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Received: 22 July 2023 | Accepted: 13 February 2024

DOI: 10.1002/pan3.10634

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

Achieving Sustainable and Equitable Consumption of Wild Meat

Urban wild meat and pangolin consumption across southern forested Cameroon: The limited influence of COVID-19

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Funding information
Conservation Action Research Network (CARN); UK Research and Innovation, Grant/Award Number: MR/W006316/1

Handling Editor: Carla Morsello

Abstract

1. Overexploitation of wildlife is pervasive in many tropical regions, and in addition to being a significant conservation and sustainability concern, it has received global attention given discussions over the origins of zoonotic disease outbreaks. Where unsustainable, consumption of wild meat by urban residents has been identified as a major socio-environmental challenge, given it is a significant driver of wildlife declines. Yet, information on urban wild meat consumers and possible ways to target conservation interventions remains lacking.
2. Using one of the largest datasets of urban wild meat consumers (1391) collected through structured questionnaires in 20 towns and cities, we model the demographic, psychographic and spatial factors associated with wild meat consumption patterns in southern Cameroon.
3. We find that nearly half of the sampled consumers ate wild meat once per week or more, and find that the probability of being a frequent consumer was greater among men, those living in smaller towns, and those who do not consider there to be a link between eating wild meat and disease. Threatened pangolin species are highly preferred among urban consumers, and most consumers did not consider there to be a link between COVID-19 and pangolins.
4. Most respondents had eaten wild meat since the beginning of COVID-19 and had not reduced their wild meat consumption due to COVID-19. For the first time, we show that consumers with beliefs against a link between wild meat consumption

Franklin T. Simo and Daniel J. Ingram contributed equally.

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and disease and those with greater income were less likely to have decreased their wild meat consumption.

5. We identified stakeholders including teachers and religious/community leaders as potentially appropriate messengers for demand-reduction campaigns, with television and radio being the most trusted communication channels among wild meat consumers.
6. Crucially, our study advances current scientific understanding of the factors that influence wild meat consumption frequency and change due to COVID-19 by urban consumers (particularly health beliefs and settlement size). We discuss how our results could be used to inform the design of wild meat demand-reduction interventions to bring the consumption of wild meat towards sustainability in Cameroon, and our approach applied pan-tropically.

KEYWORDS
Bushmeat, Central Africa, consumer research, human–nature relationships, pangolin, Zoonoses

1 | INTRODUCTION

The scale of the hunting, consumption and trade of wild animals worldwide and its relevance to global sustainability and health policy agendas are being increasingly recognised, for example the United Nations Sustainable Development Goals (UN SDGs) and the Convention on Migratory Species (CMS) (Ingram et al., 2021; Ingram, Prideaux, et al., 2022). Recently, the need for any use of biodiversity to be sustainable took a prominent position in the Kunming-Montreal Global Biodiversity Framework (Obura et al., 2023), with one of four goals to be achieved by 2050 being '*Biodiversity is sustainably used and managed…*' (Goal B). Recently, conservation researchers and practitioners identified the consumption of wild animals among urbanites across the tropics as one of the most important emerging sustainability challenges facing wildlife (Ingram et al., 2021). The meat of wild animals (hereafter 'wild meat') is consumed in urban areas because it is variably considered tasty and healthy compared to domesticated alternatives (Nguyen et al., 2021), important to socio-cultural relations (cultural identity, family life and social networks; Morsello et al., 2015), a symbol of status/luxury (Chausson et al., 2019), and/or for its nutritional value (Carignano Torres et al., 2022). Wild meat is also a source of income for many actors along the value chain, when traded from rural to urban areas and eventually sold in markets, restaurants and behind closed doors (Lescuyer & Nasi, 2016; Randolph et al., 2022). Demand from urban consumers can contribute to overexploitation of wildlife in rural areas, which not only threatens wildlife populations but also ecosystem services and functions, and potentially jeopardises the food security of remote communities that rely on wildlife for subsistence (Coad et al., 2019). Ensuring that wild meat use in urban areas is sustainable, possibly by reducing demand, is therefore key to reducing the impacts of hunting on biodiversity.

Conservationists have increasingly engaged in consumer research to better understand the social, cultural, and economic contexts within which wildlife-products are consumed or used across the world (Bachmann et al., 2019; Chausson et al., 2019; Hinsley et al., 2015; Jones et al., 2019). Given the decision-making component of food consumption, conservationists are also increasingly interested in influencing human wildlife consumption behaviours (MacFarlane et al., 2022; Wallen & Daut, 2018), representing a new frontier for wild meat research in urban settings (Ingram et al., 2021). Where consumption of wildlife products is illegal and/or unsustainable, demand-reduction initiatives have increasingly become a more prevalent means of attempting to reduce the market value of wildlife products by encouraging consumers to change their purchasing behaviour (Veríssimo & Wan, 2018), including for wild meat (Willis et al., 2022). Urban wild meat consumers may be a particularly suitable target for demand-reduction initiatives in circumstances where wild meat is not a nutritional necessity.

Demand-reduction interventions are likely to be more effective if conservation interventions are accurately targeted to consumers (MacFarlane et al., 2022). Social marketing, particularly 'demarketing', that is discouraging a given behaviour through marketing (Kotler & Zaltman, 1971), is one means of attempting to reduce demand. In social marketing, people can be categorised into homogenous subgroups who share similar values, motives, behavioural patterns, attitudes and social pressures (called 'audience segmentation'; MacFarlane et al., 2022), which can be used to identify ways to differentially target behaviour change interventions. In Brazil, a social marketing campaign was shown to reduce consumption of wild meat by ~62% (Chaves et al., 2018). While promising, influencing human behaviour is challenging; for example, an entertainment-education intervention to reduce demand for wild meat in northern Tanzania was not successful in achieving its goals (Veríssimo et al., 2018). The decision to consume wild meat may be influenced by consumers' demographic (e.g. age, gender, ethnicity) and psychographic (e.g. attitudes, social norms, values, beliefs) characteristics, as well as factors from the physical

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(e.g. availability of wild and domesticated meat and fish) and social (e.g. social influences) environment, which need to be comprehensively explored to effectively target interventions.

The trade in wildlife and wild meat has been brought into the global spotlight given discussions over the origins and spread of the novel coronavirus, SARS-CoV-2, causing the COVID-19 pandemic (McNamara et al., 2020). Conservationists may therefore be interested in whether consumption of wild meat has reduced due to media reporting about possible disease links with wildlife, particularly pangolins (Order: Pholidota), which were widely purported to have links with the virus (Cyranoski, 2020). Furthermore, given the increasing interest in zoonotic disease risk, knowing whether consumers' beliefs about disease risk affects consumption patterns may be important for designing interventions. Understanding urban wild meat consumption patterns and preferences, as well as possible avenues for intervention, will therefore be important for guiding pathways towards sustainability (e.g. contributing to achieving the UN SDGs), and ultimately ensuring the survival of wildlife in the region.

The consumption of wild meat in urban areas is prevalent in southern forested Cameroon (Edderai & Dame, 2006; Harvey-Carroll et al., 2022; Nguyen et al., 2021; Randolph et al., 2022). However, little is known about the socio-cultural, psychographic, and spatial factors that shape wild meat consumption patterns among urban consumers (Nana et al., 2022), including in Cameroon. Given the extent of urban demand for wild meat, we conducted one of the largest studies of urban wild meat consumers to date, focussing on Cameroon to: (1) describe wild meat consumers' demographics, animal consumption preferences, frequencies, and sourcing locations of wild meat; (2) describe consumers' attitudes and perceived norms around wild meat consumption; (3) identify whether wild meat consumers have changed their wild meat consumption patterns due to the COVID-19 outbreak; and, (4) ascertain the levels of trust for dissemination tools/media outlets and information messengers, to guide wild meat demand-reduction intervention design.

