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RESEARCH ARTICLE

Achieving Sustainable and Equitable Consumption of Wild Meat

The dynamics of wild and alternative meat consumption across Gabon, Central Africa

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Abstract

1. Long-term overharvesting of wild animals for their meat threatens wildlife and the people dependent on wild animal meat for their diets and incomes. Interventions to reduce wild meat consumption must be built upon a complete understanding of the roles of wild meat and its alternatives within food systems. Here, we conduct a national-scale analysis of how urbanization, market access and price impact the use of wild and alternative meat and fish in Gabon.
2. We obtained data on the acquisition and consumption of wild and alternative meat and fish for >6900 households from the WILDMEAT database, the largest dataset for Gabon to date. We then analysed associations between settlement size, market access, and price with the probability of consuming wild meat, alternatives, or no meat, and how these foodstuffs were acquired by households.
3. We found the probability of consuming wild meat and no meat to be negatively associated with settlement population size, whereas consumption of alternative meats was more likely in larger settlements. In villages, consumption of both wild and alternative meats became more likely as market access increased. Consumption of all meat types was then negatively associated with price, except traded fish products, which were consumed more in villages at higher prices. Acquiring meat through hunting and fishing was more likely in the most isolated and smallest villages and, as population sizes and market access increased, buying meat became more likely.

4. Our results suggest that more isolated, rural households depend on harvesting wild meat and fish from the environment, alongside a narrow range of traded, tinned fish products, as alternatives to hunting and fishing. Conversely, households in larger settlements and high-market-access villages can purchase and consume alternative meats and traded wild meat.
5. *Policy Implications*: In Gabon, settlements >3500 people, where most wild meat is bought and alternatives are usually available, may suit market-based and behaviour change interventions. Settlements of 900–3500 people may be effective targets of livelihood support projects. Nutritional analyses should be conducted in settlements <900 people, to understand the conditions under which wild meat is essential to nutritional security.

KEYWORDS
bushmeat, conservation, food systems, wild meat

1 | INTRODUCTION

Overharvesting of wild animals ranks alongside habitat loss as a driver of defaunation and extinction risk (Dirzo et al., 2014). The term 'empty forest syndrome' (Redford, 1992) describes vertebrate depletion spatially decoupled from forest loss, which results in tropical forests that appear intact but are depleted of medium-sized and large animals (Bogoni et al., 2023). These losses both directly impact hunted species and indirectly affect the wider ecosystem (Pires & Galetti, 2023) through, for example, predator and seed disperser loss (Effiom et al., 2013).

Subsistence hunting and consumption of terrestrial wild animals for their meat (hereafter 'wild meat') is practiced throughout tropical regions (Ingram et al., 2021). In remote areas, wild meat consumption underpins food and nutritional security, by providing protein and micronutrients (van Vliet et al., 2015). Local availability of wild meat also acts as a safety net during crisis periods when other foods are unavailable or unaffordable (Emogor et al., 2024). From an economic perspective, selling wild meat is often one of the best cash earning opportunities for low-income rural households (Nasi et al., 2008) and urban women lacking formal employment (Randolph et al., 2022).

As tropical forested regions are increasingly affected by economic development activities, remote forests are becoming more connected to urban markets through road construction (Kleinschroth et al., 2019). Per capita wild meat consumption by urbanites is often low, but large populations and rising incomes can produce substantial aggregate demand (Simo et al., 2024; Wilkie et al., 2016). The resulting commercialized wild meat hunting is associated with increased animal offtakes (Froese et al., 2023; Ingram et al., 2025) and a focus on larger, rarer species (Kuehl et al., 2009), which may be facilitated by improved hunting technology, such as a switch from spears to guns (Braga-Pereira et al., 2020) or using flashlights to induce animal freeze responses (Bowler et al., 2020). Due to greater hunting pressure, wild meat hunting and consumption now appear unsustainable throughout much of the tropics (Benítez-López et al., 2017). For example, wild meat hunting is implicated in population declines of approximately one quarter of threatened terrestrial mammal species (Ripple et al., 2016). Conservation and sustainable development interventions in wild meat using communities should therefore be carefully aligned, to ensure viable terrestrial vertebrate populations that provide sustainable wild meat supplies (Vasquez & Sunderland, 2023). On a global level, interventions ensuring sustainable wild meat harvests will contribute to international cooperative agreements, such as Target 5 of the Kunming-Montreal Global Biodiversity Framework (Obura et al., 2023).

New national policies and interventions are needed to build sustainable food systems in tropical forested regions that rely less heavily on wild meat for rural populations (Willis et al., 2022). To be successful, these must be built on a clear understanding of factors influencing consumption of wild meat and 'alternative meats' (Chaves et al., 2019), defined here as all other animal proteins, including fish. For example, previous studies have suggested that urbanization produces lower per capita wild meat consumption as alternative meats become available (Nasi et al., 2011). Similarly, increased market access and income-generating opportunities in rural areas may increase alternative meat availability and affordability (Chaves et al., 2017). Price differences influence consumer choice in different ways depending on the type of good (Wilkie et al., 2005): If consumption falls with increasing price, a food may be defined as a 'normal good' that is price elastic; however, if consumption remains constant or rises with increasing price, then a food may be defined as an 'essential good' that is price inelastic (Wilkie et al., 2005). Knowledge of how different meat types are acquired by households should also inform interventions aiming to improve food system sustainability (Torres et al., 2021). For example, characterizing which consumers purchase the majority of their wild meat could guide interventions targeting the commercial wild meat trade (Simo et al., 2024; Torres et al., 2022).

While previous studies have demonstrated that urbanization, market access and price impact wild meat consumption and acquisition, few have considered how these factors influence dynamics between wild and alternative meat use within the wider food system. Furthermore, studies are often conducted on local scales, potentially reducing their generalizability. In this study, we describe wild and alternative meat use in a range of population centres of different sizes across Gabon, Central Africa. Wild meat is a crucial component of the food system in Gabon, particularly with regard to rural food security (Abernethy & Ndong Obiang, 2010). Gabon is also heavily import reliant, importing the majority of food consumed within the country (African Union, 2023). In terms of alternative meats, 74% of meat (96% of poultry) and 56% of fish are imported (FAO, 2022). The reliance on imports makes many food products expensive, especially once transported to rural areas (Abernethy & Ndong Obiang, 2010), and price increases due to disrupted imports have the potential to increase wild meat consumption (e.g. in Nigeria; Emogor et al., 2024). Understanding the dynamics of wild and alternative meat consumption in the country can therefore inform policy and actions to improve the sustainability and resilience of the food system.

We use household-level data on wild and alternative meat consumption with nationwide coverage from >6900 households, collected from surveys conducted since 2000 in settlements ranging from <100 to >700,000 people. We investigate how wild and alternative meat consumption varies with settlement population size (i.e. urbanization), village market access and price and describe patterns of wild and alternative meat acquisition, at the national level. We discuss the implications of our findings in terms of interventions targeting wild meat sustainability and food system resilience.

