Understanding drivers of urban bushmeat demand in a Ghanaian market

Abstract

Wild meat (or bushmeat) is consumed as a luxury item in many African cities. By contrast, bushmeat is an important source of food and income for many poor households in rural areas. To curb the flow of bushmeat from rural to urban areas, understanding drivers of demand in city markets, and their impact on hunter revenues remains fundamental. Here, we present a simple econometric model for the trade of a commercially important bushmeat species in Ghana, the grasscutter (*Thryonomys swinderianus*). We explore own-price and cross-price elasticity of demand of grasscutter meat relative to commonly consumed alternative meats (goat, beef, poultry and fish) in the Atwemonom market in Kumasi city, Ghana. We show that: 1) grasscutter demand is elastic to its own price, 2) beef has an elastic cross-price elasticity, and 3) grasscutter is a luxury good, highly sensitive to consumer income. The elastic nature of the market suggests that price control policies e.g. “wild meat” tax, could reduce demand. Given that beef is the best substitute in our study area, we suggest that investment in Ghana’s underdeveloped cattle industry may reduce wildlife demand while also supporting herding economies. Critically, our results demonstrated that policies that aim to reduce bushmeat demand are likely to impact hunter revenues. This finding underscores the need for complimentary

investments in the rural economy to drive incomes and off-set any revenue losses as a result of a decline in bushmeat demand.

1. Introduction

1.1. Drivers of demand in urban bushmeat markets

The meat of wild animals (wild meat or bushmeat) provides an essential source of protein and income for human livelihoods for millions of tropical forest inhabitants (Coad et al., 2019). Bushmeat consumption is influenced by wealth, price and the availability of alternative proteins (Fa et al., 2009; Godoy et al., 2010; Wilkie et al., 2005). In line with economic theory, studies have consistently shown that bushmeat is sensitive to both its own price and consumer wealth; as the price of bushmeat increases so its consumption decreases, and this effect is mediated by changes in wealth (Rentsch and Damon, 2013; Wilkie and Godoy, 2001).

Evidence of substitution between different meats is less clear. A study of several communities in Latin America by Wilkie and Godoy (2001) found little evidence of substitution between bushmeat and domestic meats. However, this was not universally true on a case-by-case basis. One Amerindian community in Bolivia, who were part of the study, showed a strong link between beef and bushmeat. A 10% decrease in the price of beef led to a 74% drop in bushmeat consumption. This result is important in that it highlights the fact that consumers in diverse markets behave very differently. For example, Brashares et al. (2004) found strong evidence that consumers in Ghana will switch between fish and bushmeat, but Rentsch and Damon (2013) found only a weak link between fish and bushmeat in rural communities in the Serengeti. In contrast, bushmeat consumption was inelastic to the price of all tested alternatives in Gabon (Wilkie et al. 2005).

The underlying differences between markets are important to understand. In the rural system studied by Rentsch and Damon (2013) in savanna Africa, bushmeat was relatively cheap compared to other meats, notably beef. Harvested illegally, often during large mammal migrations when game was relatively abundant, bushmeat was sold cheaply in local black markets. By comparison in Ghana, bushmeat is legal for most species and tends to be among the most expensive meats on local markets (McNamara et al., 2016).

Important differences also exist between rural and urban markets. In Ghana, Brashares et al. (2011) presented compelling evidence that while bushmeat consumption was correlated to wealth in urban areas, the reverse was true in rural settings. This relationship was predicated on the fact that hunters in rural settings who have access to wildlife are often among the poorer members of society. In urban areas, where bushmeat is accessible as a cash commodity, only those with disposable income can afford it. This wealthy versus poor dynamic presents different challenges when it comes to managing the underlying drivers of people’s reliance on wildlife. Differences in the effects of wealth on bushmeat demand in rural and urban settings have been observed elsewhere (Wilkie et al., 2005). Non-wealth factors are also critical. In their analysis of bushmeat consumption in four West African countries, Luiselli et al. (2017) found that factors such as age and gender played a critical role, notably that young urban consumers were less likely to consume bushmeat than their rural counterparts. In their studies of rural communities in the Serengeti, Moro et al., (2015) and Walelign et al., (2019) found that ethnicity, household size and livestock ownership all had implications for bushmeat demand. Despite these facts, most published studies that quantify demand elasticities (with the exception of Wilkie et al., 2005) have investigated rural systems, using household survey data to estimate trade volumes and market prices. Even Wilkie et al. (2005), who conducted surveys in the major urban centres of Libreville and Franceville in Gabon, combined data from urban settings with those from rural communities when quantifying demand elasticities. This is potentially problematic, since consumers in rural communities have shown to exhibit quite different bushmeat consumption behaviours to their urban counterparts.

1.2. The importance of quantifying urban demand

Given the underlying heterogeneity existing in bushmeat consumption between rural and urban communities, drawing inference from rural assessments when seeking to understand urban behaviours should be treated with caution. That urban systems are under-represented in studies that have quantified demand elasticities for bushmeat is all the more surprising when one considers the pivotal role that urban markets are increasingly playing in driving the unsustainable trade in wildlife (Guy Cowlishaw et al., 2005; Cronin et al., 2015; East et al., 2005).