2 | METHODS

2.1 | Data collection

We conducted a structured questionnaire study in 20 towns and cities located in four regions (Centre, East, Littoral and South) across the forested southern half of Cameroon (Figure 1). The towns/cities were stratified by size, and were: small towns <20,000 people (Batchenga, Boumnyebel, Ma'an, Meyo Centre, Pouma), medium towns 20,000–70,000 people (Abong Mbang, Akonolinga, Ayos, Lomie, Makenene, Ngoumou), large towns/cities >70,000 people (Bafia, Bertoua, Ebolowa, Edea, Mbalmayo, Nkongsamba, Sangmelima), and very large cities >1 million people (Douala, Yaoundé). The study was conducted between 10 and 18 August 2021 during a trough in reported coronavirus cases, which was several months after the peak outbreak in Cameroon (March–May 2021).

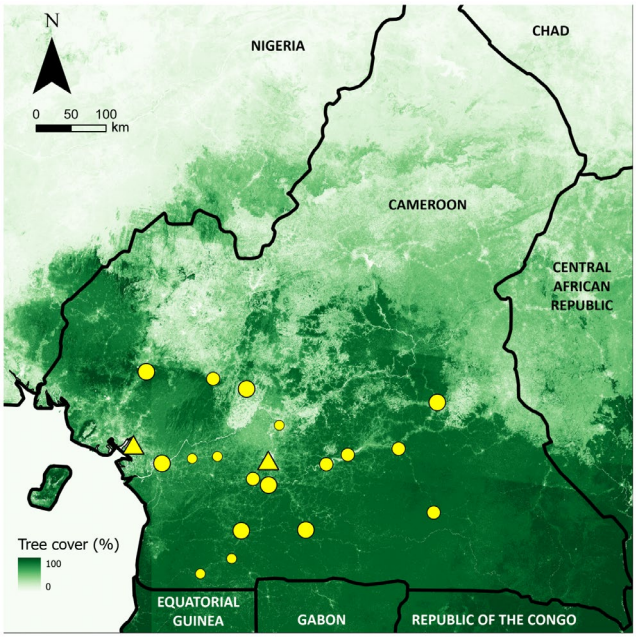

FIGURE 1 Study sites in Cameroon, Central Africa: small to large towns and cities (yellow circles increasing in size) and very large cities (yellow triangles). Country boundaries displayed by thick black lines (ESRI 2015), and forest cover by green shading (Hansen/UMD/Google/USGS/NASA; Hansen et al., 2013).

Prior to data collection, research teams participated in a training day at the University of Yaoundé I to discuss the methods and to standardise the interpretation of questions to minimise bias. We formed teams of three researchers each, and each team was assigned to one region. Research teams travelled to towns and cities in their allocated region before data collection, and between towns and cities using cars and buses. While teams were allocated to a given region, they also sampled towns and cities strategically if they were located along roads between Yaoundé and their allocated region (e.g. the Littoral team also sampled Boumnyebel). In small towns, respondents were recruited to the study using the street-intercept method (Buschmann, 2019), whereby pedestrians were approached in the street. A semi-random sampling method was adopted, whereby researcher teams randomly approached pedestrians near to central market areas, and actively attempted to recruit men and women of all age groups evenly to improve sample representativeness. Doing so meant that we significantly reduced biases from not sampling households, as both women and men are active in town and at markets (Randolph, 2016). It is also important to note that our questionnaire asked about respondents' typical consumption patterns, regardless of whether respondents eat wild meat at home or in restaurants or other locations. The same method was used in medium, large and very large towns/cities, but we targeted our sampling efforts to areas where wild meat is sold to maximise the likelihood of identifying people who consumed wild meat given the population size of these towns/cities. We did not conduct household-based sampling due to safety concerns and the pandemic. Before starting the questionnaire, team members introduced themselves, presented the research

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permit, and the objectives of the study. Questionnaires were administered in French but were translated into English where necessary, covering both official languages in Cameroon. The research team facilitated the completion of the questionnaire by reading the questions aloud to respondents and inputting their responses on the phones/tablets on their behalf. On average, the questionnaire took less than 15 min to complete with each respondent. Each team of three separately administered the questionnaire with different respondents at the same time to maximise the number of respondents that could complete the questionnaire at once. We excluded those who stated they did not eat wild meat from our sample.

The questionnaire was developed and deployed using KoBoToolbox (2018), loaded onto tablets and smartphones, and was structured into different sections addressing the respondents: (i) socio-demographic profiles (e.g. age, sex, ethnicity, etc.); (ii) levels of trust for communication outlets; (iii) wild meat consumption preferences; (iv) attitudes and (v) perceived social norms around wild meat, pangolins, and links to human health. The structured questionnaire comprised only closed-ended questions (Newing, 2011), as well as several five-point Likert-type items to assess respondents' levels of agreement towards a set of statements regarding wild meat and pangolins, some adapted from Veríssimo et al. (2020). Throughout this article, we use the generic term 'wild meat', whereas respondents were presented with 'bushmeat' or 'viande de brousse' in the questionnaire. The questionnaire was developed in part with the theory of planned behaviour (TPB) in mind, which contends that attitudes towards a behaviour, subjective social norms, and perceived behavioural control together shape an individuals' behavioural intentions and consequently their behaviours (Ajzen, 1991).

2.2 | Permits and ethics

We obtained a research attestation from the University of Yaoundé I, and a research permit from the Ministry of Scientific Research and Innovation (MINRESI) in Cameroon to conduct this work (No. 000014/MINRESI/B00/C00/C10/C13). These approvals demonstrate that the research was recognised and authorised by both the lead academic institution and the relevant government authority. Ethical considerations were assessed and approved by the ethics committees of the Czech University of Life Sciences Prague and the University of Kent (ID: 20231702630596584). Throughout, we followed the principle of free, prior and informed consent (Social Research Association, 2021), and provisions to protect research participants (Ibbett & Brittain, 2020; St. John et al., 2016). All individuals approached to take part in the study (≥18 years old) were read aloud (or could read if preferred) a statement about the objectives of the study, and then asked to provide oral consent to take part, which was also recorded in the questionnaire. Participants therefore understood that they would remain anonymous, how the data would be used, that they could refuse to participate, could stop the questionnaire at any time without reason, and could ask for their data to be removed.

During our research, we followed several COVID-19 safety protocols. During travel this involved minimising the number of people travelling in a car and wearing facemasks. During data collection, the research team maintained a 1 m distance from respondents, used facemasks and hand sanitizer, and were responsible for using the research phones and tablets.

2.3 | Data analysis

As is typical of questionnaire studies, not all respondents answered every question, so sample sizes differ between analyses. Prior to analyses, we prepared the data in the following ways. Given the low number of respondents who reported consuming wild meat 'once per year', 'less than once per year', and 'every six months' we grouped these responses into one category called 'once every six months or less'. We normalised the self-reported monthly incomes of respondents using the common logarithm ($\log_{10}(x)$), adding 1000 CFA to all respondents to correct data analysis issues arising when monthly income was reportedly zero. All continuous predictors were then scaled and centred. To include the disease-related Likert items into the models described below, we merged the strong agreement/disagreement responses into the agreement/disagreement responses, so the final variable only included the following categories: disagree, neutral and agree. To model the factors associated with decreasing consumption of wild meat during COVID-19, for the questions on whether respondents had changed their consumption of wild meat/pangolins, we merged responses of 'no change' and 'increased' into a single category prior to analyses. This resulted in a dichotomous response of 'decreased' or 'no change/increased'. We did not include religion as a predictor in the analyses because most respondents identified as Christian (~90% of 1391 respondents), and we did not include ethnicity because respondents came from >20 ethnicities which, given our sample size, would not be appropriate to include in our models. We found that education was positively associated with normalised monthly income of respondents, so we included income but not education in the models described below.