2 | METHODS

2.1 | Data on wild meat and alternative meat consumption

We obtained data from the open-access WILDMEAT database (https://www.wildmeat.org/), which provides standardized, household-level data on wild and alternative meat consumption throughout Central Africa. The WILDMEAT data for Gabon was sourced from three peer-reviewed articles (Foerster et al., 2012; Ngama, 2015; Wilkie et al., 2005), four unpublished datasets (Abernethy, 2005; SWM Gabon, 2022; Whytock et al., 2022; Wilkie, 2003), and one PhD thesis (Starkey, 2004). In towns and cities, stratified-random sampling was used to evenly sample socioeconomic variation between quarters, before randomly selecting households in each quarter (see Foerster et al., 2012; Wilkie et al., 2005). In general, village surveys were conducted by interviewing the households present during surveys. Across all settlements, household heads were either asked whether meat had been consumed (i.e. directly assessing consumption) or whether meat had been cooked (i.e. the 'cooking-pot method') in the household over the preceding 24 (n households = 6150), 48 (n = 614), or 72 (n = 188) h, with longer surveys divided into 24-h recall periods. The use of the direct or cooking-pot method varied between data sources.

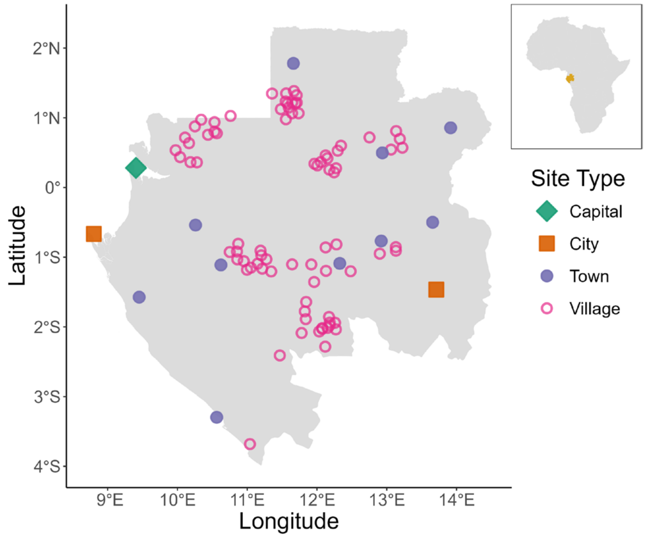

FIGURE 1 Locations of surveyed settlements. Some points lie outside Gabon as a jitter has been applied to the points, by adding 0.2° (22.2 km) of random variation, to anonymize village locations. Cities (including the capital) were defined as >100,000 people (larger coloured points), towns as >2000 people and villages as ≤1999 people (smaller coloured points). The inset displays the location of Gabon (yellow) within Africa (grey).

However, previous analyses have found that studies recording meat consumption per se do not differ systematically from those recording meat cooked by households (Bessone et al., n.d.), and we therefore combined all survey types during analyses. Household surveys were carried out between 2000 and 2022 and produced 55,508 unique 24-h recall periods. These recalls were gathered from 6952 households, spread throughout Gabon in 96 sites, including three cities (2116 households), 10 towns (2774 households) and 83 villages (2062 households) (Figure 1).

2.2 | Data processing

When meat or fish was consumed, the taxon was recorded to the lowest possible resolution, alongside its condition (e.g. 'fresh', 'tinned', 'smoked'). From these data, we classified meat into eight categories: non-domesticated terrestrial vertebrates as 'wild meat'; domesticated birds as 'domestic poultry'; domesticated mammals as 'domestic livestock'; fish harvested by households themselves or bought fresh as 'local fish'; fish bought by, or gifted to, households in a preserved condition (e.g. 'tinned', 'smoked', 'frozen') as 'supply chain fish'; invertebrates from aquatic or terrestrial habitats as 'aquatic invertebrates' or 'terrestrial invertebrates', respectively; and recall periods in which no meat was consumed as 'no meat'. Our supply chain fish definition may have included some fish caught, preserved and sold locally, but was the best approximation we could use to split locally sourced wild fish from fish traded on national or international scales. Terrestrial and aquatic invertebrates were rarely consumed (see Section 3) and excluded from further analyses.

During surveys, information on meat acquisition was recorded, from which we produced three levels: 'bought', 'gifted' and 'hunted' for wild meat and local fish and 'bought', 'gifted' and 'locally raised' for domestic livestock and poultry. As per our definition above, supply chain fish could only have been bought or gifted. If the mass of meat consumed was known by households, this was recorded in kilograms. If unknown, mass was recorded in local units of sale (e.g. 'entire', 'gigot') or informal units (e.g. 'plat', 'tas') and converted to kilograms using conversion factors derived from published data on whole animal body mass (Kingdon et al., 2013), empirical data collected by the authors of Bessone et al. (n.d.) or the amniote life history database (Myhrvold et al., 2015). Prices of bought meat were recorded directly or, for hunted or gifted meat, the price the household could potentially sell the meat for was recorded. We calculated price per kilogram by dividing the price in Central African Francs (FCFA) by the mass in kilograms. For use as an independent variable in our price analysis, we calculated the mean price per kilo for each meat type within a settlement, during a single study (Wilkie et al., 2005).

Socioeconomic data gathered included the age and sex of each household member. To account for age and sex differences in nutritional requirements, household composition was standardized to per Adult Male Equivalent (AME) (Vega et al., 2013). Calculations of meat consumption per person were therefore expressed as per AME instead of per capita. Settlement population sizes were either recorded during surveys or taken from the most recent Gabonese national census, conducted in 2013 (DGS, 2015). Some villages were excluded from analyses if population data were missing from both data sources. We defined settlements with ≤1999 people as villages, 2000 – 100,000 people as towns and >100,000 people as cities. To approximate the effect of market access in villages, we calculated the distance from villages to the nearest major road and the nearest large town. The location of all towns >5000 inhabitants according to the 2013 census, which we defined as 'large towns', and all roads classified as motorways, trunks (next largest after motorways), primary roads (linking larger towns) and secondary roads (linking smaller towns), which we defined as 'major roads', were obtained from OpenStreetMaps (www.openstreetmap.org). We then calculated the Euclidian distance from each village to the nearest large town and nearest major road.

2.3 | Statistical analysis

To investigate the use of different meat types throughout Gabon we examined associations between the consumption probability of six meat types (including no meat) within a 24-h recall period and settlement population size, market access and price per kilogram, using binomial generalized linear mixed models (Zuur et al., 2009). When analysing the impact of market access on consumption, we compared alternative models with distance to the nearest major road and distance to the nearest large town as independent variables. When analysing the impact of price, we compared alternative models in which all settlements were pooled and in which villages were modelled separately from large settlements. In both cases, we selected the best model with approximate leave-one-out cross validation (Vehtari et al., 2017). We scaled and centred the price per kilogram independent variable to facilitate model convergence.

To examine how households acquire meat, we modelled associations between settlement population size (all sites), market access (villages) and the binomial probability of meat acquisition via each pathway (e.g. 'hunted' or 'bought'). For all the above consumption and acquisition models, we included random intercepts for study ID, site name, household ID and recall ID.

To determine whether market access influenced price per kilogram, we constructed a Gaussian generalized linear mixed model with settlement mean price per kilogram as the dependent variable and meat type, distance to major roads and their interaction as independent variables, alongside random intercepts for study ID. When analysing the relationship between market access and wild meat consumption per AME per day in villages, we fitted a generalized linear mixed model, with a Gamma error structure and log link function. Here we included random intercepts for site name and household ID nested within site name, but study ID contained too few levels for inclusion. We then used the coefficients from this model examining mass consumed, alongside those from the model examining associations between market access and consumption probability, to calculate the mean mass consumed per AME per day, at a given distance to major roads.

