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Perceptions and uses of pangolins (Pholidota) among remote rural communities in the Republic of the Congo: A baseline study from the Odzala-Kokoua National Park

Markéta Swiacká[1] | **Daniel J. Ingram**[2] | **Torsten Bohm**[3] | **Francisco Ceacero**[4]

[1]Department of Spatial Sciences, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic

[2]Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, UK

[3]African Parks, Brazzaville, Republic of the Congo

[4]Department of Animal Science and Food Processing, Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Prague, Czech Republic

Correspondence
Markéta Swiacká, Department of Spatial Sciences, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic.
Email: marketaswiacka@seznam.cz

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Abstract

Habitat loss and overexploitation are the most severe threats to wild animals in Central Africa. One mammalian group under pressure from hunting is the Pholidota (pangolins), with three species of pangolin inhabiting the region. While local uses of pangolins have been investigated in several Central African countries, data originating from the Republic of the Congo are lacking. To address this knowledge gap, we conducted a semistructured questionnaire survey in 65 rural communities around the Odzala-Kokoua National Park. Our research focused on collecting baseline information on local knowledge of species ecology, and perceived economic values and uses of pangolins in local communities. We identified significant differences in our data corresponding to respondents' sociocultural and demographic profiles in the surveyed villages. Recognition of pangolins was high (98.2%), we recorded 22 traditional medicinal or cultural uses of pangolins by respondents, and the taste of pangolin meat was ranked highly (71.3%). Respondents based along the northern boundary of the park were more familiar with pangolins and the market value of their meat and scales, which could be due to better quality roads in the area and proximity to Cameroon. We then provide guidelines for further research to better understand the dynamics of local use, needed for conservation policy and actions.

KEYWORDS

bushmeat, Congo Basin, local knowledge, *Phataginus tetradactyla*, *Phataginus tricuspis*, *Smutsia gigantea*, traditional medicine

1 | INTRODUCTION

In Central Africa, 4.5 million tons of animals are estimated to be hunted from the Congo Basin for wild meat (hereafter called bushmeat) each year (Nasi et al., 2011). Such volumes are considered to be unsustainable and threaten the majority of large African rainforest mammals (Abernethy et al., 2013). In large urban areas, bushmeat can be considered a luxury food, and a symbol of prestige notably for wealthy classes (Chausson

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et al., 2019; Duda et al., 2018; Gluszek et al., 2021; Mbete et al., 2011). For rural inhabitants, however, bushmeat is an essential source of food for many people, it can also provide an important source of income, and can be connected to the cultural identity and traditional beliefs of local communities (Ingram et al., 2021). This is particularly true for local communities in remote areas who often rely on natural forest resources. Across Central Africa, as with much of sub-Saharan Africa, traditional remedies and other ethnozoological practices involving the body parts of wild animals are deeply rooted in some local cultures and may be the only source of "medicine" for up to 80% of the continent's population (Alves & Albuquerque, 2017; Lee et al., 2020; WHO, 2010). While animal symbolism and species consumption taboos have been investigated in some hunter-gatherer ethnic groups such as the Baka (Duda et al., 2018) and other residents in the region (Lowes & Montero, 2019), the ethnozoological uses of wildlife (i.e., the many ways of wildlife utilization embedded within complex human-species relationships, including consumptive, medicinal, and spiritual uses) remain greatly understudied despite their likely importance to local communities and possible impacts on wildlife. Remote rural communities reliant on, and extracting, forest resources often live in areas adjacent to protected areas and national parks, and may therefore be at odds with conservation goals to protect wildlife. Local compliance with, and thus effectiveness of, rules may therefore be low. Understanding local values and uses of wildlife is therefore needed as a first step towards informing the design of equitable conservation measures (Alves & Albuquerque, 2017; Bennett, 2016; Lee et al., 2020).

Pangolins (Pholidota: Manidae) are one of many animal groups used for ethnozoological purposes, and they are globally threatened with extinction due to multiple anthropogenic factors such as overexploitation (for bushmeat and illegal international trade) and habitat loss (IUCN, 2022). All extant pangolin species are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora since 2017 (CITES, 2017) and are nationally protected in the majority of countries in which they occur (Vallianos, 2016). Four Asian species of pangolins have been intensively used in Traditional Chinese Medicine as well as for local consumption for decades in Eastern and South-East Asia (Sexton et al., 2021; Xing et al., 2020); and thus, their populations have been reduced dramatically (Wu et al., 2004). Consequently, a steady increase in demand for African pangolin species has been clearly identified in Asia since 2008 (Challender & Hywood, 2012; Ingram, Cronin, et al., 2019; UNODC, 2020; Zhang et al., 2020). Recent studies have identified that the main trafficking hubs of pangolin scales to Asia are countries in West and Central Africa (EIA, 2020; Emogor et al., 2021; Ingram, Cronin, et al., 2019; UNODC, 2020).

Three species of pangolins are distributed throughout Central Africa: the black-belied pangolin (*Phataginus tetradactyla*), the white-bellied pangolin (*Phataginus tricuspis*), and the giant pangolin (*Smutsia gigantea*), with limited information about their exact distributions and population sizes (IUCN, 2022). Pangolins are valued by many rural and urban Central Africans for their meat, and sometimes other body parts such as their scales (Brittain, Kamogne Tagne, et al., 2022; Duda et al., 2018; Ingram et al., 2018; Malimbo et al., 2020; Mouafo et al., 2021). Ingram et al. (2018) estimated that ~400 thousand pangolins are hunted in Central African forests each year for meat, with the most widespread and commonly available species on the bushmeat markets being the white-bellied pangolin. In some West and Central African countries, pangolins also have a significant role in some traditional remedies and cultural activities (Boakye et al., 2014; D'Cruze et al., 2020; Fopa et al., 2020; Ingram et al., 2022; Mouafo et al., 2021; Nguyen & Roberts, 2020; Soewu et al., 2020; Soewu & Ayodele, 2009; Zanvo et al., 2021).

In the Republic of the Congo (RoC), only two pangolin species, the white-bellied and the giant, are fully protected by Congolese law, whereas the third pangolin known to occur in the RoC, the black-bellied pangolin, receives no formal protection (Arrêté n° 6075 of the 9th of April 2011; MEFDD, 2011). Most information about pangolins in the RoC refers to seizures (Ingram, Cronin, et al., 2019; Shepherd et al., 2016), or bushmeat hunting and market reports (Hennessey & Rogers, 2008; Ingram et al., 2018; Mockrin et al., 2011). Recently, Gore et al. (2021) characterized the types of individuals involved in urban trafficking of scales and meat, and Gluszek et al. (2021) evaluated the value of pangolins for the bushmeat trade in Brazzaville. However, until now, identification of local knowledge, perceptions and uses of pangolins by rural local communities located in pangolin source areas has not been explored in the RoC, particularly in relation to traditional medicine and cultural practices, which provides crucial information to determine patterns in local demand for pangolins. This community inclusion is one of the key elements for effective and long-term conservation practices which is often ignored in decision-making (Bennett, 2016).