All analyses were conducted in R version 4.1.1. (R Core Team, 2021). When simply testing for associations between two categorical variables, we used chi-squared tests and identified explicit differences with post-hoc tests with Bonferroni corrections. When the response variable was an ordered categorical variable (e.g. wild meat consumption frequency), we used Ordinal Logistic regression (OLR) analysis to test potential predictors, using the 'polr' function in the *MASS* package in R (Venables & Ripley, 2002). Proportional odds assumptions for the OLR analyses were tested using Brant tests (Brant, 1990). When the response variable was dichotomous, we built binomial generalised linear models (GLM) with a logit link function. First, we explored whether respondents had eaten wild meat since the COVID-19 outbreak. Second, we explored whether respondents had decreased their consumption of wild meat/pangolins since the beginning of the pandemic. In all the analyses, we tested the following predictor variables which were selected a priori: monthly income, sex, age, the size of the town/city, and the respondents' level of agreement towards whether '*Eating wild meat causes disease*'. Given the relatively small number of possible predictor

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variables that were selected based on a priori hypotheses, and to avoid omitted variable bias, we did not conduct model-selection. Instead, we interpreted the effect sizes and corresponding confidence intervals from the full models. Odds ratios were not deemed important when their 95% confidence interval (CI) included 1. To determine differences between the estimated marginal means of categorical predictor factor levels, we conducted post-hoc tests using the *emmeans* R package (Lenth, 2021), with p-values adjusted for multiple testing. We checked for multicollinearity in our models using variance inflation factors (VIFs), considering variables with a VIF >5 as problematic (Fox & Monette, 1992).

To explore possible linear relationships between Likert items, and wild meat consumption frequency, we used nonparametric Spearman's rank correlations which are suitable for discrete ordinal variables. We included only respondents who answered the questions on wild meat consumption frequency and all Likert items relating to attitudes and perceived norms. Likert items were visualised using the R package *Likert* v.1.3.5 (Bryer & Speerschneider, 2016).

3 | RESULTS

3.1 | Socio-demographics of respondents

In total, 1391 wild meat consumers completed our questionnaire, across 20 towns and cities in southern Cameroon (Table 1; Figure 1). A slightly larger proportion of the respondents were male (~64%), and the average age of respondents was 35.0 ± 12.5 (mean ± SD; range: 18–90). Wild meat consumers were predominantly from four ethnic groups including Bamileké (~19%), Beti (~14%), Bassa (~13%) and Bulu (~9%), with the rest coming from several other ethnic groups. The majority of respondents were most frequently educated to secondary school level (~63%; $n = 871/1389$), followed by superior level (~19%) and primary (~16%), followed by none (~2%). The self-reported mean monthly income was 97,511 ± 254,171 FCFA (mean ± SD) while the median was 50,000 FCFA (~87.5 USD in 2022).

3.2 | Animal consumption preferences

Within the respondents' top three most preferred animal meats, chicken was the most frequently reported, followed by wild meat, beef, then pork (Figure 2a). However, when considering only the first preference, wild meat was most frequently reported with ~39% of respondents ($n = 537$), followed by chicken with ~34% ($n = 463$), and all others. For the preferred wild meat species, porcupine (*Atherurus africanus*) featured most frequently within the respondents top three and first preference, followed by pangolins (Family: Manidae) (Figure 2b).

3.3 | Wild meat consumption frequency and acquisition

Across all regions, of the 1000 wild meat consumers who answered the question, nearly half stated that they consumed wild meat once

TABLE 1 Number of respondents per settlement and settlement size, including respondents' sex and age.

Settlement size	Settlement	Female	Male	Age (mean ± SD)
Small	E	6	15	38.9 ± 11.1
	G	25	42	36.3 ± 9.5
	L	26	57	32.0 ± 12.0
	O	31	76	29.1 ± 9.3
	R	30	46	38.3 ± 11.2
Medium	A	13	39	32.2 ± 8.2
	B	18	51	35.6 ± 14.3
	C	14	58	27.7 ± 10.2
	K	8	23	28.7 ± 8.0
	M	51	47	41.0 ± 14.1
	P	37	24	35.2 ± 13.8
Large	D	36	58	40.8 ± 14.0
	F	22	69	31.6 ± 9.8
	I	33	67	33.0 ± 12.2
	J	26	19	41.4 ± 12.5
	N	25	32	32.2 ± 10.8
	Q	17	41	39.9 ± 14.9
	S	25	42	30.2 ± 9.4
Very large	H	40	37	41.4 ± 12.9
	T	16	49	36.4 ± 9.8
Total		499	892	35.0 ± 12.5

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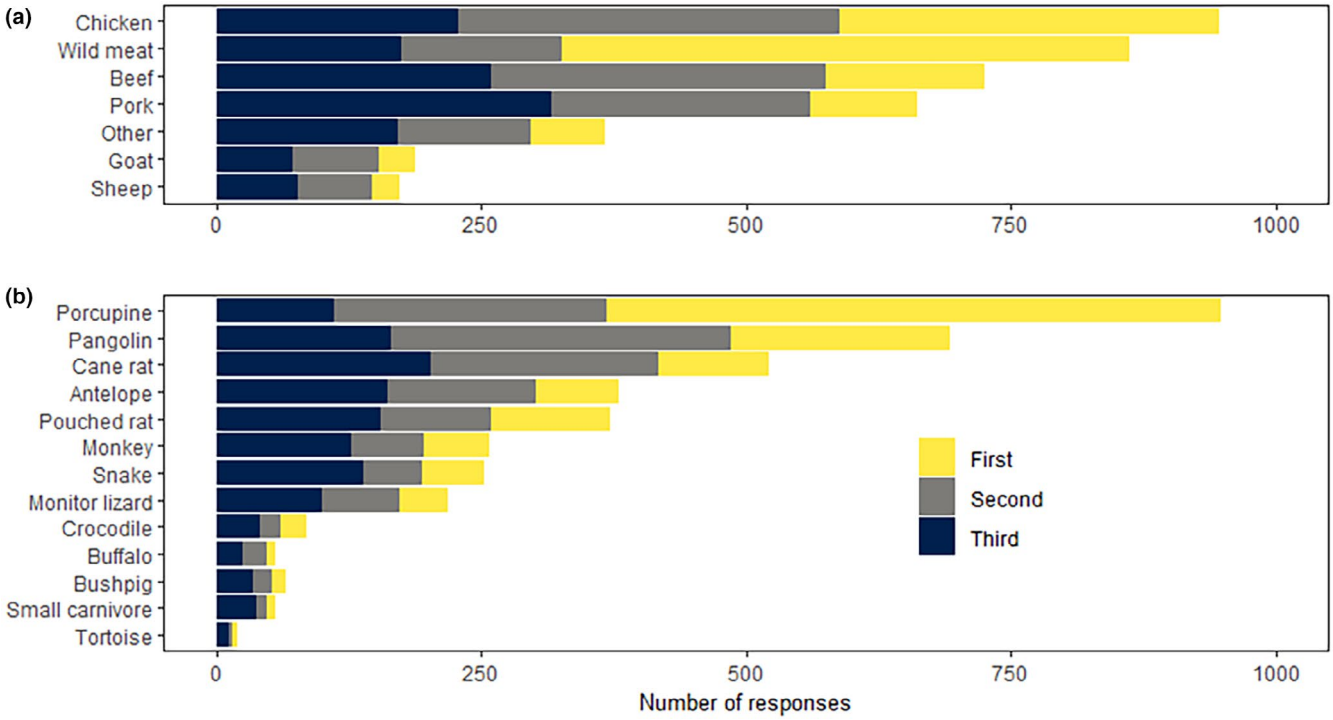

FIGURE 2 Top three most preferred animal meat types (a; $n = 1380$ respondents) and wild meat animals to eat (b; 1308), among wild meat consumers. In panels (a) and (b) each respondent has three responses (one for each preference rank) represented in each panel. If respondents reported having no second or third preference, we have not included it in panels (a) and (b).