To quantify the differences between meat types and settlement types in the way in which meats are packaged and sold, we calculated the mean, 2.5% and 97.5% quantiles of mass in kilograms, absolute price and price per kilogram of all units of each meat type present in the database. We took the 2.5% quantile as an indicator of minimum price and 97.5% quantile as an indicator of maximum price to avoid the influence of extreme outliers. These calculations were performed separately for villages and large settlements, to facilitate comparisons between settlement types.

2.4 | Software

We conducted all analyses using R v4.4.1 (R Core Team, 2024). Data wrangling was completed using 'tidyverse' v2.0.0 (Wickham et al., 2019) and 'sf' v1.0.20 (Pebesma, 2018) for spatial objects. All models were fitted with the Stan probabilistic programming language (Carpenter et al., 2017) via 'brms' v2.22.0 (Bürkner, 2017). We produced all plots and maps using 'ggplot2' v3.5.1 (Wickham, 2016) and tables with 'flextable' v0.9.6 (Gohel & Skintzos, 2024).

2.5 | Ethics statement

No direct ethical approval was sought for this study because all data concerning food acquisition and consumption by households consisted of secondary data, which was anonymized before inclusion in the WILDMEAT database.

3 | RESULTS

3.1 | Summary data

In our sample, the most frequently consumed meat type across all recall periods was supply chain fish (32.8%), followed by domestic poultry (18.7%), local fish (14.6%), wild meat (13.7%), domestic livestock (8.2%), aquatic invertebrates (0.3%) and terrestrial invertebrates (0.04%). No meat was consumed in 20.8% of recall periods. In terms of wild meat acquisition, 53.4% of items were recorded as bought, 35.4% as hunted and 11.2% as gifted. For local fish, 66.6% were bought, 30.8% were hunted and 2.6% were gifted. Pooling domestic livestock and poultry, 98% of items were recorded as bought, 1.8% as gifted and 0.2% as locally raised.

3.2 | The probability of consuming different meat types is associated with settlement population size

We found that the probability of consuming five of six meat types was meaningfully associated with settlement population size (Table S1). Wild meat consumption was negatively associated with population size, with consumption most likely in the smallest villages (33.9% recall periods [95% CI: 28.0% – 40.4%]) and least likely in Gabon's capital city, Libreville (8.3% [6.4% – 10.7%]) (Figure 2). The likelihood of no meat being eaten was highest in small villages (42.3% [35.7% – 49.3%]) and lowest in Libreville (14.9% [11.7% – 18.9%]). Local fish consumption was not meaningfully associated with population size. Supply chain fish, poultry and livestock showed positive associations, being least likely to be consumed in small villages and most likely in Libreville. Supply chain fish was the most likely alternative meat type to be consumed across all settlement sizes (Figure 2). Tinned fish constituted 61% of supply chain fish consumed in villages, but 18.9% in towns and cities.

3.3 | In villages, the consumption probability of different meat types is associated with market access

When comparing village market access measures, distance to major roads was taken as the preferred independent variable over distance to large towns (ELDP Difference = −273, SE = 59.1). Wild meat consumption probability declined with increasing distance to major roads, being most likely adjacent to major roads (29.7% [95% CI: 22.2% – 39.0%]) and least likely in the most isolated villages

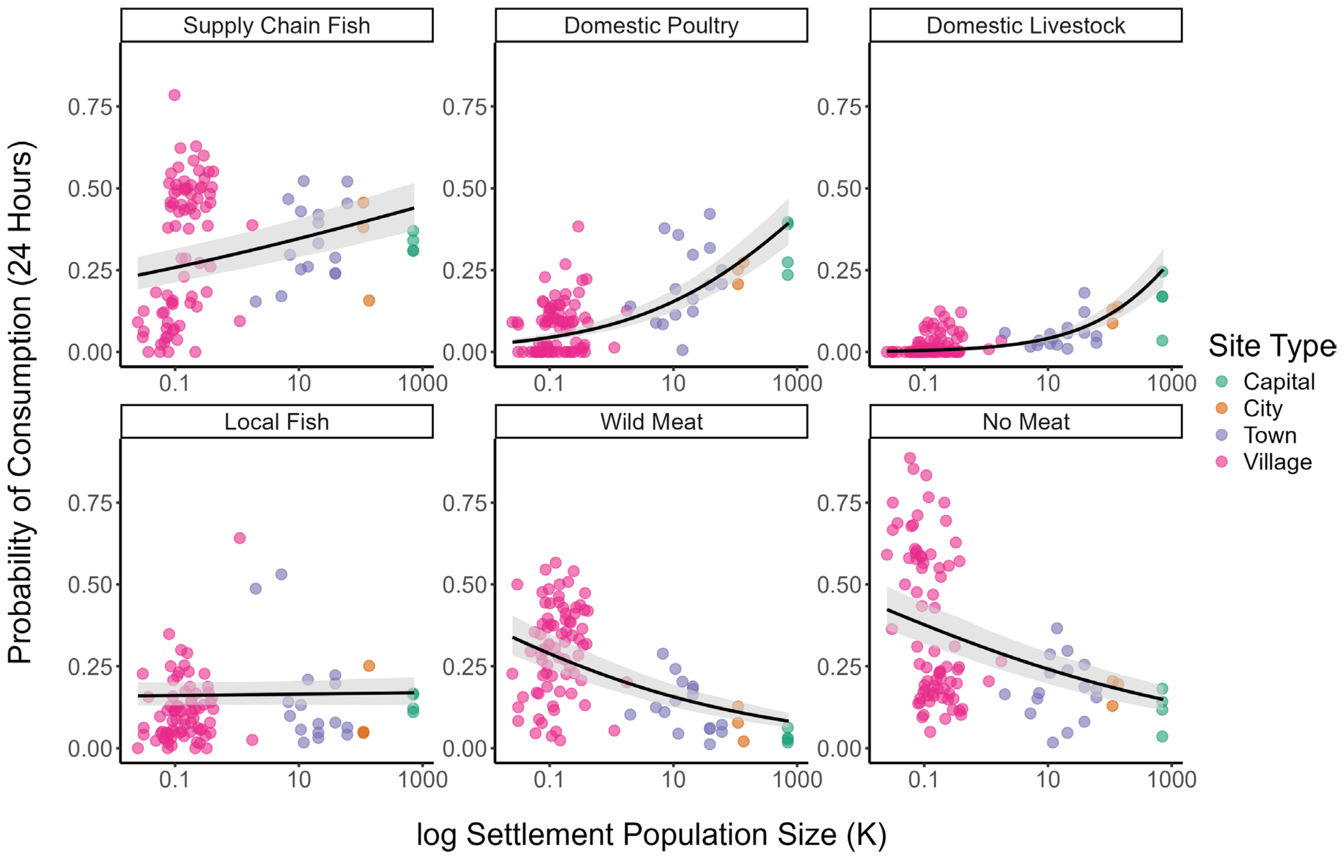

FIGURE 2 Associations between log population size (expressed in thousands) and the probability of six meat types being consumed within a 24-h recall period. Black lines represent the predicted mean consumption probability of a given meat type in a 24-h recall period and grey ribbons illustrate the 95% credible interval around the mean. Coloured dots display the settlement-level probability of each meat type being consumed (distinct from the recall level at which the model was fitted).