Looking to the future, the significance of urban markets is likely to increase. Forecasts by the United Nations suggest that Africa will experience a dramatic shift in population from what was predominantly rural only a decade ago to one where almost 70% of the population will be in urban centres by 2030 (United Nations, 2014). This increasing urbanisation is likely to be accompanied by increasing wealth, and the impact on demand for animal protein is expected to be dramatic (Seto et al., 2012). According to data from the FAO, while the developed world is projected to experience growth in demand for animal protein of approximately 15% between 2016 and 2050, demand in Africa may grow by as much as 170% (Alexandratos, 2012; FAOSTAT, 2017). Quantifying demand elasticities for urban centres should therefore be a priority for both the conservation and development sectors.

1.3. Why demand elasticities matter

Quantifying demand elasticities is important information for policy makers. In addition to assessing how sensitive demand for a commodity is to its own price and that of alternatives, the shape of the demand curve also defines how producers' revenues change with price. Where demand is elastic, relatively small variation in price can lead to large changes in demand. Under this scenario, revenues are maximised at high trade volumes even where this supresses market prices. Where demand is inelastic, however, the opposite is true. Demand is much less sensitive to price, meaning that relatively large increases in price lead to comparably small changes in demand. Under this scenario revenues are maximised at high prices even though trade volumes will be lower (Dilts, 2004).

This has important implications for the management of the bushmeat trade. A policy that successfully reduces consumption by raising prices by, for example, restricting the flow of bushmeat into urban markets through enforcement measures, might be effective where demand is elastic. In this case, higher prices would lead to a relatively large fall in consumption and revenue. If, however, the same policy was applied where demand was inelastic, the opposite might be true. High prices would reduce consumption only marginally, while revenues could potentially increase despite the fall in consumption. This could exacerbate the challenges of reducing long-term reliance on hunting, by encouraging an increase in black market trading behaviour as hunters sought to benefit from higher prices while avoiding trade restrictions. Ultimately such market behaviour would likely increase supplies, supressing prices, restoring demand and undermine the effectiveness of the original policy.

This is the problem that the largely unsuccessful global war on drugs has encountered, as well as, to a degree, the illegal trade in ivory. Historically, enforcement has done little to reduce demand, while consistently driving up prices and hence supplier revenues. Higher revenues have led to suppliers developing increasingly sophisticated measures to circumnavigate the restrictions (Miron and Zwiebel, 1995)

While this effect has not been documented in the bushmeat trade, there is some anecdotal evidence that enforcement can lead to an increase in hunting activity. Cronin et al. (2015) found that attempts to limit bushmeat sales on Bioko island were only transitorily effective, and that hunting rates actually increased shortly after the ban was introduced. While it is important to stress that this study did not quantify demand elasticities or prices, it is possible that the ban itself might have created the incentive for more hunting by driving up prices.

The above example assumes that producers benefit from the associated price increase. This may not always be the case, such as under taxation where proportion of the price increase go to government (Hutchinson, 2017). However, it highlights the importance of understanding elasticities in the context of both demand and revenue when considering which policy interventions are likely to be most appropriate.

1.4. Study objectives

What has been missing from the literature, therefore, is a detailed analysis of consumer demand for bushmeat in a major urban centre using long-run market data. This study aims to address this gap. We focus on four core research questions to assess potential policy interventions:

1. Is bushmeat demand in Atwemonom elastic or inelastic?
2. What are the primary substitute goods for bushmeat?
3. How does growing consumer wealth impact demand for bushmeat?
4. What impact does demand reduction policies have on hunter revenues?

Using bushmeat market data collected over a 4-year period in the Atwemonom market in Kumasi, we developed a monthly linear log-log demand model, based on the assumptions of perfect competition and linearity, to quantify own-price and cross-price elasticity of demand for fresh bushmeat. Demand is assessed in relation to a basket of commonly consumed alternative proteins; goat, beef, poultry and fish.

From a policy perspective, delineating alternative proteins as precisely as possible, as opposed to considering a single good such as livestock is important to identify the most effective substitutes for bushmeat. Investing in the poultry sector is a very different proposition to investing in the beef sector, with markedly different trade-offs around feed production, land use, carbon emissions and associated logistics (Searchinger, 2013).

The Atwemonom market makes an ideal case study for this purpose. In addition to the availability of long-term market data, the city of Kumasi is a major urban centre, and Ghana’s second largest city after the capital, Accra. The Atwemonom market in Kumasi itself is recognised as one of the largest fresh bushmeat markets in West Africa, attracting trade not just from Ghana itself, but also regionally from neighbouring Burkina Faso and Cote D’Ivoire (Falconer, 1992; Ntiamoa-Baidu, 1998).

