local knowledge, perceived population trends, cultural importance, and hunting dynamics of pangolins in the study area. Overall, our results reinforce the notion that local knowledge and consumptive uses of wildlife are important to consider in conservation planning and prioritisation, and that LEK-based methods can provide a valuable snapshot of the potential status and threats of data-poor and elusive species such as pangolins (Archer et al., 2020; Nash et al., 2016).

Pangolin Recognition, Sighting, and Perceived Population Trends

Our findings suggest that both white-bellied and giant pangolins are well known by local communities, and the majority of respondents reported to have seen them at least once in their lives. This can be explained by the dependence of local people on forest resources for food and livelihoods, the use of unselective snaring in hunting and to protect their farms, and the presence of pangolins occasionally offered for sale in the village or at markets. White-bellied pangolin is considered to be the most common pangolin species, inhabiting rainforest and forested savannah, and residents of the study area report the species to come close to human settlements e.g., one respondent claimed to have caught WBP more than once in his kitchen. We found that the respondents from the Atlantic ethnolinguistic group were less likely to recognise both WBP and GP than people from other ethnolinguistic groups. This is perhaps because members of this group are typically nomadic pastoralists, and largely lived in the northern savannah region of the study area. Few respondents recognised the BBP, and did not misidentify the species with WBP as observed elsewhere (Difouo Fopa et al., 2020; Ichu et al., 2017; Swiackà, 2019). Those that did recognise the BBP, reported it to occur in the Eastern part of MDNP, where the predominant habitat type is dense forest, as opposed to forest-savannah mosaic in other parts of the park. Further field studies are needed to confirm the presence and distribution of the BBP within the national park and surrounding areas.

We found that WBP was often seen within the prior week, and that younger respondents were more likely to have seen WBP more recently. This is likely due to younger respondents spending more time practising forest activities or outdoor livelihoods than older respondents. White-bellied pangolin is frequently reported to occur on farmlands, and degraded habitats outside of

protected areas (Khwaja et al., 2019), thus increasing the chances of encounter. Men were more likely to last see a WBP in the bush compared to women, who were more likely to see the species in the village, which is likely due to gendered differences in labour activities. The perceived population trend for WBP was mixed amongst respondents (as in Difouo Fopa et al., 2020), but we found that those who had seen WBP more recently were more likely to perceive its population to be increasing. Similar results were also found in Archer et al. (2020) for the Philippine pangolin. As the perceived trend is sensitive to the recent experiences and age of respondents, perceived population trend data should be interpreted with caution, especially from younger respondents. We recommend that such results are used as a preliminary method of selecting areas for more robust threat assessments and species population monitoring.

Most of the respondents reported to have seen GP a year or more ago, which could be due to its low density (Willcox et al., 2019), or scarcity in the study area. Most respondents perceived the population trend of GP to be decreasing, with older respondents more likely to perceive a declining trend. Older respondents may be more likely to report declines due to shifting baseline syndrome, whereby the perceived threshold of environmental conditions that is considered 'normal' is downgraded across generations (Jones et al., 2020; Soga & Gaston, 2018). For example, in the past, giant pangolins may have been more abundant, and hunted just for local consumption, but the species may have declined in the area possibly due to overhunting for subsistence or commercial purposes. This would corroborate evidence from several studies in western Cameroon reporting that GP had declined or may have already been locally extirpated (Abugiche, 2008; Laurent, 1992; Mouté, 2010; Ngoufo et al., 2014).

Cultural Importance and Local Perceptions of Pangolins

In our ecologically and culturally diverse study area, we found that nearly all reported cultural importance of pangolins were specific to giant pangolins, and nearly all those who reported such importance were older men. Whilst the number of responses was low, thus we do not ascribe cultural importance broadly within ethnic groups or across the study area, several older *Gbaya* (Adamawa-Ubangi) men stated that the giant pangolin was a sacred animal, and considered the species to be a food taboo for women which has also been reported by Ichikawa (1987) for pregnant women in northeastern DRC. A couple of men from the ethnic groups within the Bantoid ethnolinguistic group reported that giant pangolin was a totem animal, which in some cases was reserved for chiefs. This is similar to results from two studies in the Salonga-Lukenie-Sankuru Landscape of the Democratic Republic of Congo (DRC), where giant pangolin has also been reported as a totem animal for the Nkundu people (Steel et al., 2008), a Mongo sub-group within the Bantu language classification, and where the species was not allowed to be eaten alone otherwise there will be a bad omen or death in the family (Abernethy et al., 2010). Whilst not necessarily culturally significant, we also found an association between pangolins and luck, whereby 15% of all Bantoid men surveyed considered giant pangolin to be bad luck. Luck has been associated with pangolins across West Africa (Soewu et al., 2020), and in southern Africa for Temminck's pangolin (Baiyewu et al., 2018; Setlalekgomo, 2014).

