Income and Price Elasticities of Bushmeat Demand in Lowland Amerindian Societies

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Abstract: *Consumption of bushmeat is an important component of household economies in most tropical forested regions of the world and is resulting in unsustainable levels of hunting, even in relatively isolated regions. We conducted standardized surveys of household consumption, income, wealth, and education level among Amerindian societies in Central and South America. Results suggest 1) demand for bushmeat may follow an inverted ∪ pattern with income, 2) consumers, particularly the most well-off, reduce their consumption of bushmeat as the price increases; and 3) a small decrease in the price of meat from domesticated animals is likely to lead to a large decrease in the consumption of fish but not of bushmeat. Policy makers may be able to reduce demand for bushmeat by raising the price of bushmeat, by increasing the direct and opportunity costs of hunting, and by raising household income.*

Elasticidades de Insumo y Precios de Demanda en Sociedades Amerindias de Tierras Bajas

Resumen: *El consumo de carne silvestre es un componente importante de las economías caseras en la mayoría de las regiones tropicales boscosas del mundo y está resultando en niveles insostenibles de caza, aún en regiones relativamente aisladas. Llevamos a cabo prospecciones estandarizadas de consumo familiar, riqueza y niveles de educación entre sociedades Amerindias en América del Sur y Central. Los resultados sugieren que 1) la demanda de carne silvestre podría seguir un patrón de ∪ invertido con los ingresos; 2) los consumidores, particularmente la mayoría de los persistentes, reducen el consumo de carne silvestre en tanto que el precio aumenta; y 3) una disminución pequeña en el precio de carne de animales domesticados es posible que conduzca a una disminución grande en el consumo de peces, pero no de carne de animales silvestres. Los políticos deberían de reducir la demanda de carne silvestre incrementando su precio, incrementando los costos directos y de oportunidad de la caza e incrementando los ingresos familiares.*

Introduction

Wildlife is a primary source of animal protein in the diet of rural and urban households in most forested regions of poor nations (Redford 1993; Chardonnet 1995) and provides higher than average annual incomes to hunters and to many traders (Dethier 1995; Ngnegueu & Fotso 1998). Hunting of wildlife for food (i.e., bushmeat), rather than habitat loss, will also be the most significant threat to the conservation of biological diversity in the tropics over the next 15–25 years (Robinson & Bennett 1999*b*; Robinson et al. 1999; Wilkie & Carpenter 1999). Unsustainable hunting risks the extinction of species unique to tropical forests (Bodmer et al. 1988, 1997; Winterhalder & Lu 1997), and irreversible loss of the value they confer to communities and to the world (Bowen-Jones & Pendry 1999; Wilkie & Carpenter 1999). Moreover, loss of wildlife species that are primarily frugivores will alter the seed-dispersal potential of up to 80% of the tree species, affecting seed shadows, seed rain, and the probability of seedling survival (Gautier-Hion 1984; Howe 1984). Overexploitation of wildlife species will alter the dominance hierarchies of tree species, will change forest composition, structure, and bio-

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mass (Chapman & Chapman 1997), and will have unknown effects on rates of succession, regrowth of fallow fields, accretion of soil nutrients, and carbon sequestration. Unsustainable hunting will also result in declines in carnivores, particularly large cats, that rely on bushmeat species as prey.

Reducing Pressure on Wildlife

Two broad approaches have been tried to reduce pressure on wildlife: (1) increase supply of wildlife and (2) reduce demand for wildlife, either by restricting the supply or by educating consumers about other options.

Increasing the supply of wildlife could be done in two ways. First, habitat could be manipulated to increase the food supply of some wildlife species, and predators could be eradicated to reduce natural mortality. Total biomass of wildlife larger than 1 kg adult body mass in tropical forests rarely exceeds 3000 kg/km^2, and harvest of game meat appears sustainable if kept under 200 kg/km^2 (Robinson & Bennett 1999*a*). This is an order of magnitude less than biomass and production rates of typical savannas (Robinson & Bennett 1999*a*). In the Ituri Forest of northeastern Democratic Republic of Congo, annual predation by big cats of forest antelope that are a primary target of bushmeat hunters averages 25% of all individuals and 31% of standing biomass (Hart 2000). If forests were felled and converted to grasslands to favor herbivores, and if big cats were extirpated, the biomass and sustainable harvest of bushmeat could be increased, but at a substantial cost to the conservation of biological diversity. Less drastic measures such as selective felling or poisoning of some trees to increase the relative abundance of fruit trees favored by the primarily frugivorous antelope and primates would increase wildlife production by a small amount but would simplify forest composition and structure, reducing forest biodiversity and potentially undermining forest function and resilience. Increasing the wild supply of bushmeat is unlikely and undesirable for conservation: unlikely because the carrying capacity of the forest and the productivity of forest wildlife is low, and undesirable because it would adversely affect forest structure and species composition.