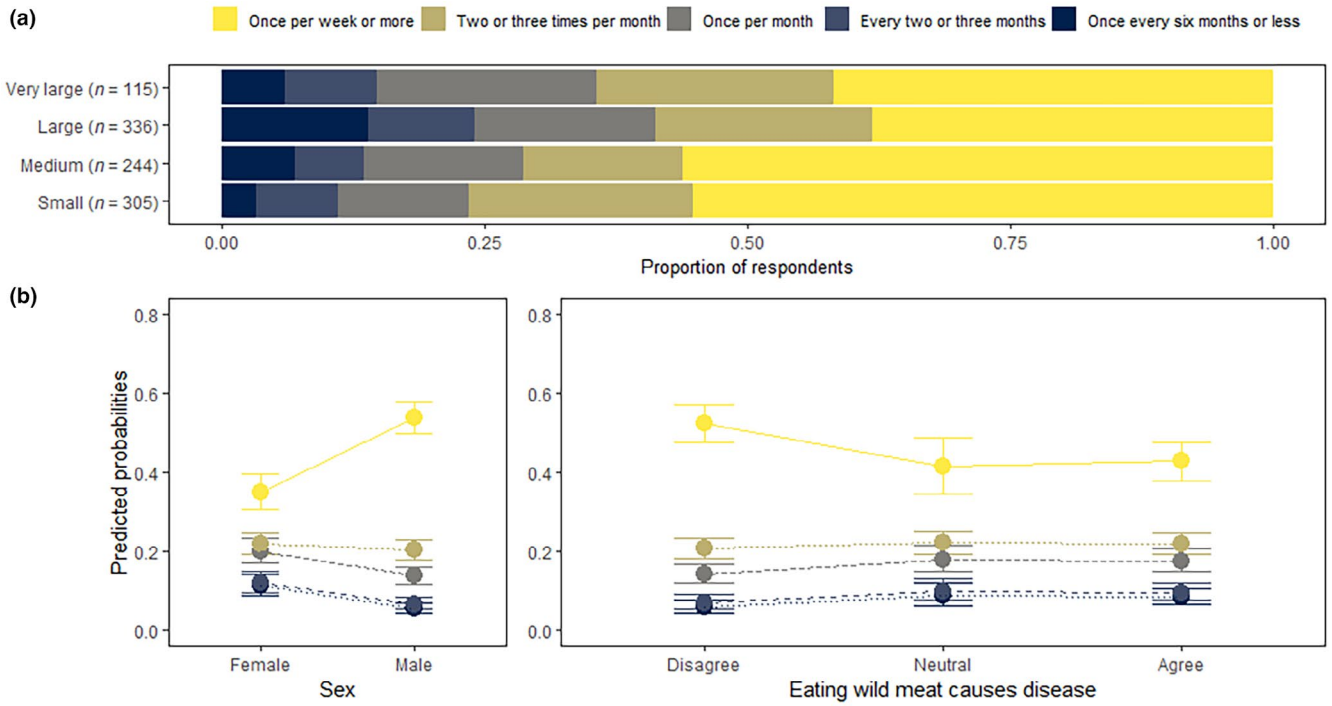

FIGURE 3 Self-reported wild meat consumption frequency separated by settlement size in Cameroon (a), and the predicted probabilities of respondents to consume wild meat at different frequencies based on sex and level of agreement towards the statement '*Eating wild meat causes disease*' (b).

per week or more (~48%), and this was higher in small and medium towns, compared to large and very large cities (Figure 3a).

Respondents were able to report multiple places from which they acquire wild meat ($n = 1391$). The largest number of respondents reported that they acquired wild meat from restaurants (~48% of women, ~62% of men) and from other members of their household (~56% of women, ~46% of men), followed by markets (~34% of women, 23% of men), and directly from hunters (~30% of women,

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21% of men). A smaller number reported acquiring wild meat from roadside vendors (~16% of all respondents).

In our ordinal logistic regression of wild meat consumption frequency, settlement size (GLM: $\chi^2=37.945$, $d=3$, $p<0.001$), respondent sex ($\chi^2=38.377$, $d=1$, $p<0.001$), and their beliefs about whether eating wild meat causes disease ($\chi^2=10.933$, $d=2$, $p=0.004$) were found to have an effect. We found that the odds of consuming wild meat more frequently were lower for respondents from large towns and cities (OLR: odds ratio 0.43; 95% CI 0.32–0.58, $p<0.001$), compared to small towns (Figure 3a; Appendix S1). Respondents from very large cities also tended to have lower odds, but the 95% CI included 1 (0.67; 95% CI 0.45–1.01, $p=0.054$), and those from medium towns had similar odds to small towns. We found that for male respondents, the odds of consuming wild meat more frequently were two times that of female respondents (OLR: odds ratio 2.17; 95% CI 1.70–2.79, $p<0.001$), holding all other variables constant. Differences in the predicted probability of consumption frequencies between male and female respondents was most pronounced for respondents who consumed wild meat once per week or more (Figure 3b). For respondents who disagreed that eating wild meat causes disease, the odds of consuming wild meat more frequently were ~1.5 times that of other respondents (OLR: odds ratio 1.47; 95% CI 1.13–1.92, $p=0.004$), holding all other variables constant. Again, differences were most pronounced for those who consumed wild meat the most frequently (Figure 3b). Estimated marginal means were significantly different between those who disagreed and those who agreed (post hoc contrast: $z=-2.848$, $p=0.013$; Appendix S2) or were neutral ($z=2.570$, $p=0.015$) that eating wild meat causes disease, and there were no differences between those who agreed or were neutral ($z=0.299$, $p=0.765$).

3.4 | Wild meat consumer attitudes and perceived norms

A large proportion of people agreed and more commonly strongly agreed with statements about the role of consuming wild meat and pangolins in Cameroon: '*Wild meat will always be consumed in Cameroon*' (together 88% of 1371 respondents) and '*Eating pangolin meat is part of the Cameroonian culture*' (69%; $n=1335$; Figure 4a). However, there was also mostly strong agreement, and agreement, with the statements that pangolins are part of Cameroon's natural heritage (72%; $n=1344$) and should be protected (64%; $n=1352$). A large proportion of people (56%; of $n=1349$) strongly disagreed or disagreed that pangolins were easy to find at the market. However, there were significant differences in agreement between regions ($\chi^2[n=1349]=248.06$, $p<0.001$), whereby respondents in the South Region agreed that '*Pangolins are easy to find at the market*' significantly more than expected (54% of 355 respondents in the South; $p<0.001$). Regarding diseases, there was no clear pattern for agreement about whether eating wild meat causes diseases with respondents split between agree and disagree categories (39% and 44%, respectively, $n=1367$), whereas most respondents strongly disagreed or disagreed that '*Pangolins cause coronavirus*' (78%; $n=1346$). Across all attitude statements, neutral responses were very infrequent (8%–18%), and respondents veered toward strong agreement or disagreement. These attitudes were strongly supported by the respondents' perceived norms about the preferences, behaviours, and beliefs of other people. Most respondents strongly agreed, and to a much lesser extent agreed, that most people (1) prefer wild meat to domestic meat (together, 71% of 1366 respondents), (2) eat pangolin meat (65%; $n=1359$) and (3) do not believe that wild meat causes diseases (58%; $n=1370$; Figure 4b).