(15.2% [10.8% – 21.7%]) (Table S2; Figure 3). Local fish consumption probability increased with declining market access, but this association appeared to be driven by a single isolated coastal village, and removing this village from the dataset reversed the association between market access and local fish consumption (dashed line Figure 3; Table S3). The probability of consuming no meat was highest in the most isolated villages (56.0% [46.4% – 65.9%]) and lowest in the villages with the highest market access (35.7% [27.2% – 45.5%]). Supply chain fish, poultry and livestock were all most likely to be consumed in villages with high-market access and less likely as villages became more isolated (Figure 3).

We found a negative association between market access and mass of wild meat consumed per AME, meaning households in the most isolated villages consumed the highest amounts of wild meat during consumption events (Table S4). Using coefficients from this model and the binomial model above, we calculated that households in villages 0 and 60 km from roads consumed on average the equivalent of 153 g (95% CI: 99 – 230 g) of wildmeat per AME per day and 184 g (105 – 325 g) per AME per day, respectively.

3.4 | Settlement population size and market access covary with meat hunting and buying

We found that population size was meaningfully associated with the probability that wild meat and local fish were bought or hunted, but not with the probability of gifting (Table S5). The probability of both wild meat and local fish being bought or hunted was positively and negatively associated with population size, respectively (Figure 4). According to the model, the population size at which 50% of wild meat records were hunted was 869 [95% CI: 667 – 1120] people, and 50% were bought at a population size of 3533 [2764 – 4571] people. The population size at which 50% of local fish records were hunted was 254 [132 – 436], and 50% were bought was 321 [158 – 567]. The reason for a greater discrepancy in the populations sizes at which these transitions occurred for wild meat was because more wild meat was gifted than local fish (Figure 4). We also found an increase in the probability of wild meat being hunted as villages became more isolated and an increase in wild meat being bought as market access increased (Table S6; Figure 5).

3.5 | Prices effects differ between villages and large settlements

When examining the impact of commodity price on consumption, the model containing site type, that allowed price effects in villages and large settlements to be contrasted, was preferred over a model pooling all sites (ELPD Difference = −1424.6, SE = 52.2). The probability of consuming wild meat, local fish, poultry and livestock was negatively associated with price per kilo in both villages and large settlements. Supply chain fish consumption was also negatively

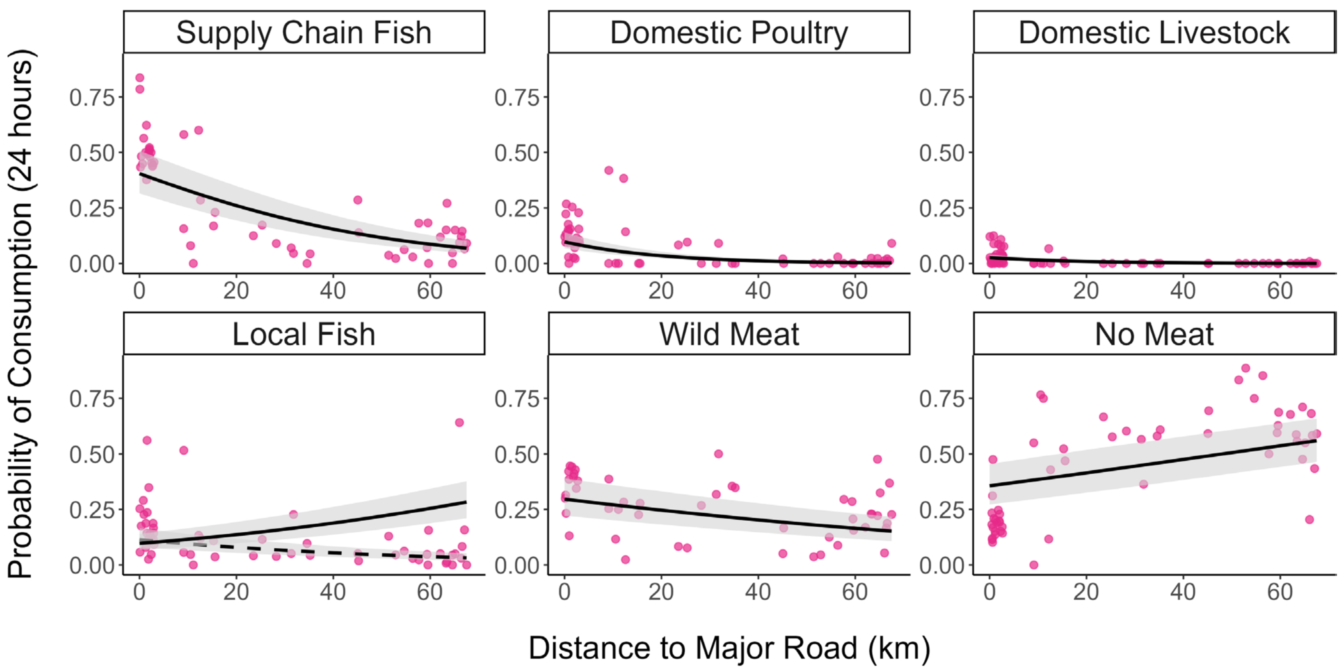

FIGURE 3 Associations between distance to the nearest major road as a proxy for market access and the consumption probability of different meat types. Black lines indicate the mean probability of a food type being consumed in a 24-h recall period and grey ribbons indicate the 95% credible interval around the mean. Pink dots indicate the settlement-level probability of each meat type being consumed (distinct from the recall level at which the model was fitted). Dots <1 km from major roads have been horizontally jittered by 3 km to reduce overlap between points. The dashed line in the Local Fish panel indicates the association between market access and the probability of local fish consumption with a single outlier village removed, taken from the model in Table S3 (see text).