We aim to explore the local knowledge, demand, and uses of pangolins among remote rural communities around the Odzala-Kokoua National Park (OKNP, northern RoC), a topic which has been identified as a significant knowledge gap (see Heighton & Gaubert, 2021). Here, this study documents baseline information about: (1) the local knowledge and perceptions of rural communities about pangolin ecology, (2) the perceived market

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value of pangolins by surveyed communities as an indicator of demand and possible trade dynamics (Mambeya et al., 2018), and (3) the local uses of pangolins. Specifically, we seek to identify differences in the responses of stakeholders based on their sociocultural and demographic characteristics that might be useful for designing conservation measures more effectively and equitably. Our findings will also provide a fundamental baseline for future research on pangolins in northern RoC, valuable for informing conservation practitioners, policy-makers, and law enforcement officials, about the current uses and value of pangolins in the local area.

2 | METHODS

2.1 | Study area

Our study focused on communities located in the immediate vicinity of the OKNP (Figure 1) in the RoC, Central Africa (0°09′–1°35′N, 14°18′–15°21′ E). The OKNP is the largest protected area in the RoC (~13,600 km^2) and the park intersects both the Sangha and Cuvette Ouest departments, which had a combined population of more than 180,000 in 2010 (FCPF, 2014; Latour & Stiles, 2011). The major regional urban settlements are Etoumbi, Makoua, Ouesso, and Sembé, with a total population of around 45,000 (Buttoud & Nguinguiri, 2016). The population is comprised of several Bantu sub-ethnic groups as well as hunter-gatherer Indigenous people (Baka, Mbendjele, Mikaya, Luma, Gyeli, Twa, Babongo) that live in communities of varying sizes along the border of the park. The Indigenous people often live together in camps on the periphery of Bantu villages. All ethnic groups in the area extract natural resources from the forest (including in the OKNP) to varying extents, and the main livelihood activities of the local populations involve a mixture of farming, hunting, fishing and, in the northern part of the park, growing cocoa in plantations. Small-scale supplementary incomes from formal work rarely exist and thus, unemployment is common (Latour & Stiles, 2011; Robineau, 1987).

The OKNP, created in 1935, is considered to be one of the oldest protected areas in Africa, and since 2010 the

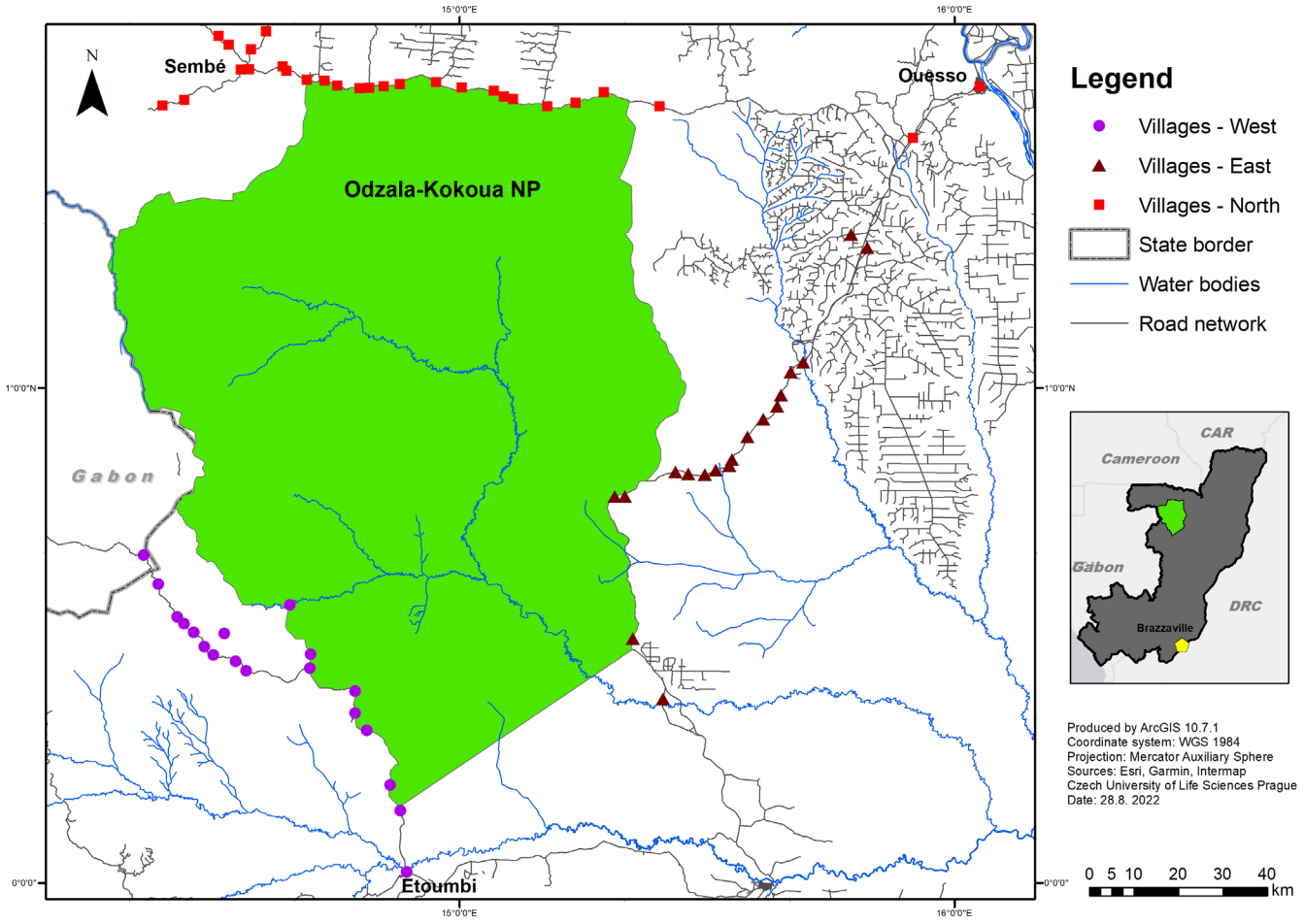

FIGURE 1 Surveyed communities (villages, towns) situated near to the Odzala-Kokoua National Park in the Republic of the Congo

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park has been managed by the African Parks Network (African Parks, 2022). The average annual temperatures are between 23 and 25 °C with two dry and two rainy seasons. The major vegetation types are closed and open-canopy forests (interspersed with swamps, watercourses and rivers) with an understory dominated by plants of the families Marantaceae and Zingiberaceae (Hecketsweiler et al., 1991). A forest-savanna mosaic, dominated by Gramineae (*Andropogon schirensis*) with scattered fire-resistant shrubs (*Hymenocardia acida*), of the size of around 800 km^2 is found in the south of the park (Dowsett-Lemaire, 1996). The area is a stronghold for many different animal species including forest elephant (*Loxodonta cyclotis*), western lowland gorilla (*Gorilla gorilla gorilla*), and other large-bodied species (Hecketsweiler et al., 1991).

