Supporting Information

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SI Text

Details of Household Sampling and Consumption Estimates. Our study brings together four large datasets collected over different time periods in four countries. Sampling methods were coordinated before data collection for only two of the four countries, and thus, some effort was needed to determine areas where data were comparable. Furthermore, differences in sampling among countries, although mostly subtle, demand a more detailed description of methods than given in the text. Below, we clarify details of our sampling in Ghana, Tanzania, Madagascar, and Cameroon.

Sampling period. Data used in this study from Madagascar were collected over a single year in 2006, but collection was part of a multiyear study of bushmeat, livelihoods, and public health that remains active. After 2006, a subset of 75% of settlements and households became the focus of research, and thus, we include only surveys from 2006 in this study. Repeat visits as well as a detailed study of a subset of 28 households allowed validation and calibration of wildlife consumption and other estimates (Fig. S1).

Surveys of households in Ghana occurred in 2004, 2005, and 2008. In each year, households were visited monthly by local members of our research team from January to November. Households were occasionally missed in a given month, but our final dataset includes 503 households each sampled a minimum of 24 times across the 3 y of study, with at least eight visits in each of the 3 study y.

Household surveys in Tanzania were designed and implemented using protocols developed in Ghana. Sampling occurred monthly from June 2007 to January 2009 for more than 500 households. For panel analyses, we included only those households sampled a minimum of 16 times during the study period, and this sampling resulted in a final sample of 491 households.

Surveys in Cameroon were conducted over a 2-mo period in October and November of 2007. Each of 478 households was formally sampled only one time during this period, but a large amount of informal information was gained through engagement of communities included in the study.

Bushmeat consumption recall. Accurate recall of food intake over long time periods is a challenge for any study of consumption rates and particularly for studies of bushmeat. We relied on recall estimates of annual wildlife consumption in Madagascar and Cameroon, but we took additional steps to validate and calibrate reported estimates using empirical observation. Specifically, in Madagascar, we selected a subsample of ~30% of households from one village within which we provided daily diet diaries and scales that allowed heads of households to record consumed foods and their weight on a daily basis. Estimates from these diaries as well as regular household visits over the year allowed us to calibrate reported annual wildlife consumption rates with observed rates (Fig. S1).

Our somewhat short study period in Cameroon limited our ability to fully calibrate reported estimates of wildlife consumption, particularly our efforts to account for seasonal variation in consumption. However, our sampling period did include the transition between dry and wet seasons, and direct observation of bushmeat harvest and use during those seasons was consistent with information provided in annual estimates. Although not ideal in its duration, our sampling produced measures consistent with our previous and subsequent research in Cameroon. Perhaps more importantly, consumption trends in Cameroon paralleled those trends in Ghana, where household surveys were conducted at high frequency and over a prolonged period. Ghana and Cameroon experience similar seasonality and comparable habitat types and traditions of wildlife use.

Household surveys in Ghana and Tanzania were designed in part to compare the accuracy of different forms of recall, and thus, we conducted recalls at daily intervals for a subset of 15% of households (n = 160 households), weekly intervals for another 15% of households, and monthly intervals for all other households. At least two times a year, we also asked all households to carefully estimate their wildlife consumption in the past 6 and 12 mo. Thus, we compared recall estimates of annual consumption with recall and empirical observation of consumption recorded at finer time intervals. Our sampling fully accounted for seasonal variation in wildlife use and when combined with market surveys and hunter follows, provided detailed insight on the dynamics of local bushmeat use (Fig. S1).