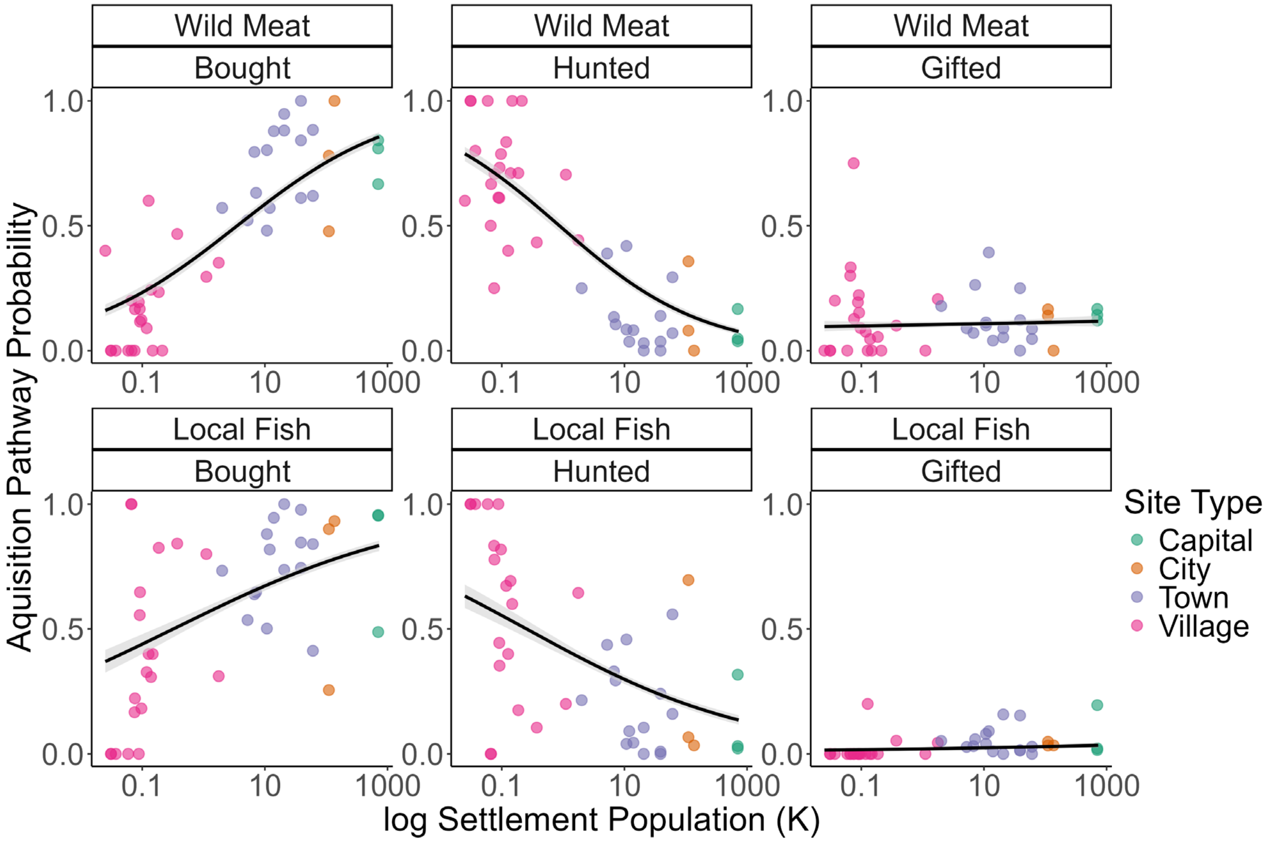

FIGURE 4 Associations between settlement population size (expressed in thousands) and the probability of acquiring wild meat or local fish via buying, hunting or gifting. Black lines indicate the mean probability of a food type being consumed in a 24-h recall period and grey ribbons indicate the 95% credible interval around the mean. Coloured dots indicate the settlement-level probability of each meat type being consumed (distinct from the recall level at which the model was fitted).

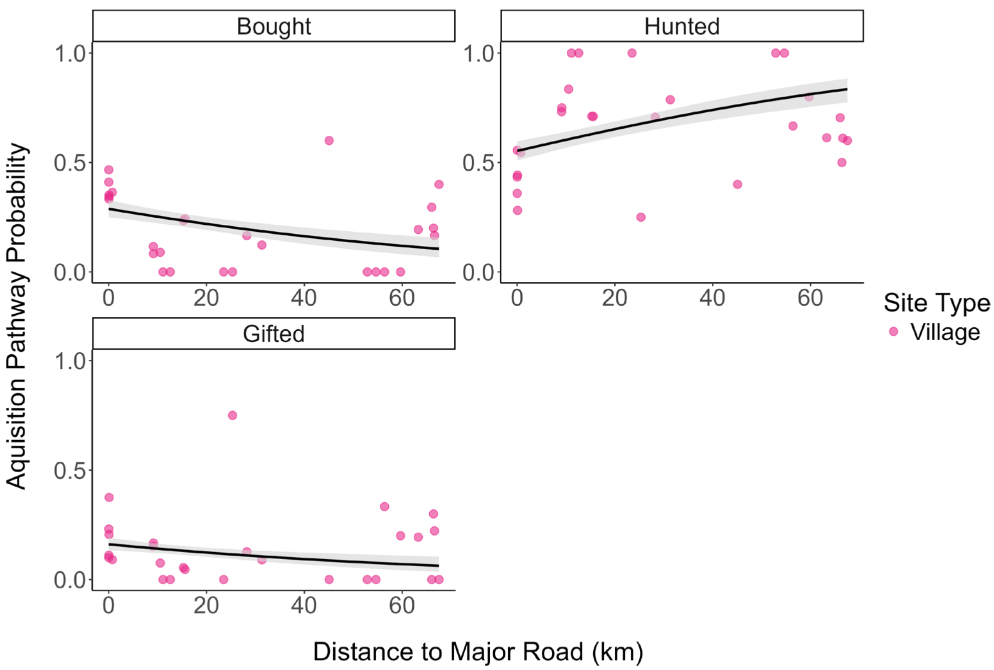

FIGURE 5 Associations between village market access and the probability of acquiring wild meat via buying, hunting or gifting. Black lines indicate the mean probability of a food type being consumed in a 24-h recall period and grey ribbons indicate the 95% credible interval around the mean. Pink dots indicate the settlement-level probability of each meat type being consumed (distinct from the recall level at which the model was fitted).

associated with price per kilo in large settlements. However, the probability of consuming supply chain fish was positively associated with price per kilo in villages (Table S7; Figure 6).

To investigate whether this positive association between price and village supply chain fish consumption was driven by low-market-access villagers paying higher prices, we examined associations between market access and price per kilo in villages (Table S8). However, there were no meaningful associations between price and market access for any meat types (Figure S1).

3.6 | Variance in units of sale by site type

In both villages and large settlements, the mean and minimum mass of supply chain fish units offered for sale were lower than for other meat types. Wild meat was consumed in the largest average units but was the most variable in terms of unit mass. The mean and minimum mass of domestic poultry and livestock units exceeded those of supply chain fish in villages and large settlements (Table 1; Figure S2).

In terms of absolute unit price, mean prices were highest for wild meat in both settlement types, whereas mean supply chain fish unit price was lowest. Minimum prices were lowest for supply chain fish in villages and lowest for wild meat in large settlements. In both settlement types, the mean and minimum prices of poultry and livestock were higher than the prices of supply chain fish (Table 1; Figure 7). Regarding price per kilo, in large settlements mean price per kilo was lowest for poultry and minimum price per kilo was lowest for wild meat. Though, notably, the mean and maximum prices per kilo were also highest for wild meat in large settlements, signifying high variances in price for wild meat in these settlements. In villages, mean and minimum price per kilo were lowest for wild meat. Supply chain fish was the most expensive meat per kilo in villages (Table 1; Figure 7).

4 | DISCUSSION

We investigated consumption and acquisition of wild and alternative meat and fish in Gabon, in relation to urbanization, market access and price. Overall, we found consumption of hunted wild meat and instances where no meat was consumed to be most likely in smaller, isolated settlements and consumption of purchased wild meat and alternative meats to be more likely as urbanization and market access increased. In contrast to all other meat types, supply chain fish was an essential good in villages, suggesting it plays a crucial role in the rural food system.

4.1 | Meat consumption patterns are in part driven by urbanization, with 'no meat' the most likely recall in small villages

Wild meat and no meat were most likely to be consumed in the smallest villages and least likely in Libreville, whereas supply chain fish, poultry and livestock showed the inverse trend. Thus, our national-level analysis is consistent with smaller scale studies (Wilkie et al., 2005) showing that, in Gabon, wild meat is most frequently consumed in rural areas and that alternatives predominate as urbanization takes place. Though, notably, wild meat was still consumed in Libreville (8.2% recall periods), as seen in other Central African cities, and even these lower frequencies will result in substantial wild meat consumption in large settlements (Simo et al., 2024; Wright et al., 2022).