The study took place in 65 settlements/villages situated around the OKNP, chosen because they were located in close proximity to the park (Figure 1). Furthermore, so that we could include a more representative sample of the diversity of local communities around the park, we divided the area into three groups (west, east, and north) and selected villages within each group. The western group stretched from the Gabonese border to Etoumbi, while the eastern group comprised villages between Makoua and Ouesso, found along the National Road 2 (NR2). The northern group comprised villages that were located close to the northern boundary of the protected area between Ouesso and Sembé.

2.2 | Data collection

Fieldwork was conducted from May to June 2018 during the open hunting season (May–October), when hunting using shotguns and traditional methods is permitted (Mockrin et al., 2011), and respondents may be more likely to discuss hunting activities. Data were gathered by the first author (female) with the help of a Congolese research assistant (male) who spoke French and Lingala, two out of three officially-used languages in the RoC. In each village, the researchers first approached the chief of the village to obtain verbal consent for community entry and permission to engage in research activities. Given that some of the villages had a low number of inhabitants, and we wanted to sample a large number of villages with the resources available, we decided to sample six respondents per village. Respondents were selected using a non-probability convenience sampling strategy with a partial application of the snowball and target techniques (Gorard, 2003; Newing, 2011) due to limited time, resources available, and the characteristics of the sampling area (e.g., remoteness, lack of the cartographic data, and size of the study area). Nevertheless, the participation of the respondents was largely defined by their availability and willingness on the day of survey. We could not accomplish the aimed quantity of completed questionnaires in two villages because of the shortage of available people at the time of our visit. Only people above 18 years old were included in the study. Initially, we attempted to conduct the survey with individuals without an audience; however, the respondents were not comfortable with this due to a tradition of collective society, and thus, questionnaires were completed in front of the other people present at that time, which varied greatly. While this could lead to possible bias, that is, audience effects (Newing, 2011), questions were not deemed locally sensitive due to the calm position of the respondents that were observed throughout the survey. The researchers reduced these sources of potential bias during the survey through several means: (1) researchers remained neutral and consistent, (2) one male and one female researcher were present at all times, and (3) all respondents were ensured anonymity and that there were no correct responses to avoid other potential biases (Brittain, 2019; Newing, 2011).

The survey was conducted face-to-face with respondents using a semistructured questionnaire (see Supporting Information) comprising open-ended and structured questions, to collect sociodemographic descriptions of the respondents and information about pangolins. The questionnaire was prepared in French but implemented primarily in Lingala because many respondents did not speak fluent French. Direct translation from Lingala to French was conducted immediately simultaneously by the Congolese research assistant. The sociodemographic factors included gender, age, education level, ethnic group, occupation, engagement in hunting, information about the residency of the respondents, and location of the surveyed village in the park. Three levels of education are distinguished in the RoC: primary, secondary (divided into four-years long "college" and three-years long "lycée"), and tertiary. Ethnic groups were categorized into four main groups (Kwele, Mboko, Kota, Indigenous people) and "others" representing the remaining minor ethnic groups or people originating from the surrounding countries (altogether another 18 ethnic groups and residents from Cameroon, Central African Republic, Democratic Republic of Congo, Chad or Ivory Coast were recorded). Livelihoods of the respondents varied largely and therefore, the activities were grouped into five different classes based on the primary occupation mentioned by respondents: "farming," "hunting," "mixed activities" (activities equally distributed, mainly involving farming

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and hunting), "salaried work," and "others." The "others" category comprised village chiefs, students, and unemployed and retired respondents. Respondents who answered positively to the question "Have you ever hunted?" were considered to be engaged in hunting. Then, respondents were regrouped into the following four different categories based on their length of time spent in the surveyed village: "I do not live there" (0 years), "less than two years," "more than two years" and "whole life." Finally, respondents were divided into three categories according to their surveyed location around the OKNP: "west," "east," and "north." The second section of the questionnaire was dedicated to the respondent's knowledge and perceptions about pangolins and uses of these animals. Photos of all three pangolins living in the area were presented at the beginning of each questionnaire in case of respondent uncertainty. Based on the limited time spent in each village, the survey was conducted at various times of day.

2.3 | Data analysis

All statistical analyses were performed using the IBM SPSS Statistics software (version 25.0; IBM, USA). After regrouping data from open-ended questions, all variables became categorical (nominal or ordinal; Newing, 2011). Data were analyzed using a combination of descriptive statistics (frequencies, percentages), Correspondence Analysis (CA), Multiple Correspondence Analysis (MCA) and Generalized Linear Mixed Models (GLMMs). CA and MCA techniques enable the relationships between several categorical variables to be explored and help to visually understand the respondent profiles in several dimensions (Costa et al., 2013; Hjellbrekke, 2018). In our study, this was used to differentiate respondents according to their knowledge of pangolin ecology and market values. In MCA, the variable principal normalization method was used to investigate the relationship among the six dependent variables, as it is recommended for understanding the correlation among three and more categorical variables (see Figure 2). Regarding the CA, the symmetrical normalization method, recommended for examining the differences between the categories of two variables, was applied to identify the connectivity between the education level of the respondents and their pangolin meat taste ranking (see Figure 3). The two-dimensions solution was selected to be the most adequate both for MCA and CA since they explained most of the variance in the data set.

To explore the relationships between the independent (predictor) variables and the dependent (response) variable, GLMMs were used due to the non-normally distributed and primarily binary character of the data. The mixed model approach was used to account for the structured character of the data (respondents in villages). The ethnic groups of the respondents were not included in the modeling due to a significant correlation with the variable location ($rs = -0.421$, $p < .001$). Otherwise, multicollinearity among the rest of the predictor variables was tested by Variance Inflation Factor (VIF) and was not found to be high in any of the variables. We determined a total of seven predictor variables (gender, age, education, engagement in hunting, occupation, residency status, location) describing the respondent's knowledge and market values of pangolins, and their local uses: (1) last