2. Methods

2.1. The Atwemonom bushmeat market

The Atwemonom bushmeat market has been surveyed on a regular basis between 1978 – 2004 (Ntiamoa-Baidu, 1998). For the purpose of this study, we used a subset of the data from the period 2001 – 2004, summarised on a monthly basis to align with the availability of complementary price data for fish and livestock (goat, beef and poultry). While this subset is notably short compared to the full data, the choice was constrained by the fact livestock pricing was not available prior to 2001.

The Atwemonom market specialises in the sale of fresh bushmeat. Hunters tend to arrive early in the morning to trade their quarry from the night before. Data were collected on species traded, carcass weight and price. The recorded transactions relate to the wholesale purchase of fresh whole carcasses from hunters at the market gate before they are butchered in preparation for sale to the public. Identification of species was therefore straightforward.

From regular observation of the market over the 27-year period, observers reported that all meat on sale almost always clears. Demand for bushmeat in the city is strong, as evidenced by the high prices paid for the most preferred species. Previous surveys of consumers in the city have consistently ranked bushmeat among the most preferred meats available on the market (Falconer, 1992; McNamara et al., 2016; Ntiamoa-Baidu, 1998).

2.2. Defining bushmeat trade volumes

A total of 27 species were recorded entering the market during the study period. In this study we focussed only on the trade of the greater cane rat or grasscutter (*Thryonomys swinderianus)* as a proxy for the trade in bushmeat. The grasscutter is one of two species of cane rats, a small family of African hystricognath rodents, often inhabiting reed-beds and riverbanks in Sub-Saharan Africa. Cane rats can grow to nearly 60 cm in length and can weigh a little less than 8.5 kg.

We choose to focus on this species for a number of reasons. Firstly, treating bushmeat as a single basket of goods for a demand analysis is problematic since various consumer surveys in Kumasi have highlighted marked differences in preference for bushmeat species (Falconer, 1992; Hofmann et al., 1999; McNamara, 2014). These surveys showed that consumers prefer different types of bushmeat in much the same way as they do for poultry or pork with market prices reflecting these preferences. Grouping multiple bushmeat species into a single price index will therefore distort these price signals.

Secondly, grasscutters are viewed as an important commodity in their own right in the Kumasi market, with consumers selecting to consume grasscutter rather than other bushmeat and farmed meat. In a survey of 100 consumers in Kumasi in 2011, 73% stated that grasscutter was their most preferred bushmeat (McNamara et al., 2016). It is also a highly valued commodity. The same study found that on average, a kilo of grasscutter was 108% more expensive than a kilo of beef and 67% more expensive than a kilo of goat.

Thirdly, grasscutters are the most abundant bushmeat species in the market, and there is good evidence that hunters target them specifically. A one-week survey in 2011 found that grasscutters accounted for 64% of the carcasses entering Atwemonom market (McNamara et al., 2016). In a survey of hunting communities' supplying Atwemonom market Alexander et al., (2014) found that hunters were targeting grasscutters specifically, using dogs or by focusing on fields of crops such as maize where grasscutter are frequently found. Personal observations by the authors of hunting trips confirm these behaviours. This is important, since hunting is largely a non-selective process, and consequently it has been argued that hunters are unlikely to respond efficiently to the price signals generated by the market (McNamara et al., 2016; Wilkie and Godoy, 2001). While this is likely true for many species, the trade in grasscutters appears to exhibit unique supply and demand-side characteristics that means of that for all species, their supply is likely best able to respond to price signals generated by the market.

Finally, a focus on the grasscutter maximises the data for analysis. The bushmeat trade in Ghana is a legal, regulated trade that consists of two hunting seasons. During the Open Season, which runs for eight months from December to July the following year, all species can be traded except those listed as protected in Schedule 1 of the Wildlife Conservation Regulations 1971

(Government of Ghana, 1989). During the Closed Season, which runs for four months from August to November, only grasscutter can be traded. Choosing to focus on the grasscutter therefore allows analysis of trade volumes over the full year period. Ideally, demand elasticities would have been analysed for multiple bushmeat species. However, the low occurrence of these species on the market during the annual Closed Season meant that there were not adequate data to support such analysis.

2.3. Bushmeat consumption and price data

Grasscutter trade volumes were represented by total weight of meat traded on the market in a given month. The assumption that commercial trade volumes passing through Atwemonom could be used as a proxy for consumer demand was based on a number of observations.

First, observers of the market over a 27-year period confirmed that the market ladies who run the trade are skilled traders who work competitively to capture trade from hunters at a price that ensures the market almost always clears. This is important as it suggests that the market is operating efficiently such that supply equals demand. Second, Atwemonom is the only market dedicated to the sale of fresh bushmeat in the City. While fresh bushmeat can, on occasion, be purchased from vendors elsewhere in the city, these operations are far smaller and more irregular than Atwemonom. Finally, discussions with hunters supplying the market confirm that Atwemonom is the only market capable of absorbing large quantities of meat owing to its long-established networks with hunters and consumers. Based on this knowledge of the structure and operation of market, the assumption that trade flows were indicative of the commercial demand for fresh bushmeat appear reasonable.