Bushmeat consumption measurement. Studies of bushmeat consumption display a range of methods to calculate total biomass consumed. Differences between methods of calculation become increasingly important when researchers attempt to extrapolate consumption rates from a relatively small window of sampling (e.g., weeks to years, etc.). Our study sites differed in the size and type of bundles in which bushmeat was typically sold. Moreover, as is observed elsewhere, bushmeat purchased at markets was typically butchered or packaged into semistandard size units, whereas bushmeat consumed by the households that harvested it was typically prepared as a whole animal. In all four countries, households reported the size of portions consumed or the number of animals consumed when animals were small (e.g., bats, birds, or small rodents). When meat of larger animals was reported as purchased from a local market, households provided the number of units consumed, and we were easily able to derive an approximation of the weight (in grams) of meat eaten. When smaller animals were eaten or when households reported consuming whole larger animals, we relied on published estimates of average body mass for each species and calculated meat consumed from these values after removing 15% to account for observed differences in whole vs. dressed (e.g., postbutchered) weights. It is sometimes suggested that dressed weights of animals will be closer to 60% of live weight; however, this suggestion is based on cattle butchering in the United States, where consumers eat only select cuts of meats and bones, hides, and many organs are generally not eaten. In our study areas, butchered meat is typically sold with hide and bone, and nearly all parts of the animal are consumed. We weighed 96 animals in Ghana and Tanzania representing 16 frequently eaten wildlife species pre- and postdressing and observed a consistent difference of 7–28%, with a mean of value of 15%.

Household wealth assessment. Wealth assessments in each country were built on a standard basket of owned assets; however, the items in this basket varied between countries. Furthermore, additional assets were considered, and these assets varied among countries. In Madagascar, wealth calculations added the total value of products sold, wages earned, and items bartered to the standard basket. Similarly, in Ghana and Tanzania, wealth included the standard basket plus cash and noncash earnings (estimated from costs of replacement/substitution). Land tenure is complex and defied simple quantification in our assessments, and thus, we did not attempt to include land ownership as a variable in our estimate of wealth; however, we did include direct and indirect monetary and nonmonetary earnings from cultivated or managed lands, including value of harvested and consumed crops and other resources. Clearly, the fact that our methods for estimating household wealth differ among countries would in-

validate efforts to compare raw values of wealth across our study sites. However, wealth for each country was first transformed to a relative scale before cross-site comparison. Specifically, household wealth was assigned a rank measure on a 0–100 percentile scale independently for each country, such that households receiving ranks of 25 in Ghana and Tanzania would both be at the top of the first wealth quartile for their respective country.

Tracking bushmeat movement and sales. Our research is associated with efforts of the Bushmeat Monitoring Network to track thousands of wildlife products through distribution networks from harvest to consumption. However, estimates of rural and urban consumption used in this study are based on reported rates of consumption by households along a rural–urban gradient and not calculations of wildlife transport rates from rural to urban areas. Put another way, we did not assume that all meat observed to leave rural settlements would make it to urban markets; we relied instead on direct reports from more urban households to assess their use of wildlife. This parameter is important, because estimates of urban consumption based solely on observed transport will ignore leakage to spoilage, side sales, redirection, etc.

Clarification of Data Used in Analyses. Panel data (longitudinal sampling) was used for households in Ghana and Tanzania but not Cameroon and Madagascar. Additionally, market surveys, hunter follows, and time budgets were completed only in Ghana and Tanzania. Thus, as mentioned in the text, analyses summarized in Figs. 4 and 5 included only data from these countries, whereas analyses reported in Figs. 2 and 3 included data from all four countries. Similarly, the panel model 1 reported in Table 1 includes data from all sites, and model 2 includes only data from Ghana and Tanzania.

Wildlife Consumption and Access to Alternatives. Access to relatively inexpensive alternative sources of meat is widely believed to be a powerful predictor of wildlife consumption where that consumption is driven by food insecurity. We included measures of consumption of alternative meats as part of our household surveys. However, in examining these data against bushmeat consumption, we realized that our alternatives variable is what economists would call endogenous to our model (i.e., it is defined by consumers not choosing to consume bushmeat, and thus, the two are simultaneously determined). Therefore, the alternative meat variable may be correlated with the regression error, causing the coefficient estimate on the alternatives variable to be biased and inconsistent. Nevertheless, because this relationship is of interest to many observers, we provide results of that analysis here (Table S1). Similar to our findings on wealth and consumption, we observed that households in rural areas that regularly consumed fish, fowl, goat, and beef consumed less bushmeat than households that consumed few of these alternatives ($r = -0.55$, $P < 0.001$, $n = 500$ households). However, a similar analysis for the 500 most urban households showed no clear relationship between alternatives and bushmeat consumption ($r = 0.07$, $P = 0.12$, $n = 500$), and our analysis of the complete dataset showed a negative trend that accounted for very little variance ($r = -0.09$, $P < 0.01$, $n = 2{,}000$). Consumption of domestic meat and fish was positively related to wealth across our complete sample ($r = 0.49$, $P < 0.001$, $n = 2{,}000$), but for the reasons mentioned above, we suggest wealth is preferable to alternatives as an indicator of bushmeat use in both rural and urban settings.