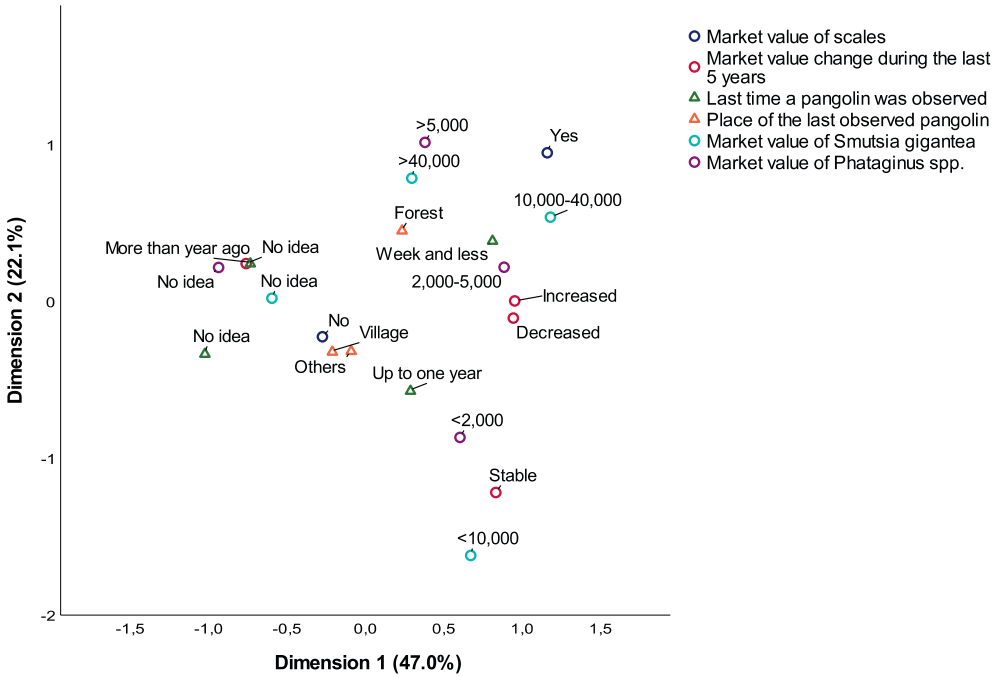

FIGURE 2 Joint plot of the chosen dependent variables about pangolins explaining the relationship among the categories in two dimensions; and evaluated by Multiple Correspondence Analysis ($n = 376$)

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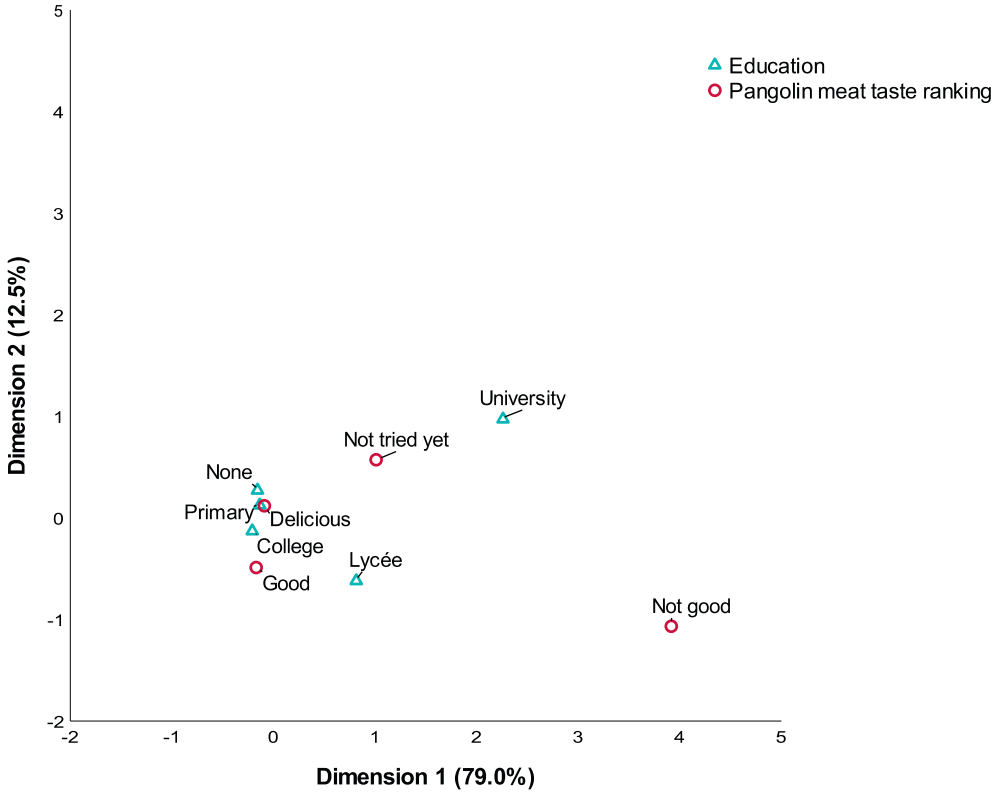

FIGURE 3 Biplot of the association between education and pangolin meat taste ranking variables; and evaluated by Correspondence Analysis ($n = 376$)

time a pangolin was observed, (2) knowledge about pangolins, (3) knowledge of market values of pangolins, (4) knowledge of market value of pangolin scales, (5) medicinal and cultural usage of pangolins, and (6) consumption preferences of pangolins. Education and residency status were ordinal predictors while the rest of the predictors were nominal. Villages and ID of the respondents were established as subjects. Villages were also included as a random effect in the models to account for structure in our data and variation (Bolker et al., 2009). Responses were not included in GLMMs when respondents did not know the answer to a question. For most models, we used binomial distribution with a logit link, but for one model the gamma distribution with a log link function was used. Based on the significance level ($p < .05$), the variables were removed from the model following the stepwise backward selection method. The nonsignificant predictors were eliminated one by one until the final model consisted only of significant effects (Harrison et al., 2018).

3 | RESULTS

3.1 | Sociodemographic description of the respondents

Altogether, our survey yielded 387 questionnaires carried out with local people living in 65 villages around the OKNP, and each questionnaire was completed in 2–33 min. Most of the respondents were men ($n = 338$, 87.3%) engaged in hunting ($n = 245$, 63.3%), aged between 18–30 years old ($n = 129$, 33.3%), had a college education ($n = 148$, 38.2%) and were from the Kwele ethnic group ($n = 137$, 35.4%) living in the northern border of the park ($n = 169$, 43.7%; Table 1).

The majority of the respondents could accurately identify pangolins ($n = 380$, 98.2%) and reported their local names depending on the locality and ethnic language. Communities distinguished mostly two different types of pangolins. The two "small pangolins" (*P. tricuspis*, *P. tetradactyla*) living in the RoC were called *zele* by the Kwele, *kokolo* by the Indigenous people, and *kaka*, *lekara*, *lekaka* and *okara* by the other ethnicities (western and eastern boundaries of the park). The giant pangolin (*S. gigantea*) was called *guime* by the Kwele, *kelepa* by the Indigenous people, and other ethnic groups commonly recognizing them by the term *pige* (western and eastern boundaries of the park).