Grasscutter prices were wholesale prices paid to hunters, reported as the average price paid per kilo, calculated by dividing the total sales revenue by total carcass weight recorded in a given month. Unfortunately, data were not available for retail sales owing to the complexity of recording these transactions in a busy and vibrant market. Analysis of the data shows marked variation in price between traders and between days, indicating market ladies are adjusting prices in response to supply and demand in a competitive fashion. With this in mind, and in light of the long monitoring period, we believe this assumption that wholesale prices are a proxy for retail prices to be satisfactory, as well as necessary. Prices are deflated to 2004 and converted to United States dollars.

2.4. Supporting data

Livestock and fisheries data collected from surveys of the Kumasi market were obtained from the Ghana Statistical Service, summarised by month. Livestock data were available for beef, goat and poultry. Fish data were available for smoked herring. Smoked herring are among the most commonly consumed group of fish species traded in the market. A 2011 survey of 101 consumers in Kumasi found that herring were the most commonly consumed of all marine and freshwater species, with 34% of consumers stating herring was the fish species they ate most frequently (McNamara, 2014). All price data were presented as price per kilogram, with the exception of poultry, which were recorded as price per bird.

Consumer wealth was proxied by Gross National Income (GNI) per capita, measured in Local Currency Units (LCU). LCU was used rather than Purchase Power Parity (PPP), since we were interested in internal spending power on local goods, and thus the LCU measure of income inflation is more suited to our needs. Price data were deflated to 2004 using Consumer Price Index (CPI) data and calculated on a per capita basis using national population estimates, before being converted into USD. Since GNI data were available only on annual basis, inter-year variation was estimated on a monthly scale using an ARIMA model in R with package Tsimpute to fill in the missing values. GNI (LCU), CPI, population data and exchange rates were downloaded from the World Bank Development Indicator Catalogue (World Bank, 2013). The model data are summarised in Table1.

While the use of a general, population-level statistic such as GNI should capture some of the variation in local incomes, particularly for a city such as Kumasi which is the second largest city after the capital Accra, it remains a relatively blunt tool for understanding income dynamics at the level of individual bushmeat consumers. Ideally locally sourced data on individual incomes would have provided greater resolution of income elasticities. However, such data was not available and the use of GNI as a proxy for consumer wealth represents a necessary compromise for the model.

2.5. Statistical analysis

A log-log model was used to test correlations between bushmeat trade volumes and the price of six independent variables and a set of seasonal dummy variables (Eqn. 1). The use of a log-log model, also known as the Cobb-Douglas Production Function, to describe demand functions has strong precedent in the microeconomics literature (Cobb and Douglas, 1928; Felipe and Adams, 2005; KAZMI, 1972). A key feature of the model is that the shape of the underlying demand curve agrees broadly with expectations of demand behaviour in many markets. Notably that the quantity demanded can never go negative regardless of how high prices go while, at the other end of the scale, demand grows exponentially as prices fall to zero. Further it has the advantage that it linearizes the non-linear demand function (Eqn 2) in a fashion that enables easy identification of the demand elasticities (Gersovitz and MacKinnon, 1977).

$$\log(Q_t) = \alpha\log(P_t) + \beta_i\log(X_{it}) + \gamma_i\log(S_{jt}) + \varepsilon_1 \qquad \text{Eqn 1.}$$

$$Q = P^{\propto} + X^{\beta} + S^{\gamma} + \varepsilon_2 \qquad \text{Eqn 2.}$$

Where, in Eqn 1, Q_t is the quantity of bushmeat demanded at time *t*, P_t is price of bushmeat at time *t*, X_{it} is a matrix of the independent explanatory variables *i* at time *t*, S_{jt} are the seasonal dummy variables *j* at time *t*, and ε is the error term. Eqn 2. represents the underlying demand curve that is linearized by the log-log model described in Eqn. 1.

Ideally, the demand equation would have been estimated using an instrumental variable methodology to address the issue of endogeneity between bushmeat price and trade volumes (Haavelmo, 1943; Tinbergen, 1930). However, such an approach requires additional information to define market prices in terms of exogenous regressors that were not available for the Atwemonom market system. The inability of our model to account for potential issues associated with endogeneity means that while the estimation of model coefficients should be consistent, significance tests may be biased (Abdallah et al., 2015). Interpretation of results will therefore be mindful of these dynamics.

The number of days that the Atwemonom market was observed in any given month was not constant. To account for this variation in observer effort, an offset function was implemented. Dummy variables were incorporated to describe seasonal variation in trade volumes. Bushmeat trade volumes in the region are closely linked to agricultural seasons, with two seasonal peaks, one during the dry season when agricultural work is low, another during the late summer harvest season when crops such as maize provide ample food for the animals on the farmland (McNamara et al., 2016). Seasonality is therefore separable from the underlying relationship. Twelve dummy variables, one for each month of the year, were included in the final regression.