Of those who answered all questions on consumption frequency and attitude statements ($n=907$), there was a strong correlation between agreement scores regarding the statements that pangolins are part of Cameroon's natural heritage and that consumption of pangolins is part of Cameroon's culture (Spearman's rho correlation coefficient $r_s=0.54$, $p<0.001$; Appendix S3). Significant moderate correlations were also found between the agreement scores towards the following pairs of statements: pangolins being considered part of Cameroon's natural heritage and the notion that it is important to protect pangolins ($r_s=0.57$, $p<0.001$); wild meat causes diseases and pangolins cause coronavirus ($r_s=0.37$, $p<0.001$); and most people prefer wild meat and eat pangolins ($r_s=0.41$, $p<0.001$). We found no significant correlations between any Likert item and the reported frequency of wild meat consumption.

3.5 | Wild meat and pangolin consumption during COVID-19

Of those who answered the question ($n=1388$ respondents), ~87% stated that they had eaten wild meat since the start of the COVID-19 outbreak (Figure 5a). Most respondents stated that they have not changed the amount of wild meat they consumed due to COVID-19 (~72% of 1381 respondents who answered the question), while ~19% stated that they had decreased consumption and ~9% had increased consumption (Figure 5b).

In total, ~79% of respondents confirmed that they had consumed pangolin at least once in their life ($n=1383$). When asked whether they had eaten pangolins since the start of the COVID-19 outbreak, 70% stated that they had (of 1090 that answered the question). Most respondents reported that they had not changed their consumption of pangolins due to COVID-19 (~77% of 758 respondents), while ~14% had decreased consumption, and ~9% had increased consumption.

In our binomial GLM of whether respondents had eaten wild meat since COVID-19, settlement size (GLM: $\chi^2=34.214$, $d=3$, $p<0.001$), respondent sex ($\chi^2=12.556$, $d=1$, $p<0.001$), income ($\chi^2=4.122$, $d=1$, $p=0.042$), and beliefs about whether eating wild meat causes disease ($\chi^2=7.310$, $d=2$, $p=0.026$) were found to have an effect. The odds of having consumed wild meat since COVID-19 were 1.84 times greater if the respondent was male as opposed to female (GLM: odds ratio 1.84; 95% CI 1.31–2.57,

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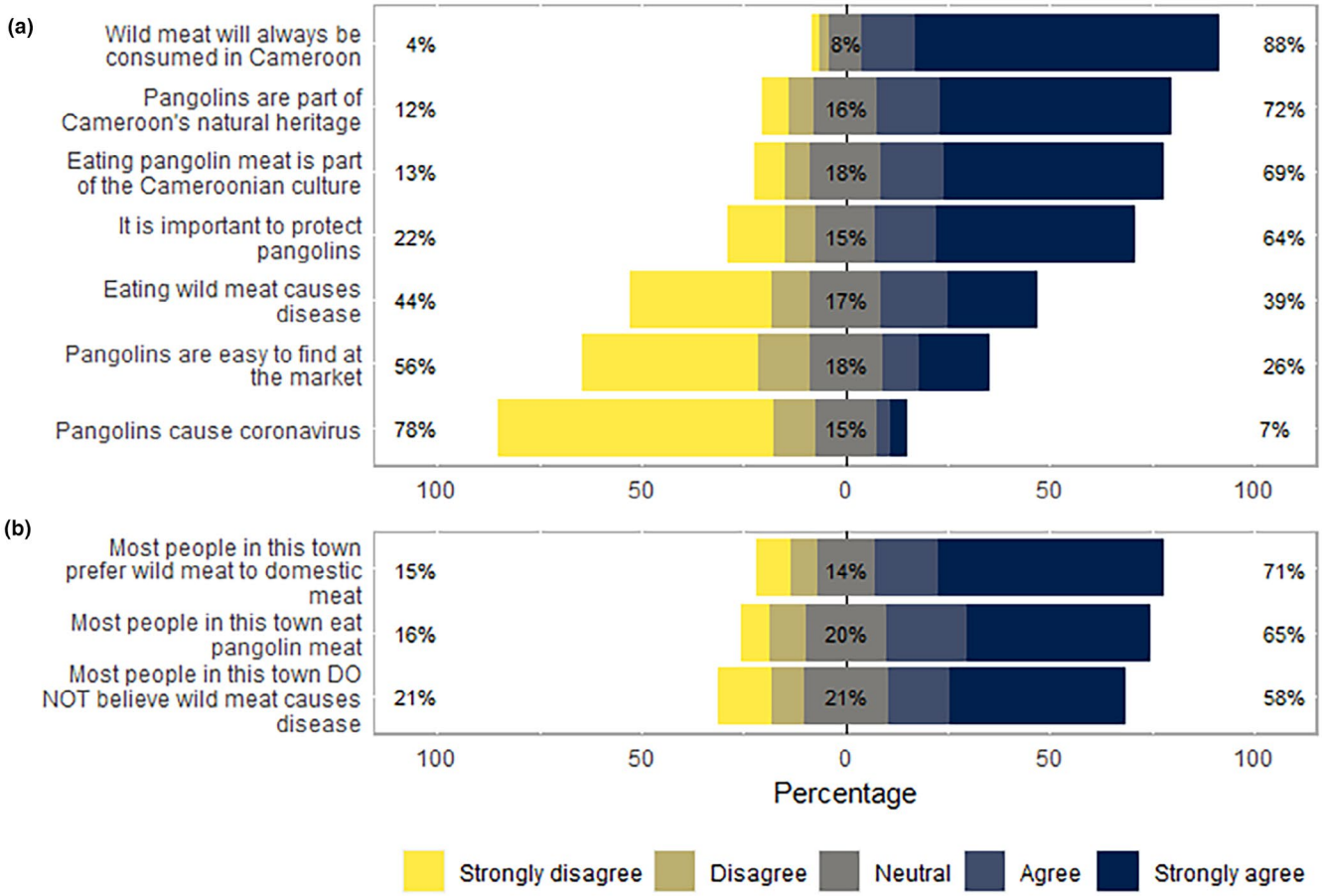

FIGURE 4 Respondents' level of agreement towards statements regarding attitudes (a) and perceived norms (b) around wild meat and pangolins.

$p<0.001$; Appendices S4 and S5), and slightly greater if the respondent reported having a higher income (standardised; GLM: odds ratio 1.19; 95% CI 1.01–1.40, $p=0.040$), keeping all other variables constant. Compared to those living in small towns, the odds of having consumed wild meat since COVID were lower for respondents living in medium-sized towns (odds ratio 0.38; 95% CI 0.20–0.68, $p=0.002$), and even lower for those living in large (odds ratio 0.24; 95% CI 0.13–0.40, $p<0.001$) and very large towns and cities (odds ratio 0.27; 95% CI 0.13–0.53, $p<0.001$). For those who disagreed that eating wild meat causes disease, the odds of having consumed wild meat since COVID-19 were 1.62 times greater than those who agreed (odds ratio 1.62; 95% CI 1.12–2.36, $p=0.011$).

In our binomial GLM of whether respondents had decreased their consumption of wild meat since COVID, we found an effect of settlement size (GLM: $\chi^2=19.9768$, $d=3$, $p<0.001$), respondent reported income ($\chi^2=9.8856$, $d=1$, $p=0.002$), and respondent beliefs about whether eating wild meat causes disease ($\chi^2=22.0560$, $d=2$, $p<0.001$). Respondents from large towns and cities had 1.49 times greater odds of having decreased their wild meat consumption since COVID-19 (although crossing 1; GLM: odds ratio 1.49; 95% CI 1.05–2.13, $p=0.027$; Figure 5c), when compared to those from small towns. However, there were limited differences between those from medium towns and very-large cities with those from small towns (Appendices S6 and S7). Respondents with greater self-reported income levels had lower odds of having decreased their consumption of wild meat during COVID-19 (odds ratio 0.79; 95% CI 0.69–0.98, $p=0.002$). Finally, those who disagreed that eating wild meat causes disease had half the odds of decreasing their consumption of wild meat during COVID-19 (odds ratio 0.48; 95% CI 0.35–0.66, $p<0.001$) compared to those to agreed. Those who were neutral had similar odds to those who agreed, and differences were confirmed by post hoc tests.