The second way to increase bushmeat supply is by raising wildlife species in captivity. This makes little sense for low-productivity species such as most antelope and primates, but it is being attempted by at least one organization in Gabon (Jori & Noel 1996) with a rodent, the cane rat (*Thryonomys swinderianus*). With a gestation of 5 months and 6–13 months to reach an adult size of 4–5 kgs (Houben 1999), production rates of cane rats are lower than for domestic pigs and chickens (D. Messinger, personal communication), although the latter may be more prone to disease. Increasing bushmeat supply either in the wild or through captive breeding therefore appears an unlikely option for mitigating the adverse effects of the commercial bushmeat trade.

The other broad approach, constraining demand, also faces hurdles. Most efforts to reduce the consumption of bushmeat have focused on restricting supply, generating scarcity, and raising prices. For instance, researchers and nongovernmental organizations are working with logging companies to stop the export of bushmeat from timber concessions and are seeking ways to help governments enforce laws that prohibit the transport and the sale of bushmeat (Robinson et al. 1999).

Enforcing existing laws will have an immediate effect on the volume of bushmeat entering markets and will consequently improve conservation. If demand for bushmeat is exceedingly strong, however, shrinking supply of bushmeat will increase prices, which will induce others to enter the market and seek ways around the supply constraints. Depending on the structure of demand, supply-constraining measures may only enhance conservation in the short term.

Moreover, the price of bushmeat in markets has little relationship to the scarcity of particular wildlife species because, other than in specialty restaurants and for ritual use, the price of bushmeat is determined primarily by the weight of the edible portion, not by the species of the animal on sale. In most markets, at least in Africa, there is little difference in the price of antelope, primate, ape, and rodent per kilogram, and the relative abundance of a particular species in the market and in the forest is almost irrelevant to its price as bushmeat. For example, a highly endangered sun-tailed guenon (*Cercopithecus solatus*) on sale in the Libreville market in Gabon was priced the same as the much more abundant white-nosed guenon (*C. cephus*) (H. Mboroubou, personal communication).

The absence of price signals that could influence demand for and hunting of individual species is further compounded by the multispecies character of most hunting techniques. When people go hunting they seldom target single species. They either roam the forest in search of any animal worth killing or set wire snares that are indiscriminate killers. A bushmeat hunter with a shotgun is inclined to shoot the largest animal possible because this will generate the most profit per cartridge. Although an animal may become scarce, even to the point of local extinction, a hunter will shoot it if he encounters it and it is large enough to warrant using expensive ammunition. Similarly, even the least common antelope will be killed if it steps into and springs a leghold snare. Given this, rare and endangered species are likely to be driven to extinction by hunters when other more abundant animals continue to make generic bushmeat hunting profitable.

Other attempts to reduce the demand for bushmeat have focused on environmental education (Ecosystèmes Forestiers d'Afrique Centrale/Enviro-Protect 1998), raising consumer awareness of the unsustainability of the commercial bushmeat trade or revitalizing cultural taboos associated with bushmeat consumption (Rose 1999; Trefon & de Maret 2000). Both law enforcement (command and control) and education approaches to curbing consumption of bushmeat rest on the assumption that the demand for bushmeat changes significantly with availability and price and that affordable, available, and palatable alternatives exist.

Consumer Demand for Bushmeat

Despite the importance of bushmeat to rural populations and despite the threat that hunting poses to the conservation of biological diversity and to the future of tropical forests, little quantitative research has been done on the factors that drive consumer demand for bushmeat in poor tropical countries (de Garine 1993; Wilkie & Carpenter 1999). We know relatively little about how the consumption of bushmeat responds to the price of bushmeat and its substitutes, or to changes in household income.

Increases in household wealth appear to drive a shift in preference from bushmeat to the meat of domesticated animals (Schmink & Wood 1992; Stearman & Redford 1995) or to narrow the range of bushmeat species consumed (Hames 1991; Layton et al. 1991). Apocryphal accounts might lead one to believe that residents of the Congo Basin prefer the taste of bushmeat over the meat of domestic animals and that bushmeat consumption is a deeply rooted tradition impossible to change (Hladik et al. 1990). Yet food studies of preference have often simply documented that consumers note "meat hunger" when their diet is composed primarily of starches (Harako 1981; Hawkes et al. 1987; Bahuchet 1990; de Garine & Pagezy 1990; de Garine 1993) and have not established that consumers have clear taste preferences for bushmeat over the meat of domesticated animals.