3.2 | Local knowledge of pangolins

Of 376 respondents (97.2%) who self-reported having seen a pangolin at least once in their life, 315 respondents (83.8%) recognized two species of pangolins, 30 respondents (8%) said they could recognize three species of

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TABLE 1 Sociodemographic description of the respondents living in the communities situated near to the Odzala-Kokoua National Park ($n = 387$)

Independent variables	Count (n)	Valid percentage (%)
Gender		
Men	338	87.3%
Women	49	12.7%
Age		
18–30	129	33.3%
31–40	107	27.6%
41–50	82	21.2%
51–60	46	11.9%
60+	23	5.9%
Education		
None	83	21.4%
Primary	105	27.1%
College	148	38.2%
Lycée	41	10.6%
University	10	2.6%
Ethnic group		
Kwele	137	35.4%
Mboko	70	18.1%
Kota	51	13.2%
Indigenous people	42	10.9%
Others	87	22.5%
Occupation		
Farming	134	34.6%
Hunting	41	10.6%
Mixed activities	110	28.4%
Salaried work	60	15.5%
Others	42	10.9%
Engaged in hunting		
Yes	245	63.3%
No	142	36.7%
Residency status in the village		
I do not live there	32	8.3%
Less than 2 years	41	10.6%
More than 2 years	103	26.6%
Whole life	211	54.5%
Location of the respondents		
Western border of the park	111	28.7%
Eastern border of the park	107	27.6%
Northern border of the park	169	43.7%

pangolins, and 31 respondents (8.2%) said they could not distinguish the various species. Moreover, almost all respondents ($n = 329$, 87.5%) encountered more often *Phataginus* spp. compared to *Smutsia gigantea* ($n = 9$, 2.4%), and 12 respondents (3.2%) mentioned that they observed the species at a similar frequency. The respondents who were aware of three species ($n = 30$) in the study area determined the third species (*P. tetradactyla*) to be a diurnal animal in comparison to the two others. Additionally, this species was known to live secretively in higher tree crowns and to have a black color of skin. The majority of the respondents ($n = 325$, 86.4%) provided supporting information about pangolins; mostly reported their habitat preferences, appearance, or myrmecophagous specialization of feeding. This previously mentioned knowledge about pangolins was significantly lower in women ($\beta = -1.138 \pm 0.455$, $t = -2.499$, $p = .013$), and higher in older respondents ($\beta = 0.606 \pm 0.184$, $t = 3.290$, $p = .001$) and hunters ($\beta = 2.391 \pm 0.491$, $t = 4.868$, $p < .001$; Table 2).

Of the respondents, 140 (37.2%) mentioned that they last observed a pangolin "a long time ago" for the last time, followed by "up to one year ago" ($n = 120$, 31.9%), "one week or less" ($n = 102$, 27.1%) and 14 people (3.7%) did not know. GLMM analyses revealed that time since last observation was predicted by respondent age, occupation, engagement in hunting, and location. Pangolins were detected more recently by the younger groups for the last time, and the likelihood of detection decreased with increasing respondent age ($\beta = 0.046 \pm 0.015$, $t = 3.072$, $p = .002$; Table 2). Hunting respondents were more likely to have observed pangolins more recently than nonhunters ($\beta = -0.175 \pm 0.046$, $t = -3.837$, $p < .001$), and similarly, respondents whose principal occupation was hunting observed a pangolin for the last time significantly more recently ($\beta = -0.166 \pm 0.082$, $t = -2.021$, $p = .044$). Finally, respondents from the western ($\beta = 0.318 \pm 0.067$, $t = 4.756$, $p < .001$) and eastern ($\beta = 0.392 \pm 0.068$, $t = 5.772$, $p < .001$) border of the park were significantly more likely to have observed pangolins less recently in comparison to those from the northern border of the park. Regarding the last time a pangolin was observed, more respondents reported that these pangolins were alive ($n = 213$, 56.6%) than dead ($n = 163$, 43.4%). Respondents stated that they observed a pangolin for the last time in the "forest" ($n = 156$, 41.5%), "village" ($n = 137$, 36.4%) and in "other" areas ($n = 83$, 22.1%) including markets, fields, roads and other villages. Almost all respondents ($n = 363$, 96.5%) were aware of the protection status of pangolins in the RoC, only three people (0.8%) assumed that pangolins were not protected species and 10 people (2.7%) did not respond to the question.

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TABLE 2 Summary of the effects of sociodemographic factors on the selected dependent variables about pangolins provided by respondents living in the communities situated near to the Odzala-Kokoua National Park

Response variables	Function	Significant predictors	*F*-values	*p* values
(1) Last time a pangolin was observed	Gamma log	Age	$F_{1,353} = 9.439$	.002
		Occupation	$F_{4,353} = 2.630$	.034
		Engaged in hunting	$F_{1,353} = 14.724$	<.001
		Location	$F_{2,353} = 20.266$	<.001
(2) Knowledge about pangolins (Y/N)	Binomial	Gender	$F_{1,372} = 6.243$	.013
		Age	$F_{1,372} = 10.823$	.001
		Engaged in hunting	$F_{1,372} = 23.700$	<.001
(3) Knowledge of market values of pangolins (Y/N)	Binomial	Engaged in hunting	$F_{1,372} = 6.083$	.014
		Location	$F_{2,372} = 6.580$	.002
(4) Knowledge of market value of pangolin scales (Y/N)	Binomial	Education	$F_{1,368} = 4.649$	.032
		Occupation	$F_{4,368} = 2.934$	.021
		Location	$F_{2,368} = 7.808$	<.001
(5) Medicinal or cultural usage of pangolins (Y/N)	Binomial	Education	$F_{1,370} = 10.367$	.001
		Occupation	$F_{4,370} = 4.305$	.002
(6) Consumption preferences of pangolins (Y/N)	Binomial	Engaged in hunting	$F_{1,352} = 5.646$	.018