For readers interested in examining the contribution of alternatives in the full-panel regression models, we provide results of those models in which alternatives were included with all other variables (Table S1). Model 1 includes a sample of 2,000 households from 96 settlements. Model 2 includes a subset of 994 households from 54 settlements in Ghana and Tanzania for which weekly price of bushmeat (relative to other meats) was collected. Values shown represent coefficients with associated probabilities in parentheses. Household was included as a fixed effect in both models. The overall fit of the models below is only slightly improved over those models that did not include alternatives (Table 1).

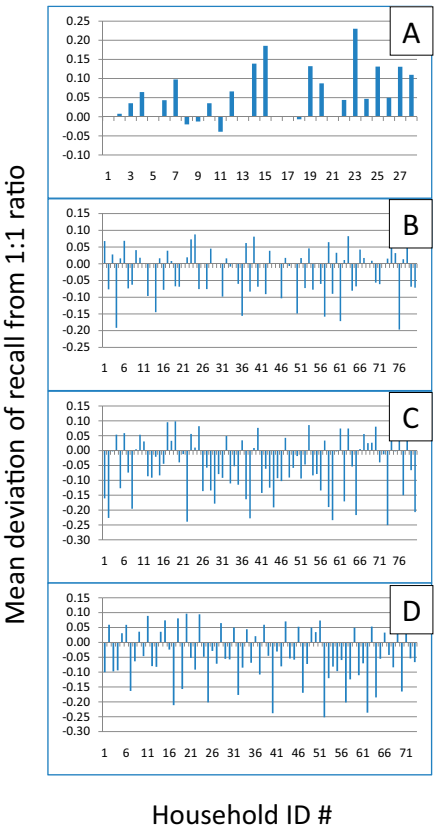

Fig. S1. A comparison of daily, monthly, and annual recall estimates of household bushmeat consumption allowed us to assess the bias introduced when relying on annual recall. A perfect 1:1 match between two temporally dissimilar recalls (e.g., day vs. year) is represented by a value of zero. Values above zero indicate households that overestimated bushmeat consumption when asked to recall longer time periods. Values below zero represent underestimates. A comparison of daily records vs. annual recalls for 28 households in Madagascar (*A*) showed that most households overestimated bushmeat consumption when asked to recall a full year but only slightly (5.6 ± 1.3% SE). In contrast, monthly (*B*) and annual (*C*) recalls for 80 households in Ghana tended to slightly underestimate bushmeat consumption compared with daily records (−2.2 ± 1.1% SE and −5.3 ± 1.4% SE, respectively). Annual recall of bushmeat consumption for 73 households in Tanzania (*D*) also produced estimates lower than those derived from daily records but again, only slightly (−4.3 ± 0.9% SE). In general, values of annual household bushmeat consumption calculated from daily records were highly correlated with estimates provided by annual recalls with agreement between the two measures (*r*) above 0.85 for each country individually and above 0.9 for all three countries combined (n = 181 households, $P < 0.001$).

Table S1. Predictors of household wildlife consumption (grams per day per household) in Ghana, Tanzania, Cameroon, and Madagascar from 2004 to 2008 using mixed-effect panel regression models and including supply of alternative foods as a predictor

Explanatory variable	Model 1	Model 2
Household wealth (decile)	−0.008 (0.72)	−0.041 (0.18)
Alternatives (decile)	−0.005 (0.79)	−0.064 (0.04)
Distance from harvested wildlife (km)	−0.069 (<0.01)	0.11 (<0.01)
Distance from urban center (km)	0.056 (0.01)	−0.093 (0.01)
Wealth × distance from harvested wildlife	0.26 (<0.01)	0.294 (<0.01)
Wealth × distance from urban center	0.16 (<0.01)	0.171 (<0.01)
Relative bushmeat price (ratio)		−0.103 (<0.01)
Wealth × relative bushmeat price		0.325 (<0.01)
Constant	3.1 (<0.01)	2.4 (<0.01)
Full model R^2	0.49	0.62