2.6. Model validation

The choice of a log-log model was further supported through three key tests. First, a Ramsey's RESET test for functional form supported the hypothesis that the log-log model was correctly specified (RESET = 18, $p = 2.2 \times 10^{-6}$, H_o = model is correctly specified). Further, the goodness of fit of the resulting estimation was compared with three alternative models that might be considered as potential candidates as a proxy for the demand function, namely a linear model, log-linear and linear-log. R^2 values were transformed to allow comparison between models. Results showed the log-log model to have the superior fit (R^2 values: log-log = 0.91, linear-log = 0.69, log-linear = 0.09, linear = 0.69). Visual verification of predicted values for grasscutter trade volumes plotted against the actual trade volumes also verified the goodness of fit (Annex A).

An augmented Dickey Fuller test for a unit root verified the model was stationary (DF = -4.37, p = 0.01; where DF is the Dickey Fuller test statistic and the alternative hypothesis is stationarity.

Durbin Watson tests for serial autocorrelation over a lag period of 4 indicated no autocorrelation was present (DW = 2.03, p = 0.87; DW = 2.29, p = 0.86; DW = 2.41, p = 0.88; DW = 1.99, p = 0.61; where DW is the Durbin Watson test statistic with a range 0 – 4, where values close to 2 indicate no autocorrelation) and the alternative hypothesis is autocorrelation.

Pearson's correlation tests highlighted three problematic correlations between the independent variables. Gross National Income and grasscutter price (r = 0.88), Gross National Income and goat price (r = 0.90) and goat price and grasscutter price (r = 0.82). Variance inflation factor tests suggested that all three variables were likely to be problematic (VIF GNI = 11.7, goat price = 7.2 and grasscutter price = 6.6). Removing these variables posed the problem that doing so would mean the regression failed to define the demand function according to economic theory. Correlations between consumer wealth and commodities from the same basket of goods, such as animal proteins are likely to exhibit a degree of correlation, since rising consumer wealth is known to drive the consumption of all proteins (Searchinger, 2013). Further, removal of the highly correlated explanatory variables, did not change the direction of effect on retained variables (i.e. whether a good was identified to be a substitute or complementary good), nor on whether retained variables were elastic ($\in > 1$) or inelastic ($\in < 1$) although the magnitude of the effect did change. Similarly, a simple model of only grasscutter price and GNI, the most highly correlated variable, showed effect magnitudes in line with the full model (direction of effect and elasticity of coefficient). These did not change substantially with the stepwise addition of correlated variables. Thus, the original variable set was maintained, and interpretation of significance factors conducted with this multicollinearity in mind.

3. Results

Own price elasticity of demand was mildly elastic, $\in = -1.38$ suggesting that a 1% increase in bushmeat price will lead to a 1.38% drop in consumption (Table 2; Figure 1).

Income elasticity of demand was strongly elastic $\in = 18.2$ (Figure 2). This implies that for every percentage growth in Gross National Income per capita bushmeat consumption increased by 18%. This relationship firmly places bushmeat in the category of a luxury good, defined in the economics literature as being when $\in > 1$, indicating that consumers will tend to spend disproportionately more on bushmeat as their real incomes rise.

Cross-price elasticity results showed that of the alternative proteins, beef was the only substitute good with an elastic cross price elasticity of demand of $\in =$ 3.47. This implies that a 1% reduction in beef prices would result in a 3.47% reduction in grasscutter demand (Figure 2). Although fish was identified as a substitute good in line with other research in the region (Brashares et al., 2004), it's cross-price elasticity of demand was inelastic, suggesting that changes in the price of fish had a minimal impact on grasscutter consumption with a 1% increase in fish prices led to a 0.3% increase in grasscutter consumption. Indeed, changes in beef price were found to have a 2.5 times greater impact on levels of consumption than grasscutter price effects, and almost 12 times greater impact than a reduction in fish price.

Poultry and goat were found to be complementary goods, with negative cross price elasticities of demand ($\in$ = -2.72 and -3.61 respectively) (Figure 1). The implication is that their rates of consumption increase in line with bushmeat consumption, so that when their prices are high, consumption of bushmeat decreases. Graphical representations of the demand curves for significant variables are shown in Figure 1 and Figure 2.

Hunter revenues are liable to be more sensitive to price fluctuations the more elastic the relationship. Assuming hunters efficiently adjust supplies according to changes in demand, a 5% increase in grasscutter price leads to a 6.9% reduction in consumptions, which will equate 2.2% decline in hunter revenues.

4. Discussion

4.1. Implications of an elastic bushmeat demand system

The results of this study have direct implications for the management of bushmeat demand and wildlife conservation. The finding that demand for grasscutter meat is elastic has two important implications. Firstly, it implies that policies that aim to reduce consumption by increasing price will be effective, since each percentage increase in price will result is a proportionally larger decrease in consumption. Secondly, such policies are also likely to reduce hunter revenues, despite higher prices, potentially decreasing the attractiveness of hunting, further incentivising downward pressures on supply as revenues from hunting decline relative to alternative livelihood strategies.