3.3 | Perceived market value of pangolins

A total of 221 respondents (58.8%) reported the market value for either *Phataginus* spp. or *Smutsia gigantea*. The likelihood of being able to report pangolin prices increased with being a hunter ($\beta = 0.726 \pm 0.294$, $t = 2.466$, $p = .014$; Table 2). Conversely, being a respondent from the western border of the park significantly decreased the likelihood of knowing pangolin prices ($\beta = -1.818 \pm 0.507$, $t = -3.588$, $p < .001$). A wide range of the prices for *Phataginus* spp. were reported and grouped into categories: "up to 2,000 CFA" ($n = 83$, 22.1%; seven respondents answered 500 CFA per body part and the rest of the prices were per the whole individual), "2,000–5,000 CFA" ($n = 116$, 30.9%; prices only per the whole individual), "more than 5,000 CFA" ($n = 10$, 2.7%; prices only per the whole individual) and those who did not know ($n = 167$, 44.4%). Similarly, the prices for *Smutsia gigantea* were divided into three main groups: "up to 10,000 CFA" ($n = 41$, 10.9%; nearly all prices were dedicated only to a part of the body), "10,000–40,000 CFA" ($n = 88$, 23.4%; prices only per the whole individual) and "more than 40,000 CFA" ($n = 18$, 4.8%; prices only per the whole individual), but the majority of the respondents did not report a price ($n = 229$, 60.9%). Moreover, the respondents were asked about whether there had been a market value change during the last 5 years; most did not know ($n = 206$, 54.8%), the others reported that prices had mostly increased ($n = 104$, 27.7%), or remained stable ($n = 39$, 10.4%) while only 27 people (7.2%) considered the price to have decreased. Some of the respondents ($n = 72$, 19.1%) were also aware of the market value of pangolin scales (Table 2); with significantly higher recognition of the scale prices for those with higher education ($\beta = 0.346 \pm 0.160$, $t = 2.156$, $p = .032$) and for those whose primary occupation was hunting ($\beta = 1.601 \pm 0.706$, $t = 2.270$, $p = .024$). Contrarily, respondents from the western ($\beta = -2.214 \pm 0.587$, $t = -3.770$, $p < .001$) and eastern ($\beta = -0.971 \pm 0.459$, $t = -2.116$, $p = .035$) border of the park were significantly less likely to know the price of pangolin scales.

The MCA analysis showed that the respondent's perception of market values and observation were mainly explained by axis 1 (47%; Figure 2, Table S1). The first dimension was presented by eigenvalue 2.819, inertia 0.470, Cronbach's alpha 0.774; and that the second dimension was demonstrated by eigenvalue 1.328, inertia 0.221, Cronbach's alpha 0.296. Thus together, both axes explained 69% of the variance. As a result of the joint plot (Figure 2), two clear profiles of the respondents with associated categories were determined. The first profile was characterized by the respondent's knowledge of prices of both scales and pangolins, seeing a pangolin more recently and in the forest. The second profile was dominated by the respondents who did not report knowledge about the market value of pangolins, and last observed a pangolin in places other than forest and less recently.

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3.4 | Uses of pangolins

A minor proportion of the respondents ($n = 73$, 19.4%) reported cultural or purported medicinal values of pangolins (Table 2), and the likelihood of reporting uses for traditional medicine increased with higher education ($\beta = 0.503 \pm 0.156$, $t = 3.220$, $p = .001$), and for people who were in the mixed activities category for their primary occupation ($\beta = 1.328 \pm 0.581$, $t = 2.285$, $p = .023$). In total, 22 different uses were reported, with sexual bewitchment of women by powder from pangolin scales being the most reported by respondents (Table 3).

Nearly all respondents ($n = 354$, 94.1%) had eaten a pangolin at least once in their life and most of them ($n = 268$, 71.3%) attributed the highest taste rank to the meat ("delicious"), followed by "good" ($n = 82$, 21.8%), and only four people (1.1%) reported the taste as "not good." CA analysis determined a statistically significant association between the education level of the respondents and pangolin meat taste ranking ($\chi^2 = 26.294$, $p = .010$), and two dimensions explained 91.5% of a total inertia 0.070 quantifying the variability of the data. The categories with the similar values were associated together (Figure 3); the indistinct profiles of the respondents were situated close to the origin, in our case represented in the second dimension by the categories "none" (0.272), "primary" (0.125) and "delicious" (0.119). Conversely, the categories "university" (2.260), "lycée" (0.816), "not good" (3.917), and "not tried yet" (1.011) were further from the origin and thus highly discriminated in the first dimension. Therefore, the closer two categories were, the closer their profile patterns were to each other. Additionally, 259 respondents (68.9%) expressed their preference for pangolins compared to other animals. Preference for pangolins was significantly influenced solely by being engaged in hunting ($\beta = 0.780 \pm 0.328$, $t = 2.376$, $p = .018$; Table 2).

TABLE 3 List of all medicinal or cultural usage of pangolin scales reported by respondents living in the communities situated near to the Odzala-Kokoua National Park ($n = 73$)

Uses of pangolins	Count (*n*)
Sexual bewitchment	34
Healing of wounds	12
Healing of skin diseases	11
Strength support	11
Healing of hemorrhoids	9
Remedy for constipation	7
Artificial nails	5
Luck maintenance	5
Field protection against other animals	4
Protection against witchcraft	3
Healing of mycosis	3
Protection against snake venom	3
To be bulletproof	3
Protection for pregnant women	3
Tool for playing a guitar	2
Potency support	2
Healing of ear infection	1
Against body pain	1
Healing of asthmas	1
Healing of scabies	1
To have a long life	1
Totem	1

4 | DISCUSSION

We set out to collect baseline information about the local significance of three species of pangolins (*P. tetradactyla*, *P. tricuspis*, *S. gigantea*) in the lives of communities surrounding the OKNP in the RoC, representing the first in-depth study of local knowledge and uses of pangolins in the country. Our results showed that pangolin species are favored for meat locally, and that the meat is consumed across the study area despite their protected status. Of our sampling population, we also identified strong variation in the responses of the participants, based on their sociodemographic characteristics, concerning the information related to the market value of pangolins in the north of the OKNP. Moreover, we provide evidence of ethnozoological uses of pangolins in this region, which are important to consider for finding solutions in the coexistence of conservation management and maintenance of local identity. Given the vulnerability of all pangolin species (IUCN, 2022), the large volumes of pangolin scales seized internationally that originate from Africa (Emogor et al., 2021; UNODC, 2020), and the weak law enforcement in this region (EIA, 2020), we propose that conservation initiatives target threatened areas of high biodiversity value that pangolins inhabit, such as the OKNP.

Local knowledge of communities can provide a wide range of information about species living in the study area and reflects the need for a collaborative and comprehensive approach to conservation (Archer et al., 2020; Brittain, Rowcliffe, et al., 2022; Fopa et al., 2020; Huntington, 2000; Mouafo et al., 2021). However, species misidentification happens commonly and can largely impact the reliability of data and generate biases (Newing, 2011; Willcox et al., 2019). Due to this, we do

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not make conclusions based solely on local knowledge of pangolins, because the use of long-term standard ecological monitoring is needed, possibly in combination with the other methods (Brittain, Rowcliffe, et al., 2022; Ingram, Willcox, & Challender, 2019; Willcox et al., 2019). However, just as in the other studies in West and Central Africa (Fopa et al., 2020; Mouafo et al., 2021; Segniagbeto et al., 2020), the white-bellied pangolin was reported to be the most observed species. Furthermore, only 30 respondents (8%) recognized with certainty the black-bellied pangolin, which was similarly reported in Cameroon (Fopa et al., 2020; Mouafo et al., 2021). Black-bellied pangolins are known as one of two "small pangolins," so some respondents may easily mistake them, which we also noticed during the survey in a few cases. Given that this species lives in the canopy level of trees, it is very rare to encounter them (Fopa et al., 2020). To acquire more details about the species occurrence, more accurate monitoring methods are needed (Ingram, Willcox, & Challender, 2019; Willcox et al., 2019). Interestingly, the detection rate of pangolins was also significantly increased by being a respondent from the northern border of the park. More evidence and insights into trade are required to understand what this might mean, for which spatial analysis could be useful (Zanvo et al., 2020), and we emphasize that research attention should focus on this region.