When meat consumption occurred in villages, wild meat was the most frequent recall. However, households in the smallest villages were most likely to have consumed no meat in the past 24 h. Given that animal-based foods provide the bulk of dietary protein in Gabon (Foerster et al., 2012), our results suggest that wild meat underpins the protein intake of many villagers. Authors of other studies speculated that the rural food system in Gabon would adapt poorly to losing wild meat, partly due to low alternative meat and fish supply (Booth et al., 2021). This is exemplified by our finding that poultry and livestock consumption is relatively unlikely in villages, compared to larger settlements. We also found a positive association between population size and supply chain fish consumption; however, this association was weaker because of higher supply chain fish consumption in villages. Notably, tinned fish constituted 61% of consumption events in villages, but only 18.9% in towns and cities. Though there is clearly much settlement-level variation (Figure 2), villagers often consume no meat and, compared to people living in larger settlements, much of their meat consumption relies on animals obtained directly from the environment (i.e. wild meat or local fish) or a relatively narrow range of commercial fish products.

4.2 | Higher market access raises the probability of meat consumption in villages

We found distance to major roads to better predict consumption than distance to large towns, perhaps because some villages are situated far from towns, but adjacent to roads connecting towns. The resulting flow of goods through these villages, and frequent roadside sales in Gabon (Abernethy & Ndong Obiang, 2010), might explain the influence of road proximity on consumption.

Market access is expected to increase wealth as households enter the cash economy (Kramer et al., 2009). Two competing hypotheses attempt to explain consumption changing with wealth: the 'normal good hypothesis' suggests consumption of preferred or non-substitutable meat will increase with wealth; whereas the 'inferior good hypothesis' suggests consumption of non-preferred, substitutable meats will decrease with wealth (Wilkie & Godoy, 2001). Associations between market access and consumption can be interpreted as a test between these hypotheses, because of the expected association between market access and wealth (Chaves et al., 2017). We found wild meat, supply chain fish, poultry and livestock to

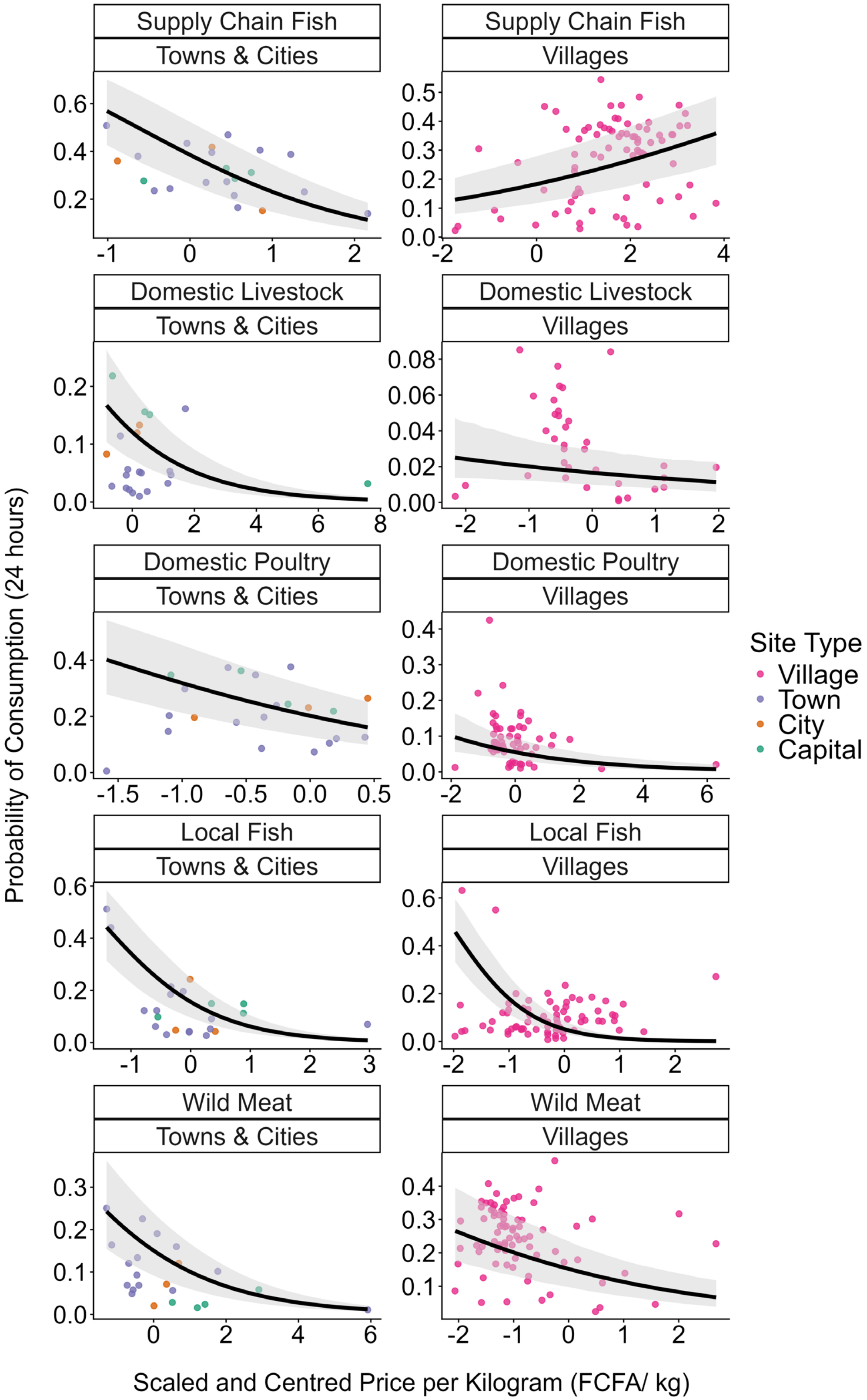

FIGURE 6 Associations between price per kilo and consumption probability of five meat types. Black lines indicate the mean probability of a food type being consumed in a 24-h recall period and grey ribbons indicate the 95% credible interval around the mean. Coloured dots show the settlement-level probability of a meat type being consumed (distinct from the recall levels at which the model was fitted). Scales differ between panels to avoid compression of model predictions and raw data.

TABLE 1 Unit mass, absolute unit price and price per kilogram of each meat type in the WILDMEAT database in large settlements and villages.

		Unit mass			Absolute unit price			Price per kilogram		
Settlement type	Meat type	Mean (kg)	95% CI lower (kg)	95% CI upper (kg)	Mean (FCFA)	95% CI lower (FCFA)	95% CI upper (FCFA)	Mean (FCFA/kg)	95% CI lower (FCFA/kg)	95% CI upper (FCFA/kg)
Towns and Cities	Domestic livestock	1.89	0.5	4	2400	700	7500	1550	400	4007
Towns and Cities	Domestic poultry	1.68	0.5	4	2034	600	6000	1240	400	2703
Towns and Cities	Local fish	1.67	0.37	5	1714	300	5000	1260	125	4054
Towns and Cities	Supply chain fish	1.12	0.088	3	1215	200	4000	1577	90.1	4698
Towns and Cities	Wild meat	3.56	0.37	17.7	3559	100	15,000	1688	25	5455
Villages	Domestic livestock	2.71	0.5	4.32	2109	420	6000	1451	268	2500
Villages	Domestic poultry	1.49	0.5	4	2041	650	5760	1564	564	2727
Villages	Local fish	1.28	0.37	3	1196	250	4052	1125	167	4000
Villages	Supply chain fish	0.556	0.088	2	925	200	3000	2747	270	4545
Villages	Wild meat	4.44	0.5	17.7	3236	400	12,000	1069	152	3643

behave as normal goods, because consumption increased with market access, presumably as households gained cash earning opportunities.