In regard to this first observation, it should be noted that bushmeat price was not a significant determinant of demand in our study. While interpretation of significance needs to be done cautiously, owing to the fact that our model did not account for the endogenous relationship between price and quantity, nonetheless the result cautions that bushmeat price may not be the most effective lever at reducing demand. Further reductions in hunter revenues may have serious consequences for the communities that rely on wildlife for their livelihoods. Such considerations are particularly pertinent in markets such a bushmeat markets where reliance on wildlife is often closely linked to poverty, and where income and livelihood support are critical components of conservation policy (Brashares and Gaynor, 2017; Robinson and Bennett, 2002). Although there is evidence that the importance of hunting is in decline in communities neighbouring Kumasi, likely driven in part by habitat conversion and historic over-depletion of wildlife resources, it continues to play an important role in the livelihoods of those who do rely on it, particularly in the dry season when income from agriculture is low (Alexander et al., 2014; McNamara et al., 2016; Schulte-Herbrüggen, 2011). As such, it will be critical that policies that aim to reduce demand by raising bushmeat, prices are accompanied by measures that support investment in rural economies to increase incomes and avoid negative socio-economic impacts of associated declines in hunter revenues.

Finally, price adjustment policies pose genuine challenges. Taxation is unlikely to be popular with consumers and traders and difficult to enforce in practice in what remains a relatively informal market. Similarly, enforcement of quotas presents numerous challenges. Indeed, quotas are already in place in Ghana, however the largely artisanal and frequently remote nature of hunting makes enforcement of such quotas extremely difficult.

4.2. What hope for substitutes?

More promising, perhaps, is improving access to alternative proteins. However, our findings highlight large differences in how consumption of grasscutter meat varies in response to prices of different protein types. While our results support the finding from other studies that fish plays a mediating role in the demand for bushmeat (Brashares et al., 2004) we suggest that this effect is small since the cross-price elasticity of demand is inelastic. This means that for every percentage drop in fish prices, bushmeat consumption falls by only 0.3%. Beef, by comparison, has an elastic cross-price elasticity of demand, such that for every percentage drop in beef prices, bushmeat consumption falls by 3.5%, almost 12 times greater than the response to fish price. The significant relationship between beef price and grasscutter demand provides further evidence, albeit cautiously owing to the unaccounted endogeneity in the model, that consumers see beef as a viable substitute for grasscutter.

The implication is that increasing beef availability on local markets is likely to be a much more effective policy for reducing bushmeat consumption than improving access to fish. Encouragingly, a report by the United Kingdom's Department for International Development, found that there was significant scope for productivity improvements in cattle production (DFID, 2014). Carcass weights in the region, a common measure of productivity, are below those achieved by neighbouring Sahelian countries, and well below international levels. Issues around feed quality and animal health that could be relatively easily resolved remain unaddressed due to low levels of investment in the sector. As a result, growth in production has fallen well below demand, and imports of live animals and meat products from abroad have had to fill the gap (DFID, 2014; FAOSTAT, 2017).

Thus, on paper, there appears to be major opportunities for improving access to locally reared beef, with commensurate benefits to the estimated 600,000 herders who rely on cattle for their livelihoods (DFID, 2014). However, beef production comes with its own raft of environmental consequences. Multiple research highlights that it has the highest land and carbon footprint of any agricultural activity (Blaustein-Rejto et al., 2019; Poore and Nemecek, 2018; Searchinger, 2013). While there are options for mitigating these impacts to a degree, any decision to invest in the sector would need to be mindful of these trade-offs. Further, there are substantial socio-cultural barriers to developing Ghana's beef herd owing to their primary significance as stores of wealth rather than as production animals. Although 84% of cattle and 60% of goats and sheep are produced in northern Ghana, only 27% of rural herders in the region use rearing as an economic enterprise (DFID, 2014). The challenge on this level, is that where cattle represent stores of wealth, the incentives to improve productivity are limited, since priority is given to the number, rather than the quantity of meat or milk produced. Yet where pastoralists have transitioned from herders (maximizing the number of animals) to producers (maximizing meat or dairy production) such as in parts of China, yields have improved, incomes have risen, and animal numbers have decreased, enabling the recovery of previously degraded grasslands (Kemp et al., 2013).

One unexpected finding from our analysis was the complementary relationship between goat and poultry prices and bushmeat demand. The rationale for this relationship is unclear. It could be tied in to wealth increases, whereby historically higher levels of urban wealth have led to proportionally similar increases in the consumption of poultry, goat and bushmeat. Certainly rising levels of wealth are known to drive consumption of all meat types, although usually consumer preferences mean these rates differ (Bruinsma, 2003). Another possible explanation may be that urban consumers view poultry and goat as protein staples. As their prices rise, consumers may cut back on luxury goods such as bushmeat in order to maintain a certain level of consumption of these more essential items, even if this means their overall protein consumption declines. A final consideration is whether the strong correlations between variables may explain the relationship. However, the direction of effects most strongly correlated with chicken and goat prices (GNI and beef prices) were opposite, and testing of basic models found the same negative relationship present. Thus, the direction of effect observed would appear valid.