Most of the respondents were based on the northern boundary of the park (Figure 1) where the Kwele people are one of the dominant ethnic groups (Dorier-Apprill & Ziavoula, 1996; Latour & Stiles, 2011). In fact, the Kwele ethnic group inhabits northeast Gabon, the north part of the RoC, and southeast Cameroon, with a total estimated 21,300 individuals (People Groups, 2022). Kwele are Bantu-speaking people, and their livelihoods are diversified with a primary dependence on farming, cash cropping, and fishing (Oishi, 2013; Oishi, 2016). In our results, respondents from the northern border of the park noted a more recent sighting of pangolins than in other parts of the park. The villages in the northern periphery were situated closer to the OKNP, where it is potentially easier to spot a pangolin in less disturbed forest. Furthermore, these respondents reported significantly more information about the market value of pangolins and their scales in comparison to the western and eastern border of the park. Little is known about the differences among the ethnic groups in the northern Congo, and we are not aware of any reason why this ethnic group would be more involved in any sort of illegal activity any more than another ethnic group. However, this area is greatly influenced by the presence of many Cameroonians because of the close vicinity to the country´s border and regular business activities, and a paved road has been recently constructed linking Cameroon with the main regional town Ouesso and the capital Brazzaville (Mavah et al., 2018; Mbon, 2020).

Cameroon has been identified as one of the largest hubs and transit points for illegal trade with pangolins in Africa with well-established infrastructure and trafficking routes (Ichu, 2019; Ingram, Cronin, et al., 2019; Latour & Stiles, 2011; UNODC, 2020). On the contrary, respondents from the western boundary of the park were based in the area where the road is unpaved and connects the Gabonese border with the town Etoumbi (Dorier-Apprill & Ziavoula, 1996; Latour & Stiles, 2011). Given the remoteness and difficulty of using this road, it is likely that this area has potentially less opportunities for trading bushmeat or scales. These respondents knew significantly less about the market values of pangolins and pangolin scales than the respondents from the other borders of the park. In this area, there are situated almost exclusively the Kota and Mboko ethnic groups which share similar subsistence and livelihood activities such as slash and burn agriculture with a variety of crops, hunting and fishing, and occasional gathering of fruits and tubers in the forest (Hewlett & Hewlett, 2007; Latour & Stiles, 2011). Respondents from this boundary of the park were thus more likely used to consume pangolin meat locally or sell it to neighbouring communities in comparison to villages along other park boundaries. Higher level of local consumption of bushmeat in more isolated areas in Africa has also been discussed elsewhere (Brashares et al., 2011), highlighting that trade is impacted by the distance to markets, the lack of alternative livelihood and protein options, and the wealth of these communities (Hennessey & Rogers, 2008; Kahler et al., 2019). Remoteness of the communities could also be an explanation for the generally low awareness of the market value of pangolins.

Similar pricing (CFA) per whole arboreal pangolin (*Phataginus* spp.) was detected in other countries in West and Central Africa (Akpona et al., 2008; Gonedelé Bi et al., 2017; Ingram et al., 2018; Mambeya et al., 2018; Zanvo et al., 2021). However, a considerable proportion of our respondents also stated pricing of approximately 2,000 CFA per arboreal pangolin because they mostly lived in remote communities where trade activities are localized. A lower number of the respondents indicated a market value for the giant pangolin, potentially suggesting it is less commonly available, predominantly ranging between 10,000 and 40,000 CFA. In terms of the market value of scales, the variety was extremely different depending on the exact species and quantity. Nevertheless, respondents ($n = 27$) mainly reported the price for scales of the giant pangolin between 5,000 and 25,000 CFA per kilogram. In our experience, scales of this

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species are more precious for the trade in the surveyed area and in extreme cases, we also found that some respondents noted prices up to 50,000 CFA per bottle of scales. West Africans (e.g., from Senegal and Mali), Chinese, and Cameroonians were mentioned most often as customers interested in purchasing scales. Zanvo et al. (2021) also recorded significantly higher selling prices for Chinese communities compared to local and West African customers. Most of the respondents reported increased prices for whole pangolins, corroborating the results of Ingram, Cronin, et al. (2019) in Gulf of Guinea countries and Ingram et al. (2018) in urban areas across Central Africa. Whereas carcasses of the arboreal pangolin species were seen multiple times in the villages and markets visited during the fieldwork, this was not the case with the giant pangolin, which could be a sign of low species abundance or clandestine trade of this species. In this regard, it is important to understand trends in demand, as well as trade and trafficking dynamics (Gluszek et al., 2021).

The MCA analysis grouped the respondents according to their perception of pangolin market values and observation of the species, showing a clear pattern whereby respondents who knew less about pangolin prices were associated with seeing a pangolin a longer time ago. Whereas respondents who were more aware of the market value (and with a higher monetary amount) of pangolins (meat as well as scales) observed both pangolins more recently and in the forest. Hence, respondents being familiar with the market value of pangolins are more likely to be those who tend to spend time in the forest (e.g., hunters), and are potentially more likely to be involved in trade. Researchers and protected area managers could conduct studies such as ours to explore the relationships among different local communities to better understand and incorporate local perceptions into policy decisions and future research (Ribeiro et al., 2019; Silva & Lopes, 2015).

For both rural and urban populations, pangolins are one of the most preferred types of meat in West and Central Africa (Boakye, 2018; Brittain, Kamogne Tagne, et al., 2022; Mouafo et al., 2021; Nguyen et al., 2021; van Vliet et al., 2015). In our study, even though we did not compare pangolin consumption to other bushmeat species, most respondents ranked the taste of pangolin meat highly, corroborating the findings of Malimbo et al. (2020) in the Democratic Republic of Congo, and Brittain, Kamogne Tagne, et al. (2022) in Cameroon. More importantly, being a hunter influenced this preference. Hunters showed a significant consumption preference for pangolins, and some of them even confessed consuming pangolins secretively without informing other members of the household or village because of this preference. Furthermore, less educated respondents ranked the taste of pangolin meat higher. On the contrary, more educated respondents liked pangolin meat less or had no experience eating pangolin meat ($n = 22$, 5.9%), but we recommend performing a survey with a greater number of respondents and probability-sampling methods to generalize more widely for a total population. Boakye (2018) and McNamara et al. (2016) suggested that consumption and preferences for bushmeat species are also affected by the shortage and rarity of species, but population monitoring of pangolins is needed in this region to know if this is the case. Nevertheless, studies conducted in the two largest cities in the RoC, Brazzaville and Pointe Noire, revealed that the surveyed respondents favored eating bushmeat mainly because of taste (Chausson et al., 2019; Mbete et al., 2011). Consumption preferences should be considered in attempts to reduce demand/consumption of pangolins using campaigns (e.g., in social marketing campaigns).