3.6 | Trust levels of different information sources

Self-reported levels of trust for media outlets across all respondents were highest for television (55%; $n=1238$) and radio (54%; $n=1345$), followed by newspaper (47%; $n=1341$), although all had between 22% and 28% of respondents distrusting these sources (Figure 6a). Social media was a widely distrusted, mostly completely distrusted, media outlet (61%; $n=1353$). Teachers (71% of $n=1345$ respondents) and religious leaders (52%; $n=1309$) were the most trusted messengers, with particularly low levels of trust for politicians (76%; $n=1316$; Figure 6b). Community leaders, the police, NGOs, and respondents' friends all had very mixed responses.

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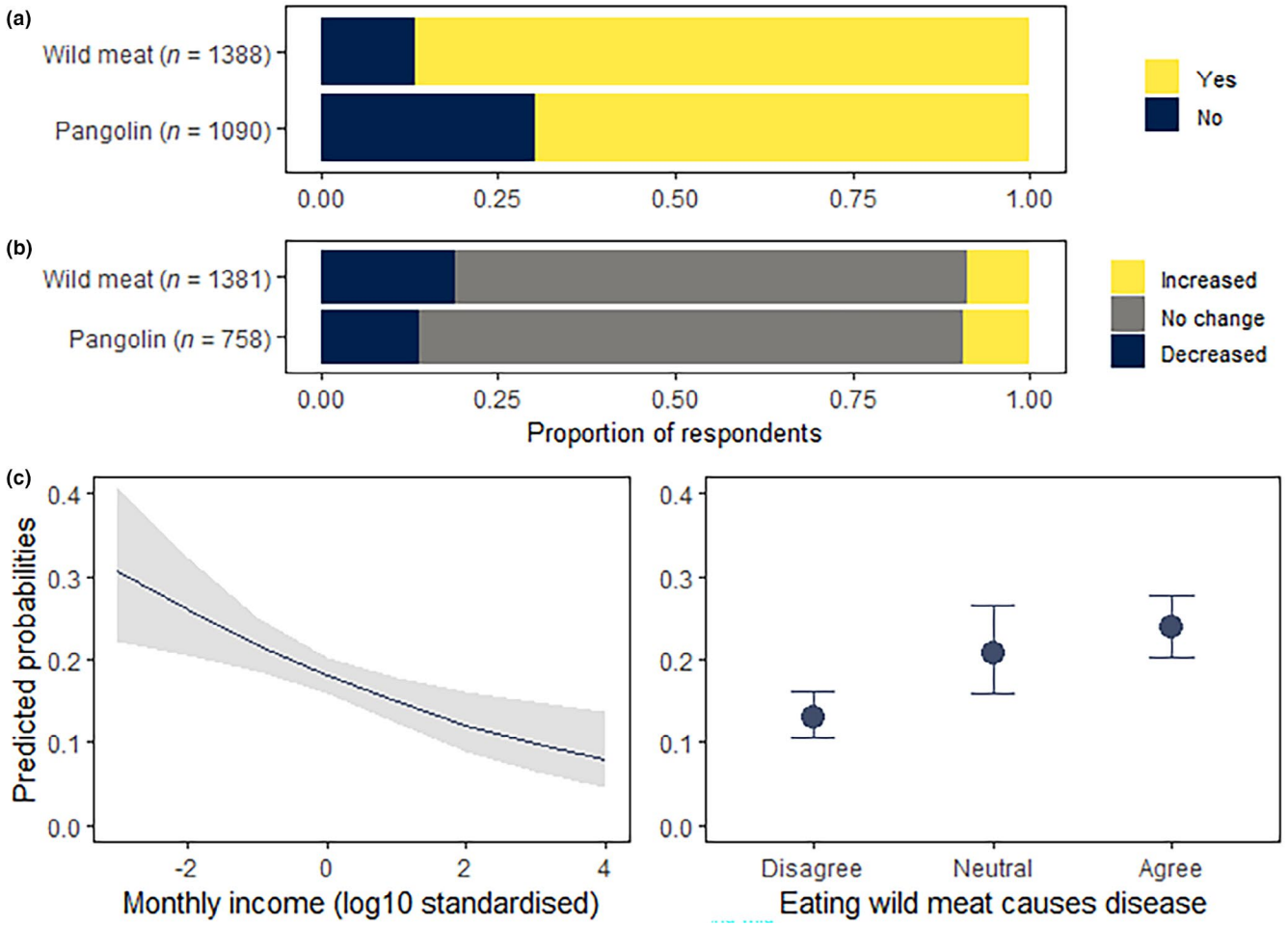

FIGURE 5 Respondents' consumption of wild meat or pangolins since the start of the coronavirus outbreak (a; between the pandemic announcement in March 2020 and our study in August 2021), and change in the amount of wild meat or pangolins eaten due to the outbreak (b). Respondents' monthly income ($\log_{10}(x)$ standardised) and level of agreement towards the statement '*Eating wild meat causes disease*' in relation to their predicted probabilities of decreasing their consumption of wild meat during COVID-19 (c).

4 | DISCUSSION

The consumption of wildlife by people represents one of many complex relationships between humans and nature, yet in the tropics the urban demand for wild meat is an emerging wildlife conservation and sustainability concern (Ingram et al., 2021). To investigate urban wild meat consumers and the factors associated with wild meat consumption patterns and changes due to COVID-19, we conducted a large questionnaire study across 20 towns and cities in Cameroon. We also explored the attitudes and perceived social norms of consumers around wild meat and links to health to help guide the design of possible wild meat demand-reduction intervention efforts, where necessary and ethical.

4.1 | Protein preferences and wild meat consumption frequency

Wild meat was the most frequently reported first preference animal protein of wild meat consumers, and most consumers across all regions in southern forested Cameroon ate wild meat at least once per month. Nearly half of the respondents consumed wild meat at least once per week, and those who lived in smaller towns, men and those who disagreed that eating wild meat causes disease were most likely to eat wild meat more frequently. Respondents living in smaller towns may be more likely to encounter or be able to acquire wild meat than in larger towns, and other protein options may be scarcer or more expensive in smaller towns (but we did not collect data on this). Greater frequency of wild meat consumption by urban men has been reported previously in West Africa (Luiselli et al., 2019) and Vietnam (Nguyen & Jones, 2022). Men may consume wild meat more frequently if they eat wild meat outside the household more frequently than women; while we did not measure this directly, a greater proportion of men reported restaurants as a primary way they acquired wild meat compared to women. Our results also reflect those of a study whereby restauranteurs stated that there is not necessarily one type of person that were the main consumers of wild meat (Wright et al., 2022). Demographic factors may be less important in distinguishing urban consumer groups for targeted campaigns, and perhaps the psychographic characteristics