There is some evidence to support such a hypothesis. Previous research in Kumasi and the wider region found that of all animal proteins, poultry was ranked as the most preferred (Ntiamoa-Baidu, 1998). The decision to reduce consumption of bushmeat in the face of rising poultry and goat prices may be driven by taste preferences. Another consideration is that the comparatively low price of poultry and goat compared to bushmeat means that the same expenditure could buy 1.7 times more goat meat and 2.5 times more poultry, based on price data from a 2011 market survey of Kumasi. Thus, reducing bushmeat consumption at times of high livestock prices may be an economically rational decision. Further research, such as quantifying the income elasticity of demand for poultry and goat, is required to understand these relationships better.

4.3. Rising wealth and bushmeat consumption

The strong relationship between GNI and grasscutter consumption observed in our analysis aligns with other studies on the subject, particularly in relation to urban centres (Auzel and Wilkie, 2000; Brashares et al., 2011; Rentsch and Damon, 2013; Wilkie et al., 2005).

Despite the acknowledged limitations of the use of GNI as an indicator for local spending power, the magnitude of the effect strikes a strong message about the risks that rising wealth poses for wildlife consumption. This risk is put into sharp contrast when one considers that per capita consumption of all meat in Ghana in 2004 was 12 kg/capita/year, compared with a global average of 39 kg/capita/year, and expectations are for this gap to close, albeit slowly, in the coming decades (Bruinsma, 2003; FAOSTAT, 2017).

These findings highlight the importance of changing consumer preferences to decouple the link between wealth and bushmeat consumption. Encouragingly, there indications that consumer preferences are changing in some markets. In their analysis of urban consumers in four west African countries Luiselli et al. (2017) found evidence that youth in urban centres were tending to favour domestic meat over bushmeat. They attributed this effect to the “westernisation” of dietary preferences. Indeed, urban centres, with their established trade connections to wider markets and greater access to amenities such as refrigeration, are well placed to capitalise on investment in the farmed livestock and fisheries sectors. But if such investments are to have beneficial impacts on wildlife demand, they will need to be designed with an understanding of the underlying dynamics driving consumer behaviour, such as the cross-price elasticities of proposed alternatives.

Ultimately, these findings relate to a bushmeat system that exhibits a degree of post-depletion sustainability, dominated by fast growing species such as the grasscutter (Cowlishaw et al., 2005). Other markets characterised by a more intact underlying biological resources, and with different cultural drivers of meat consumption, will exhibit different characteristics. Quantifying demand elasticities is however, a crucial step to step to guide the development of effective policy around food and conservation.

5. Conclusions

Understanding urban demand dynamics are among the most pressing challenges for policy makers attempting to mitigate the negative environmental consequences of the commercial wildlife trade. Our findings highlight the importance of quantifying demand elasticities in these markets for designing appropriate policy measures, not just for understanding consumer motivations, but also how policy will impact hunter revenues. This latter aspect is often overlooked in demand analyses, but represents a critical part of the system, especially where the livelihoods of rural hunters must be balanced with the need to reduce consumer demand for wildlife. The development of alternative proteins will be essential, but such policies will only be effective if they are accompanied by measures that support changes in consumer preferences, while also investing in rural economies to offset any economic losses due to the contraction of the bushmeat trade.

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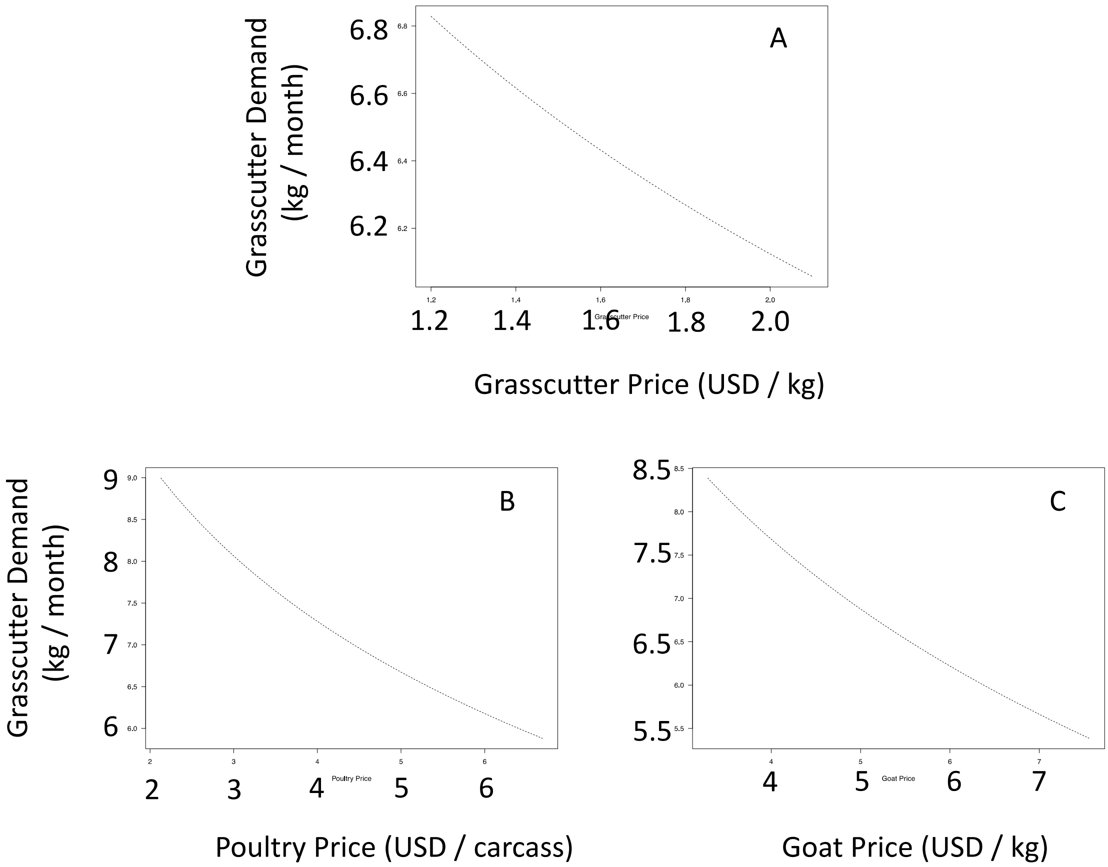
Figures