A positive association between market access and wild meat consumption is counter to results from Amazonia (Chaves et al., 2017) and somewhat surprising, as no meat consumption was highest among low-market-access households, who may be expected to hunt and consume wild meat more often. We therefore conducted two additional analyses, which together showed that low-market-access households consumed larger amounts of hunted wild meat, but less frequently, whereas high-market-access households consumed smaller amounts of purchased wild meat, but more frequently. Thus, despite lower consumption frequency, isolated households seem reliant on wild meat for nutritional security. Lack of refrigeration may compel isolated households to rapidly consume any meat they obtain, leading to infrequent consumption of large amounts. Rural electrification is taking place in Gabon, albeit incomplete (Koffi, 2023), so examining the effect of electrification and cold storage capacity on wild and alternative meat consumption would be a useful future investigation.

Regarding no meat consumption, our results suggest that households in large settlements or high-market-access villages consume no meat on ~20% of days, with the probability increasing to ~50% in the smallest, most isolated villages. Wild meat and local fish are often the main protein sources in rural Gabonese households (Foerster et al., 2012; Matsuura & Moussavou, 2015), so our results are an indicator, but not confirmation, that shortfalls in protein consumption become more likely in more rural settlements. Complete analyses of micro- and macronutrient intake, that include wild meat, alternative meats and plant proteins, are required to determine if no meat days are a health concern among wild meat reliant households (Admettons et al., 2025). Future work identifying where on the rural–urban gradient nutritional shortfalls are likely, and the contribution of different protein sources to household nutrition, would provide more details to inform future interventions, for example, by identifying settlement types that could reduce wild meat consumption without risking nutritional deficiencies.

Regarding local fish consumption, we did not find a meaningful association with urbanization and associations with market access were strongly influenced by a single coastal village. It may be that geographic variables like distance to water bodies better explain local fish consumption than the factors we considered here (Cutler et al., 2020). Though not a goal of this study, wild fish overharvesting is a conservation concern (Metcalfe et al., 2022) and understanding the drivers and sustainability of fishing in Gabon would also be worthwhile.

4.3 | Price and units of sale influence meat consumption and suggest that supply chain fish may be an essential good in villages

In large settlements, we found consumption of all meats to fall with increasing price. In villages, consumption of wild meat, local fish, poultry

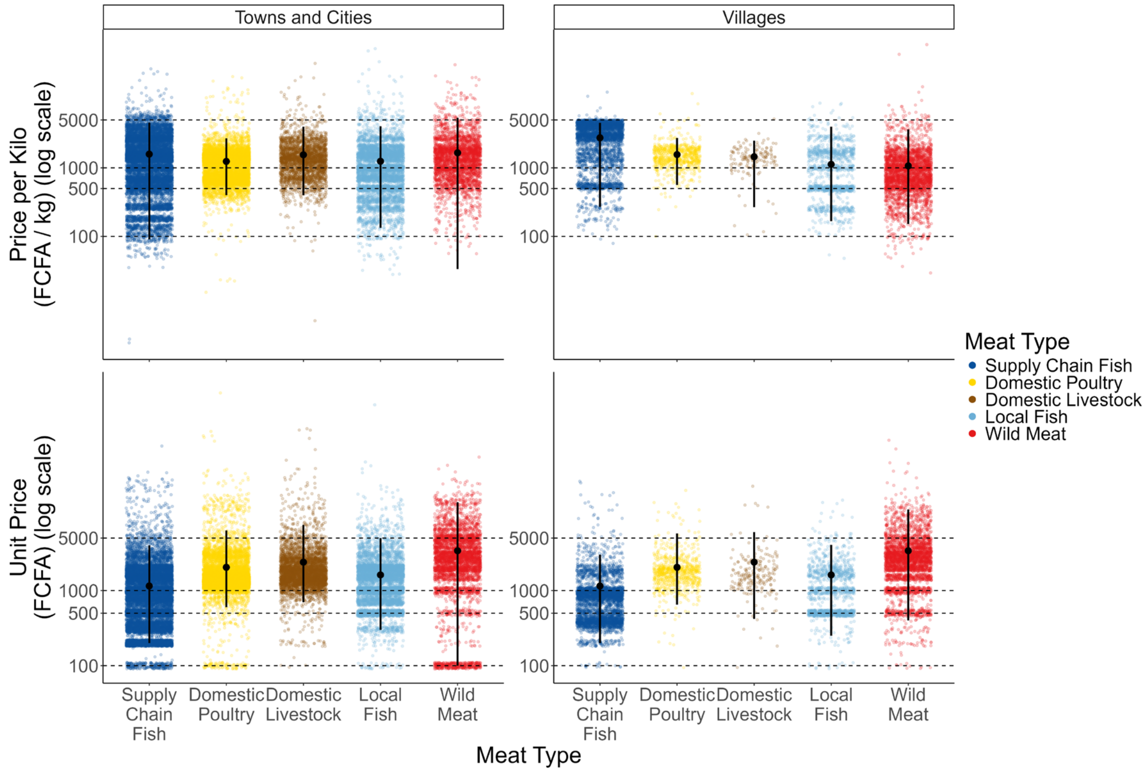

FIGURE 7 Absolute unit price and price per kilogram of each unit of meat recorded as consumed in Gabon in the WILDMEAT database in villages and large settlements. Coloured dots display the prices of individual records, black dots show the mean for each food and settlement type and vertical black lines illustrate the 2.5% and 97.5% quantiles for each food type, interpreted as an indicator of minimum and maximum price, respectively.

and livestock also fell at higher prices. However, supply chain fish consumption probability increased with price, suggesting these may be essential goods. We hypothesized that supply chain fish may be essential in isolated villages where alternatives were not available, which would imply higher prices in isolated villages. However, we found no association between market access and prices of supply chain fish, nor other meats.

We then considered whether units of sale may impact consumer decisions and explain why supply chain fish could be an essential good in villages. We found that supply chain fish was sold in the smallest units in villages and large settlements, for the lowest mean price in villages and large settlements, and for the lowest minimum price in villages. However, as Figure 7 illustrates, villagers buying supply chain fish are paying the highest prices per kilogram across all meat types and settlements, and thus receiving the worst return on investment in terms of protein intake for the money they spend.

Low unit prices may explain supply chain fish, which is mostly tinned and imported, is an essential good in villages. If most residents are on low incomes (Foerster et al., 2012), villagers failing to hunt or fish may only have enough cash to obtain a small unit of alternative meat. Domestic meat packages, averaging >1.5 kg and >2000 FCFA (>3.25 USD) in villages, may often be unaffordable. Therefore, because supply chain fish has the lowest unit size and price, this may be the only obtainable protein source for their available funds (Matsuura & Moussavou, 2015). Another contributory factor may be challenges in storing fresh or frozen, as opposed to tinned, meat in isolated village shops, which may further limit the range of options available to villagers. The result is that villages appear reliant on a narrow range of imported fish products, to offset failures to harvest wild meat or fish, and receive a bad deal for the money they spend.

4.4 | Urban areas and transitioning villages are crucial intervention points

Due to high aggregate consumption, wild meat demand reduction in larger settlements is crucial to a sustainable wild meat sector (Ingram et al., 2021). Options include persuading consumers to more often choose alternatives via behaviour change campaigns or price changes (Chaves et al., 2017; Cisse et al., 2025). Encouraging consumption of alternatives will be most effective in urban areas, where these are already available. However, urban demand reduction must be based on knowledge of wild meat consumers, to develop effective messages and target the right audiences (Shairp et al., 2016). A thorough understanding of the psychosocial drivers of wild meat consumption is therefore required, but rarely studied (Chausson et al., 2019). Future research examining these psychosocial drivers in Gabon would enhance the possibility of successful interventions targeting a sustainable wild meat sector.