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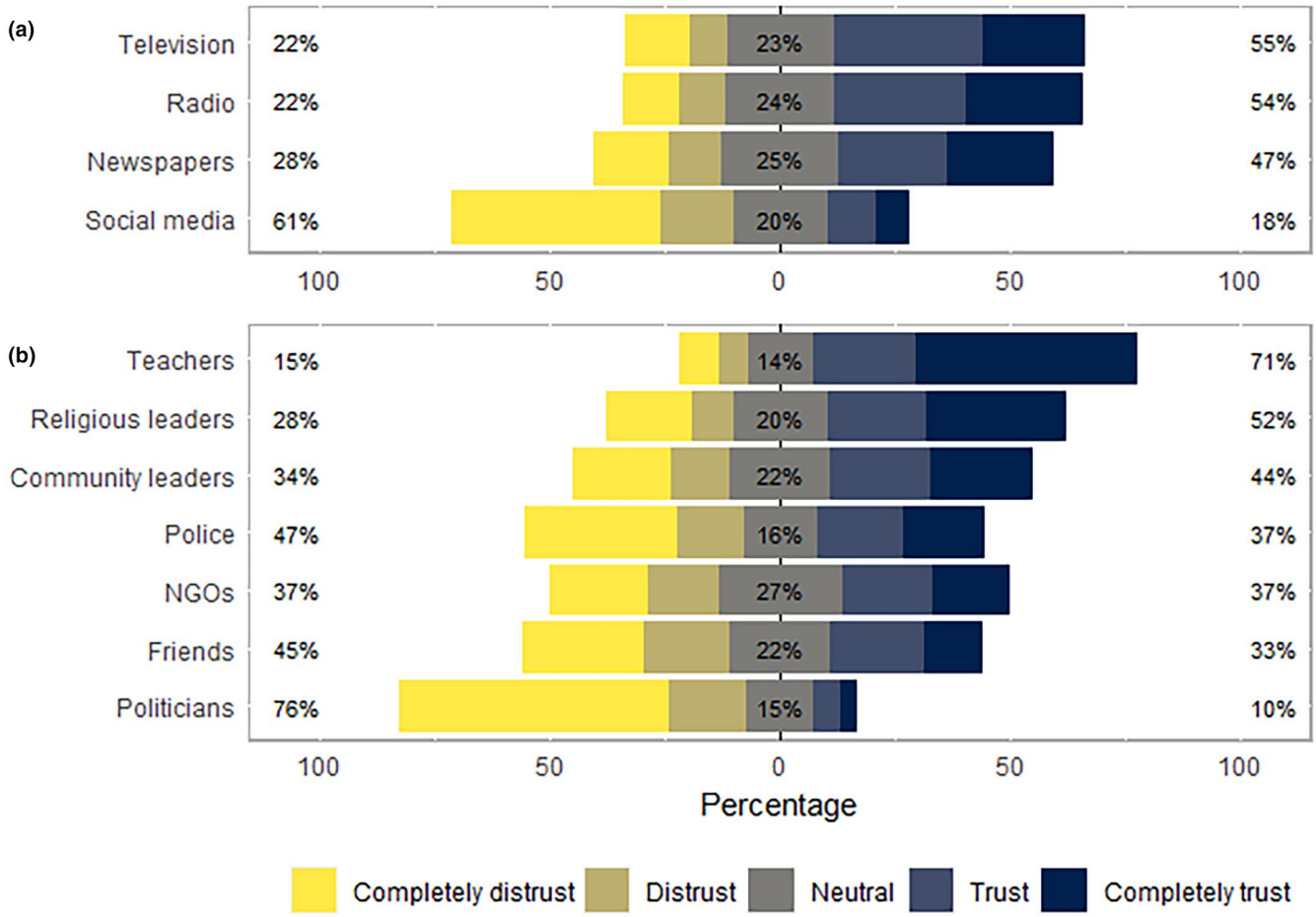

FIGURE 6 Respondents' level of trust towards dissemination tools/media outlets (a) and information messengers (b).

of respondents, and spatial characteristics of the urban environment, may be more important. However, one limitation of our study was that we rely on self-reported frequencies (rather than measured consumption rates), which could be subject to social desirability bias. Futhermore, by sampling using the street intercept method with few respondents for some towns relative to the population size, our results may be slightly biased towards people who are more active in town.

Of the species consumed for wild meat, African brush-tailed porcupines (*Atherurus africanus*), followed by pangolins, were the most preferred types of wild meat. Given the current threatened status of pangolins, and the evidence of declines and extirpations reported across the range of the endangered giant pangolin (*Smutsia gigantea*; Enuoh & Bisong, 2014; Flesher, 2013; Ingram, Edwards, & Kedzierska Manzon, 2022; Laurent, 1992; Ngoufo et al., 2014; Zanvo et al., 2020), strong preference for pangolin meat is particularly concerning. High preference for wild meat and especially pangolin meat may mean it would be challenging to reduce demand, especially when nearly half of pangolin consumers are willing to pay more for a pangolin meal (Nguyen et al., 2021). When considering the top three meat preferences of respondents, chicken was the only domesticated meat option that was favoured above wild meat. This suggests that increasing access to chicken may reduce demand for wild meat if competitively priced (Wilkie et al., 2016). However, chicken may not be considered as a locally acceptable alternative to wild meat (i.e. they may serve different socio-cultural roles). Furthermore, if access to alternative proteins is increased without social marketing in tandem, it may not necessarily reduce wild meat consumption (Chaves et al., 2018). Nevertheless, it is important that any endeavours to increase access to alternative proteins fully assess the possible environmental impacts, and incorporate human-centred design to accurately account for the needs, motivations and values of stakeholders (Wallen & Daut, 2018).

In many parts of the tropics and subtropics, both the formal and informal food sectors play important roles in urban food acquisition and livelihoods (Crush & Battersby, 2016). We found that more than half of the consumers acquired wild meat from restaurants (including informal street-food vendors and bars), further highlighting the role that restauranteurs could play in the reduction of wild meat consumption in urban areas. Nearly half of the respondents also reported sourcing wild meat from other family members, emphasising the influence of social factors in the maintenance of wild meat consumption patterns. Markets were only reported wild meat source locations for ~25% of consumers, which suggests that studies inferring consumption patterns by

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monitoring urban markets alone may not fully capture consumption dynamics and species composition. However, it is important to note that markets may still be important points for interventions given that restaurants often source wild meat from markets (Randolph et al., 2022). Interventions could include engaging restauranteurs and market vendors (Randolph et al., 2022; Wright et al., 2022), as well as 'location bans' that prohibit certain actions in certain places (MacFarlane et al., 2022).

4.2 | Attitudes and perceived social norms

Following the TPB, attitudes and social norms are considered important components of whether someone intends to perform a given behaviour, and then whether they actually perform it (Ajzen, 1991). While we did not design our study to directly test the TPB, our results do provide novel insights about urban wild meat consumers for practitioners to consider when designing demand-reduction interventions. Our results suggest that the majority of respondents hold attitudes and beliefs favouring wild meat consumption, for example respondents strongly believed that wild meat will always be consumed in Cameroon, and they perceived that most people prefer wild meat to domestic meat. Norm appeal interventions (i.e. communicating a desirable social norm to attempt to nudge people's behaviour towards that norm) have been shown to influence small behavioural changes for other behaviours and may be an intervention avenue to explore (MacFarlane et al., 2022). Such interventions would ideally increase the prevalence of the minority behaviour above 25%, a tipping point above which social conventions are estimated to be widely adopted (Centola et al., 2018).

It was clear that those who consume wild meat considered pangolins as part of their natural heritage and should be conserved. This may offer a lever for conservation activities (MacFarlane et al., 2022), for example by including information on the current state of pangolin populations in social marketing campaigns, provided appropriate messaging and messengers are used (see below section). An important avenue for future research would be to compare the attitudes and perceived social norms of wild meat consumers and non-consumers to see if consumers have distinct demographic and psychometric profiles, which would allow for greater targeting of possible interventions, where deemed necessary.

4.3 | Wild meat consumption and zoonotic disease risk

Most respondents in our study stated that they had consumed wild meat, and to a lesser extent pangolins, during the COVID-19 pandemic, with the likelihood of doing so increasing when respondents were male, wealthier, living in smaller towns and cities, and disagreed that eating wild meat causes disease. While the beliefs about links between wild meat and disease were mixed among wild meat consumers, most did not change their consumption habits of wild meat or pangolins during the COVID-19 pandemic. However, we found some evidence that respondents from large towns and cities were more likely to have decreased their consumption, while those who were wealthier and disagreed that eating wild meat causes disease were less likely to have decreased it. To our knowledge, this is the first time that the determinates of change in wild meat consumption behaviours during COVID-19 has been investigated quantitatively in Africa.