Local Uses of Pangolin Scales and Hunting

Very few local uses of pangolin scales, including for traditional medicine, were reported by the communities around MDNP. The most commonly reported use (although still very infrequent) was to increase agricultural yields, which was also reported by Difouo Fopa et al. (2020) in the Centre and East regions of Cameroon. Most respondents who stated this use were female, and from the Bantu or Bantoid ethnolinguistic groups. Although these ethnolinguistic groups contain several hundred ethnic groups, they are typically known as agriculturalists. It is likely that these local uses of scales do not drive pangolin hunting, but are a byproduct of pangolins consumed as bushmeat.

In the villages surrounding MDNP, nearly all respondents stated that WBP were hunted, and more than half reported GP to be hunted. Hunting was less likely to be reported by respondents with lower education levels for both species, and those who worked outside were more likely to report GP hunting. Our results confirmed hunting for local bushmeat consumption and to generate income, and confirm that the most commonly reported hunting methods were hand/snare for WBP, and snare for GP, similar to many other parts of Central Africa where snares are low cost and widely available (Ingram et al., 2018; Wright & Priston, 2010). Specific hunting of GP was reported by a quarter of respondents, but was confirmed during the first author's fieldwork inside the park when GP burrows were observed with traps set at the entrance (Figure 5A). Consumption of giant pangolin was also confirmed when the first author found giant pangolin meat available for sale in one of the survey villages (Figure 5B). The hunting motivation could be the large amount of meat and scales due to its large size (~30 kg), and GP scales appear frequently in law enforcement records in Cameroon (Ingram et al., 2019). Anecdotally, respondents reported specific

Figure 5. Photos of a snare trap installed at the entrance of a giant pangolin burrow entrance in MDNP (A) and giant pangolin meat on sale in one of the survey villages (B). Photo credit: Alain Delon.

hunting to be recent, since 2015, during which time an increase in demand in international trafficking has been observed (Heinrich et al., 2017; Ingram et al., 2019). By the time of this study, many of the respondents and even the conservation staff reported that trafficking of GP scales has been reduced since then due to an increase in the number of patrols, arrests and prosecutions around the park. However, further investigations are needed to ascertain whether the dynamics of hunting and trade has actually changed. Given the sensitive nature of questions asked in our surveys, respondents might have been reluctant to be honest about the magnitude of illegal hunting activities concerning pangolins in MDNP and there is a risk that the data underestimate the scale of hunting.

Implications for Conservation

Given the recent increase in pangolin trafficking both at local and international levels, there is an urgent need to fill the large gaps in data on pangolin ecology and the extent of potential threats needed to inform conservation action and management. Despite the caveats of the study, our results showed that local knowledge can play a central role in ascertaining species presence and potential threats to them. We found strong evidence that at least two species of pangolin persist in our study area, and likely a third species, but that they may be threatened by hunting for local consumption and income generation due to a lack of alternatives. Coupled to these are the perpetual constraints facing protected areas in developing countries such as Cameroon: insufficient personnel, lack of logistics and insufficient finances. As our contribution to pangolin conservation within the MDNP landscape, we recommend the following research and actions:

Research needed to bolster conservation planning efforts:

1. Undertake ecological monitoring to determine whether black-bellied pangolin occurs in the national park, and to quantify population sizes of all pangolin species;
2. Determine trade routes, actors, and dynamics to identify target areas for law enforcement activities.

Actions needed to reduce hunting pressure on pangolins:

1. Increase awareness on wildlife laws and regulations e.g., by carrying out regular campaigns and/or using mass media such as radio as means of sensitization;
2. Establish equitable community-based conservation programs that engage local communities in the conservation process;
3. Increase the number of patrols within the park and the number of checkpoints on the recently constructed national road bordering MDNP;
4. Co-design and support the development of sustainable and environmentally-friendly livelihoods with local communities.

Acknowledgments

We thank the Ministry of Forests and Wildlife, Cameroon, Mbam and 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 are grateful to Mohamed Bin Zahed Species Conservation Fund (Grant ID: 190520489) and Chicago Board of Trade Chicago Zoological Society for providing funding for this research. We acknowledge Edgar Désiré Ambassa Ongono, Iya Paul, Kengne Paulin,

Tsetagho Guilain and finally the village chiefs and local communities for permitting us to work with them. DJI is supported by funding from the United States Fish and Wildlife Service.

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: Mohamed Bin Zayed Species Conservation Fund (Grant ID: 190520489) and Chicago Board of Trade Chicago Zoological Society.

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Supplemental material

Supplemental material for this article is available online.

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