If bushmeat demand does not respond to large changes in the price of bushmeat, then increasing the supply of bushmeat, either by manipulating the forest or by raising animals in captivity, will have a modest effect on conservation. Similarly, a cultural, deep-rooted taste preference for bushmeat may impose a significant barrier to reducing demand through environmental education. Yet if the consumption of game, like the consumption of firewood or charcoal, declines when incomes grow, then economic prosperity could enhance the conservation of wildlife.

Role of Income and Price in Bushmeat Consumption

An increase in income could produce three changes in the consumption of wildlife, depending on whether

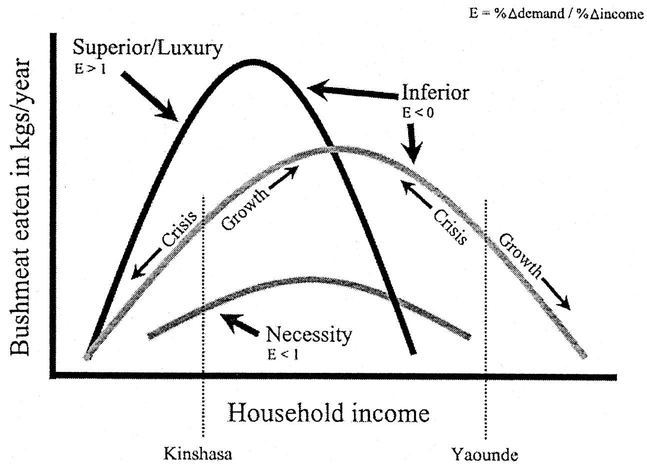

Figure 1. Potential changes in bushmeat demand with household income (assumes an inverted U pattern with income). Superior/luxury animals are species whose consumption increases by >1% for every 1% increase in income. Necessity animals are those whose consumption increases by <1% for every 1% increase in income. Inferior animals are those whose consumption falls when incomes rise.

wildlife is an inferior or a superior good or a necessity. Superior animals are species whose consumption increases by >1% for every percent increase in income (Fig. 1). Necessities are animals whose consumption increases by <1% for every percent increase in income. Inferior animals are species whose consumption falls when incomes rise. Normal goods are goods with a positive income elasticity of consumption and include necessities and superior goods. The income elasticity of consumption is calculated as follows: $E = \%\Delta\text{consumption}/\%\Delta\text{income}$, where $E > 1$ denotes superior goods, $E < 1$ but > 0 denotes necessities, and $E < 0$ denotes inferior goods. An animal may fall under more than one category depending on the level of income of the household. For instance, in poor households an increase in income may at first induce a steep increase in bushmeat consumption, but beyond a threshold of income bushmeat consumption may grow more slowly or perhaps fall (Fig. 1). The words *superior*, *normal*, *necessities*, and *inferior* summarize an empirical relation between the consumption of an animal or a group of animals and income; the words do not imply that animals are better or worse than each other.

On the demand side, two prices likely drive the consumption of bushmeat: the price of bushmeat itself and the price of close substitutes. If all else is held constant, an increase (decrease) in the price of bushmeat will reduce (increase) the consumption of bushmeat. We refer to this relation as the own-price elasticity of consumption, defined as the percent change in the consumption of bushmeat brought about by a percent change in the price of bushmeat. Typically, the higher the own-price elasticity of consumption, the greater the number of substitutes likely to be available to consumers, because a small change in the price of the good produces a large change in the quantity consumed.

A decrease in the price of another source of animal protein, such as poultry, beef, or pork, ought to decrease bushmeat consumption if meat from wildlife and meat from domesticated animals are substitutes for each other. If meat from domestic animals is a complement to bushmeat (as cleaning solution is a complement to contact lenses, in that when fewer contact lenses are sold, less cleaning solution is used), then an increase in, say, the price of beef should result in a decrease in the consumption of beef and a complementary decline in bushmeat consumption. We refer to the relation between a good and its substitutes or complements as the cross-price elasticity of consumption, defined, in this case, as the percent change in the consumption of bushmeat produced by a percent change in the price of another type of meat or source of animal protein. A negative cross-price elasticity of consumption between meat from wildlife and meat from domesticated animals indicates that the two goods are complements, much like bread and butter are complements; a positive cross-price elasticity of consumption indicates that the two goods are substitutes. A high, positive cross-price elasticity of consumption between meat from wildlife and meat from domesticated animals implies the potential to reduce pressure on wildlife through the development of cheaper, alternative sources of animal protein.