'Risk warnings', that is drawing consumers' attention to the potential risks of consuming a product, is one method of promoting behaviour change (MacFarlane et al., 2022), although it is not clear how effective they can be for wild meat. Our evidence of limited change in wild meat consumption behaviours among consumers could be explained in conjunction with evidence from Sierra Leone. Bonwitt et al. (2018) shows that the effectiveness of a ban on wild meat consumption during the Ebola outbreak was limited because messaging that focussed only on health risks posed by wild meat contradicted the experiences of wild meat consumers, who have reportedly consumed wild meat without issue. Further, in an urban wild meat consumption study in Sierra Leone during COVID-19, no respondents listed disease risk as the primary reason for not consuming wild meat (Sainge et al., 2023). Similarly, perceived risks of disease from wild meat were considered to be low among market workers in Nigeria, Cameroon, and the Democratic Republic of the Congo (DRC; Alhaji et al., 2022; Enns et al., 2023; Saylors et al., 2021), and among urban consumers in Peru and Guyana (Enns et al., 2023; Pérez-Peña et al., 2022). As such, wild meat continued to be openly sold in markets during the COVID-19 outbreak in Cameroon and Peru (Harvey-Carroll et al., 2022; Pérez-Peña et al., 2022). Together, these examples show how the dissonance between the personal experiences of wild meat consumers and messaging around the health implications of consuming wild meat could present significant challenges to health-oriented demand-reduction efforts. This dissonance possibly constitutes a type of science denialism highlighted in the social psychology literature, for example when science opposes lived experiences (Evans & Fetterman, 2022), or many other factors such as religiosity and political conservatism (Rutjens et al., 2018). However, in five countries in Asia respondents with increased awareness of COVID-19 were less likely to buy wildlife products (Naidoo et al., 2021). Our results confirm that consumer beliefs and social norms should be critically considered when designing interventions, and messages should be tested on specific audiences using established evaluation techniques prior to widespread use (Kidd et al., 2019).

4.4 | Messages and messengers

Various types of interventions proposed to reduce demand for wild meat involve dissemination of information or messages, such as demarketing (Veríssimo et al., 2020), and appeals to social norms. Yet, understanding who appropriate messengers are likely has important

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implications for the success of such interventions. For example, in Kinshasa, DRC, mistrust in government messaging around Ebola enabled witchcraft origin stories of the virus to proliferate by word-of-mouth (Lucas et al., 2022). Our results similarly confirmed that politicians are highly distrusted among respondents and show mixed levels of trust for NGOs, who are often messengers in conservation campaigns. Respondents in our study reported trusting teachers, followed by religious leaders and community leaders the most, representing possible key messengers for interventions based on appeals to norms around the consumption of wild meat. These results also suggest a role of school-based education through teachers and campaigns that engage religious and cultural leaders in conservation, which may link well with the reported strong beliefs relating to natural heritage and culture. Given wild meat consumers largely supported the notion that pangolins were part of Cameroon's natural heritage and should be protected, demand-reduction campaigns that target people's intrinsic motivations (e.g. national pride) in protecting wildlife could be one avenue to explore (MacFarlane et al., 2022). However, given that Cameroon is one of the most culturally diverse countries in the world (Gören, 2013), messengers that can appeal to multiple socio-cultural groups may be needed but could be challenging to identify.

Our results suggest that messaging using television and radio, and possibly newspapers, may be appropriate information dissemination tools for mass media campaigns and social marketing given their higher levels of trust among respondents. While social media may be a useful way of reaching many people, our respondents strongly distrusted social media, suggesting that campaigns wishing to spread information through social media may be less successful than through other dissemination tools. Appropriate message dissemination tools alone will unlikely be enough to drive change given that wild meat consumption can be considered an important part of cultural identity; however, including teachers and religious/community leaders in communications may yield greater impact. Given that few evaluations of conservation interventions to reduce wild meat consumption exist (Ingram et al., 2021), we recommend rigorous testing, and monitoring and evaluation of any demand-reduction interventions.

5 | CONCLUSIONS

We observed that the frequency of wild meat consumption was high among urban residents who stated that they consumed wild meat in southern Cameroon. Our study advances current scientific understanding of the factors that influence wild meat consumption by urban consumers, and this is the first quantitative assessment of both the change in urban wild meat consumption behaviours during COVID-19 within Africa and the factors that affect the likelihood of having decreased wild meat consumption. In particular, we show how spatial factors such as settlement size and beliefs about zoonotic disease risk are associated with wild meat consumption frequency and likelihood of decreased consumption. We also present novel information on the attitudes and perceived social norms of urban wild meat consumers that should be considered in the design of wild meat behaviour change efforts. Finally, we urge that any interventions are assessed for ethics, are monitored over time and evaluated for effectiveness, and that any outcomes or lessons learned are shared with others.

AUTHOR CONTRIBUTIONS

Franklin T. Simo and Daniel J. Ingram conceived and designed the study, with input from Markéta Swiacká; Franklin T. Simo secured funding with support from Daniel J. Ingram; Franklin T. Simo and Sévilor Kekeunou were responsible for obtaining research permits and local permissions; Franklin T. Simo led data collection, with Ghislain F. Difouo, Christian N. Tchana, Alain Christel Wandji, Alfiery Laurel Djomnang-Nkwala and Marcelle Mbadjoun Nziké; Daniel J. Ingram conducted the data analysis; Daniel J. Ingram wrote the first draft of the manuscript, with input on the methods from Franklin T. Simo; all authors revised the draft and approved the final version.

ACKNOWLEDGEMENTS

The authors wish to thank the Government of Cameroon through the Ministry of Scientific Research & Innovation (MINRESI; Research Permit No. 000014/MINRESI/B00/C00/C10/C13). We show gratitude to the people who were willing to participate in our study for their hospitality. We acknowledge Ipando Jean Jacques, Fonchou Signe R. Sandra, Dimi Mvele Piere, Ngo Bitjaga Marcelle Grâce, Keboun Tiya Line Stevie, Kamela Pierrick Dack, Mahi Janvion André, Mopo Diesse Valdeck, Kendeng Gilchrist Anthony, Hommo Marie Rosine and Djuitsa Ariane for their assistance in data collection. This research received financial support from the Conservation Action Research Network (CARN), to Franklin T. Simo. Daniel J. Ingram acknowledges support from UK Research and Innovation (Future Leaders Fellowship awarded to DJI, Grant ref: MR/W006316/1).

CONFLICT OF INTEREST STATEMENT

The authors declare no competing interests.

DATA AVAILABILITY STATEMENT

Anonymised data are available at: https://doi.org/10.5061/dryad.931zcrjt5.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1: Consumption frequency model odds ratios.

Appendix S2: Consumption frequency model.

Appendix S3: Spearman's correlations between Likert items relating to respondents ($n = 907$) attitudes, perceived norms, and reported wild meat consumption frequencies.

Appendix S4: Binomial model of having consumed wild meat since COVID-19 odds ratios.

Appendix S5: Binomial model of having consumed wild meat since COVID-19.

Appendix S6: Binomial model of having decreased wild meat consumption (1) versus increased/no change in wild meat consumption (0) since COVID-19 odds ratios.

Appendix S7: Binomial model of having decreased wild meat consumption (1) versus increased/no change in wild meat consumption (0) since COVID-19.

How to cite this article: Simo, F. T., Difouo, G. F., Tchana, C. N., Wandji, A. C., Djomnang-Nkwala, A. L., Mbadjoun Nziké, M., Kekeunou, S., Swiacká, M., & Ingram, D. J. (2026). Urban wild meat and pangolin consumption across southern forested Cameroon: The limited influence of COVID-19. *People and Nature*, *8*, 3221–3235. https://doi.org/10.1002/pan3.10634

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