Figure 1: Demand curves showing how grasscutter demand responds to changes in A) its own-price and the price of the complementary alternatives B) poultry and C) goat.

Figure 2: Demand curves showing how grasscutter demand responds to changes in A) beef price and B) Gross National Income per capita.



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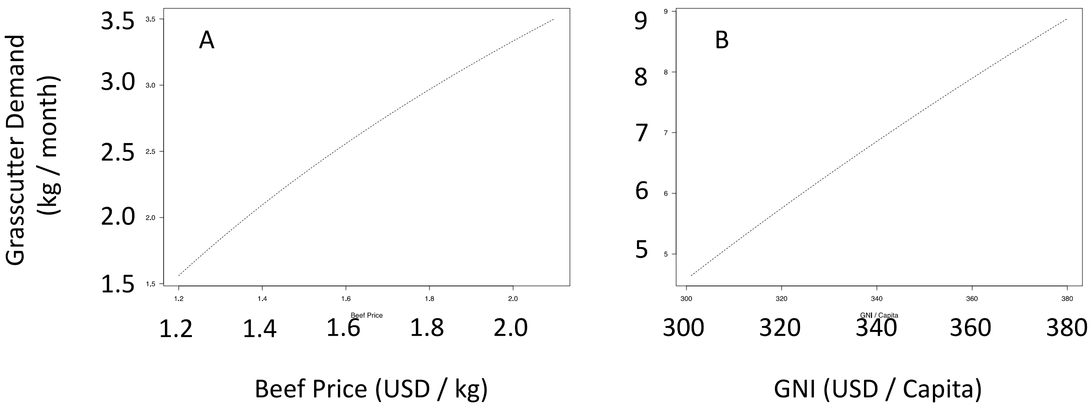

Figure 2: Demand curves showing how grasscutter demand responds to changes in A) beef price and B) Gross National Income per capita.

Tables

Table 1: Summary of model data

Table 2: Output of the generalised linear model. Response variable is grasscutter trade volume kg/ month. Confidence intervals, *** 0.1%, ** 1%, * 5%.

Table 1: Summary of model data

Data	Data	Description	Units
Bushmeat data	P_B	Bushmeat price	USD / kg
	Q_B	Bushmeat demand	Kg
Wealth	I_t	Gross National Income (GNI)	GNI per capita
Beef	B_P	Beef price	Price per kilo
Fish	F_P	Fish price	Price per kilo
Poultry	C_P	Poultry price	Price per bird
Goat	G_P	Goat price	Price per kilo
Seasonal Dummies	D	Seasonal dummies (Jan – Dec)	None

Table 2: Output of the generalised linear log-log model. Response variable is grasscutter trade volume kg/ month. The dummy variable, December, is not estimated owing to perfect co-linearity between dummy variables. Confidence intervals, *** 0.1%, ** 1%, * 5%.

Independent Variable	Coefficient Estimate (elasticity)	Std. Error	P value	
Intercept	- 94.7	24.9	0.002	**
Grasscutter (USD/kg)	- 1.28	1.46	0.398	
GNI (USD/capita)	18.0	4.39	0.001	***
Beef (USD/kg)	3.56	1.04	0.005	**
Fish (USD	0.29	0.55	0.606	
Poultry (USD/bird)	- 2.77	1.16	0.032	*
Goat (USD/kg)	- 3.64	0.89	0.001	***
January	0.05	0.41	0.903	
February	-0.68	0.45	0.150	
March	-0.91	0.47	0.075	
April	-0.81	0.43	0.082	
May	-1.14	0.46	0.028	*
June	-1.19	0.46	0.023	*
July	0.03	0.44	0.944	
Aug	0.44	0.45	0.350	
Sep	0.61	0.46	0.215	

Oct	0.33	0.42	0.452
Nov	0.10	0.40	0.810
Dec	-	-	-