Nearly one-fifth of all the respondents reported the ethnozoological uses of pangolins in the survey; and while we describe this for the first time in the RoC, we cannot estimate the prevalence or frequency of the uses among the local communities. Contrary to some other studies from West and Central Africa (Akpona et al., 2008; Boakye, 2018; Boakye et al., 2014; Fopa et al., 2020; Mouafo et al., 2021; Soewu & Adekenola, 2011), the most frequently recorded use was in the sexual bewitchment of women by scale powder mixed with palm oil and a variety of local plants, which also was detected by Zanvo et al. (2021). Our results corroborate other studies in the region which found that pangolin scales or various body parts are sometimes used as a talisman or spiritual protection, and as "treatments" for wounds or skin (Boakye, 2018; Boakye et al., 2015; Mouafo et al., 2021). Even though a wide range of pangolin uses was stated by respondents, it solely related to pangolin scales ($n = 73$), or a few respondents also cited use of their meat ($n = 6$) and tail ($n = 5$) as in the Democratic Republic of Congo (Malimbo et al., 2020). However, we did not record any respondent referencing the use of pangolin skin (Nash et al., 2016) or other pangolin body parts used frequently for traditional medicine in other countries (Boakye, 2018; Boakye et al., 2014; Zanvo et al., 2021), and we only reported utilization of pangolin derivatives as a by-product of the meat. In Benin (Zanvo et al., 2021), Ghana (Boakye, 2018), and Cameroon (Mouafo et al., 2021), studies have shown differences in medicinal and spiritual uses among the major local ethnic groups. A recent report by the World Health Organization (WHO, 2019) determined that an estimated 80%–99% of the Congolese population practice traditional medicine, although this is not necessarily derived from animals. Particularly, people

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of lower socioeconomic status rely on traditional healthcare sources, in our case remotely living forest communities near to national parks, and therefore understanding the prevalence and magnitude of wildlife use in traditional medicine is an important knowledge gap to address, given the lack of information on this topic in most sub-Saharan countries (James et al., 2018; Lee et al., 2020). Thus, we also emphasize the need for more studies with long-term and rigorous data collection about the overall usage and impacts of traditional medicine (especially animals) in the RoC and elsewhere in the Congo Basin.

Across the region, it is not yet clear whether trafficked scales are a by-product of the bushmeat trade or if hunters have started to target pangolins exclusively for these derivates in this region (Gluszek et al., 2021; Ingram, Cronin, et al., 2019). In the communities around the OKNP, we noticed that some of the respondents were gathering pangolin scales after the animals were eaten and keeping them in bags. This happened particularly in the northern boundary of the park where there is already an established trade chain in close proximity to Cameroon. Based on discussions with local communities around the park, we also recognized a specific demand for pangolin scales coming from Asian workers employed in road constructions or the logging industry as has been recently recorded in neighboring countries as well (Ichu, 2019; Mambeya et al., 2018). It is clear that illegal trade of pangolins had been thriving in the last decade almost everywhere in sub-Saharan Africa (Heinrich et al., 2017; Ingram, Cronin, et al., 2019; Zanvo et al., 2021). For this reason, more attention should be devoted to monitoring consumer demand, trade patterns, and population changes of pangolins in the wild (e.g., by use of genetic techniques or long-term monitoring studies). Furthermore, without alternative sources of meat and income for rural people, necessity to engage in commercial activities of wildlife products and the increasing threat of road expansion may increase pressure on wildlife (Abernethy et al., 2016; Kleinschroth et al., 2019; Mavah et al., 2018; Morgan et al., 2019; Poulsen et al., 2009; Wilkie et al., 2000). Nearly all respondents were aware of the protection status of pangolins, although this was not a deterrent for hunting, consumption, or trading of the species in the study area. Informal discussions also revealed that the perception of the respondents about the illegality of hunting pangolins compared with other species of the same protection status (for example *Loxodonta cyclotis*) is not equal. Batchy et al. (2018) reported that only 2% of wildlife offenses between 2008 and 2017 focused on pangolins in the RoC. This means that the law is only rarely enforced despite widespread illegal use of pangolins in the area. Therefore, emphasizing wildlife laws adequately will be one of the future challenges across the Congo Basin.

Overall, our study provides baseline data on the local knowledge and uses of pangolins by communities living around the OKNP. We illustrate how local communities can contribute to conservation with their knowledge and experiences about local species' presence and the current status of elusive animals such as pangolins. We propose that consumptive and nonconsumptive uses of pangolins should be understood using a more comprehensive approach, taking into account the sociodemographic and psychographic profiles (e.g., values, attitudes) of the consumers. We also specifically highlight the importance of quantifying the consumption rates and trade of pangolins, in conjunction with assessments of pangolin populations, to assess the true impact of exploitation on wild pangolins. By doing so, conservation actions and policies could be better targeted in the study area, and in other pangolin range states.

AUTHOR CONTRIBUTIONS

Markéta Swiacká designed the study, performed fieldwork, analyzed the data, and drafted the manuscript. Francisco Ceacero and Daniel J. Ingram contributed to the data analysis, reviewing, and editing the manuscript. Torsten Bohm contributed to the design of the study and reviewing the manuscript. All authors gave final approval for publication.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

All respondents participated in the research voluntary and were informed about the objectives of the study to obtain their oral informed consent before proceeding. The questionnaires were completed in the majority of cases in the presence of other community members, however respondents remained anonymous on our data collection forms. At the beginning of each session, all respondents were assured that they could stop participating at any time. The research design was approved by the Ethical Code of the Czech University of Life Sciences Prague and permissions were granted by the Ministère de la Recherche Scientifique et de l'Innovation Technologique (MRSIT) and the Agence Congolaise de la Faune et des Aires Protégées (ACFAP) in the Republic of the Congo.

ORCID

Markéta Swiacká https://orcid.org/0000-0002-5848-0305
Daniel J. Ingram https://orcid.org/0000-0001-5843-220X
Torsten Bohm https://orcid.org/0000-0001-5446-2321
Francisco Ceacero https://orcid.org/0000-0001-9014-147X

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