Supporting sustainable village transitions to a market-based economy is a second important intervention point, aiming to develop sustainable livelihoods before local wildlife depletion (van Gils et al., 2019). In addition, our results suggest an overall rise in meat consumption as market access increases, consistent with regional predictions (Falchetta et al., 2021). How to meet new demand sustainably is an ongoing question. The apparent reliance of some rural households on only a few alternatives to wild harvested meat and fish means interventions to improve the rural food system must also consider the diversity of alternatives available. Increasing the diversity of alternatives is important to the resilience of the rural food system, in terms of household food security, but also sustainability, to avoid import disruptions leading to more wild meat consumption (Emogor et al., 2024). The options for lower wild meat dependence, meeting new demand and increasing food system diversity may overlap. Given that only 0.2% domestic meat consumption events were recorded as locally raised, supporting animal rearing could reduce households' dependence on imported meats. However, where imported meats are required, increasing refrigeration capacity and the availability of smaller domestic meat units (i.e. 0.5–1kg, as opposed to the current average of ≈1.5kg), could reduce reliance on tinned fish. It should also be considered that commercial fish products are desirable among rural consumers, which would be consistent with the positive associations of consumption with price and market access. Further work is needed to uncover whether commercial fish products can act as a substitute, rather than a supplement, to wild and domestic meat consumption. However, efforts to expand local fish farming may offer a more sustainable alternative to increasing local rearing or importation of domestic meat. Each of these options could contribute to improving the diversity and availability of wild meat alternatives in rural areas, improving food system resilience and encouraging the choice to purchase alternatives (including meats, fish, insects or plant–proteins), as greater market access leads to a rise in cash income, potentially lowering local demand for traded wild meat.

However, consideration must be given to the ecological footprint of domestic animal production (Booth et al., 2021) and in some locations, managed, sustainable hunting may prove a more suitable solution to overharvesting (Nunes et al., 2021). Furthermore, livelihood projects supporting alternative protein production have often failed to produce tangible conservation benefits and must be built on a thorough understanding of household livelihood strategies and local culture, for successful implementation (Brittain et al., 2022; Wicander & Coad, 2018).

4.5 | Urbanization and higher market access make households more likely to buy meat than hunt it themselves, but have little impact on the traditional practice of gifting meat

Our results concerning meat acquisition can provide initial suggestions about where different interventions may be targeted. We found a positive association between buying wild meat or local fish and urbanization and a negative association between hunting and urbanization. Our model predicted that when settlement populations rise above ≈3500 over 50% of wild meat will be bought, suggesting that at this stage of urbanization wild meat switches from a wild harvested to a commercially traded good. Thus, settlements of ≈3500 people may be the lower limit at which market-based and behaviour change interventions could most effectively lower wild meat consumption. The model also predicted that most wild meat is hunted in settlements below ≈900 people, suggesting hunting remains a subsistence activity in smaller villages. As subsistence hunting tends to involve lower offtakes than commercial hunting (Ingram et al., 2025), lowering wild meat demand in villages below ≈900 people may have the least impact for conservation. In these villages, community-based management of land and hunting may be the best route to sustainable offtakes (Van Vliet et al., 2025).

The population size discrepancy between switches from hunting to buying wild meat is made up by the proportion of gifted wild meat. During rural to urban transitions, residents may struggle to gain cash income, maintain rural–urban links and receive wild meat from kin (Torres et al., 2022). Consequently, in Gabon, settlements between 900 and 3500 people may be ideal for livelihood support projects, to reduce wild meat demand and disincentivize recent migrants from using rural links to generate cash through trading wild meat, as seen elsewhere (Ingram, 2020).

5 | KEY RECOMMENDATIONS

Our results confirm locally observed patterns at a national scale, that hunting wild meat is most likely among rural households, that increased urbanization and market access lead to more consumption of traded wild meat and alternative meats, and that prices impact consumption of all meats. Though local nuances will lead to variation between countries, the general consistency of our results with the expected effects of urbanization, market access, and price changes suggests that similar results may be predicted in other food systems where wild meat plays a substantial role. Our study suggests three key targets of future research to improve the sustainability of human–nature interactions involving the hunting and consumption of wild meat (population sizes specific to Gabon): (1) complete nutritional analyses in rural villages <900 people to determine the conditions under which wild meat is crucial to food security (2) examine the economic, cultural, and psychological factors impacting the future success of domestic protein production, and marketing, in villages and towns of 900 – 3500 people (3) design and trial supply-side (e.g. price changes) and demand-side (e.g. behaviour change campaigns) interventions to reduce wild meat consumption in urban areas >3500 people.

AUTHOR CONTRIBUTIONS

Joshua Bauld, Katharine A. Abernethy, Lauren Coad, Robin C. Whytock, Kathryn Jeffery conceived the ideas and designed methodology; Robin C. Whytock, Donald Midoko Iponga, Margeorie Babicka, Sophie Pambo, Daniel J. Ingram, Mattia Bessone, Paul Loundou, David S. Wilkie, Malcolm Starkey, Steeve Ngama, Daniel Cornelis, Katharine A. Abernethy collected the data; Joshua Bauld, Katharine A. Abernethy, Lauren Coad, Robin C. Whytock, Kathryn Jeffery analysed the data; Joshua Bauld, Katharine A. Abernethy,

Lauren Coad, Robin C. Whytock, Kathryn Jeffery led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Household-level consumption, price, unit size, meat acquisition and settlement population size data will be made available as part of the open-access WILDMEAT database (https://www.wildmeat.org/). Spatial predictors, such as distances to roads and towns, can be calculated by combining WILDMEAT data and spatial data available from OpenStreetMaps (www.openstreetmap.org).

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SUPPORTING INFORMATION

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

Table S1. Binomial generalized linear mixed model examining associations between settlement population size and consumption probability of six meat types in Gabon.

Table S2. Binomial generalized linear mixed model examining the effect of distance to nearest major road (market access) on the consumption probability of six meat types.

Table S3. Binomial generalized linear mixed model examining the effect of distance to nearest major road (market access) on the consumption probability of six meat types, removing recalls from a single outlier village.

Table S4. Generalised linear mixed model with a Gamma error structure and log link function examining associations between distance to the nearest major road and consumption of wild meat per AME per day in Gabonese villages.

Table S5. Binomial generalized linear mixed model examining associations between settlement population size and the probability of acquiring wild meat and local fish via buying, hunting, or gifting.

Table S6. Binomial generalized linear mixed model examining associations between distance to the nearest major road and the probability of wild meat being acquired via buying, hunting or gifting in Gabonese villages.

Table S7. Binomial generalized linear mixed model examining associations between price per kilo and the probability of consumption of different meat types, as a measure of price elasticity.

Table S8. Generalized linear mixed model examining associations between distance to major roads (market access) and the price per kilo of five meat types.

Figure S1. Associations between market access and the price per kilo of five meat types in Gabonese villages.

Figure S2. The mass of each unit of meat recorded as consumed in Gabon in the WILDMEAT database in villages and large settlements.

Figure S3. Associations between Day of Year and the probability of consumption of six meat types, across all settlement types.

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