Methods

Surveys

To take a first look at how income and prices influence household consumption of wildlife, we draw on a unique dataset from Amerindian households in South and Central America. We used the methods of Godoy (2000) to collect information on fish and game consumption and socioeconomic and demographic attributes of 443 households in four lowland cultures in Bolivia, and for 2.5 years we tracked the consumption patterns of 32 households of Tawahka Amerindians in the tropical rain forest of eastern Honduras.

During 1997–1998, two graduate students in anthropology did ethnographic fieldwork and a household survey in four lowland Amerindian groups of Bolivia. The purpose of the survey was to collect information on the consumption of game and fish, and on socioeconomic covariates of consumption, particularly income and prices. Huanca (2000) did research and carried out a formal survey among the Tsimane', Yuracaré, and Mojeño of the river Sécure in the department of Beni, and McDaniel (2000) did a similar study using the same survey among the Chiquitano in the department of Santa Cruz. We tested the survey among the Tsimane' near the town of San Borja in the department of Beni during June–July 1997, to ensure interobserver reliability. We conducted the survey at the end of an ethnographic study (in 1998) among 886 household heads (evenly split between female and male heads), in 443 households and 42 villages. We surveyed between 2.79% and 11.80% of the households in each ethnic group, or 3.54% of all the households in the total population of the four groups (Table 1).

We completed the survey with both the female and male household heads. The most recent census of lowland indigenous people in Bolivia suggests that only 2% of households are headed by one person. Most indigenous households in the lowlands are nuclear (76%) or extended (22%) (Government of Bolivia 1995). Our survey found no households headed by only one person.

We surveyed a small subsample of households twice, once at the beginning and once at the end of the study. This explains the difference in the number of unique

Table 1. Unique number of subjects, households, and Amerindian villages surveyed.

	Ethnic groups				
	Tsimane'	*Mojeño*	Yuracaré	Chiquitano	Total
Surveyed					
subjects	58	264	124	440	886
households	29	132	62	220	443
villages	2	13	7	20	42
Population*					
people	5124	19759	3339	48524	76746
households	1022	3068	525	7876	12491
Sample					
households surveyed as % of households in population	2.83	11.80	2.79	3.54	4.30

**Population figures come from Censo Indígena (Government of Bolivia 1995).*

Table 2. Income, own-, and cross-price elasticities of wildlife consumption among lowland Amerindians, Bolivia.[a]

	Pooled		*Bottom income (average = $1041/year)*		*Top income (average = $4646/year)*	
Item	*elasticity*	p > |t|	*elasticity*	p > |t|	*elasticity*	p > |t|
Fish						
income	−0.158	0.051	−0.280	0.046	0.023	0.911
own	−0.633	0.001	−0.426	0.001	−2.632	0.058
cross						
chicken	4.361	0.001	—[b]		—[b]	
pig	2.184	0.001	−1.273	0.545	2.988	0.054
cattle	1.692	0.347	−1.184	0.442	−1.089	0.056
R^2	0.73		0.74		0.76	
observations	460		231		229	
statistical tests						
Cook	0.000		0.225		0.000	
Ramsey	0.050		0.470		0.157	
Bushmeat						
income	0.056	0.727	0.040	0.906	−0.137	0.712
own	−1.967	0.040	−2.175	0.051	−5.852	0.053
cross						
pig	3.305	0.300	3.313	0.186	2.265	0.141
cattle	−0.051	0.985	−0.059	0.978	—[b]	
R^2	0.45		0.54		0.46	
observations	325		142		183	
statistical tests						
Cook	0.132		0.370		0.443	
Ramsey	0.735		0.331		0.788	

[a]*Cook-Weisberg if probability is more than chi-square in test for heteroskedasticity and Ramsey if probability is more than* F *in Ramsey test of omitted variable bias. Regressions are ordinary least squares. Huber-White robust standard errors are used if probability in Cook-Weisberg test is less than 10%. Excluded category includes the Chiquitano. Income, prices, wealth, education, and household size in logarithms. Top and bottom split along median household income (5.23 bolivianos = 1 U.S. dollar). Under bottom and top, mean refers to the mean household income for each of the two halves.*
[b]*Omitted because of multicollinearity.*

households in Table 1 ($n = 443$) and the number of households reported in Table 2 ($n = 460$). In Table 2 we took into account both sets of responses for households that were surveyed twice because we collected entirely new information from them at two different times. The survey included questions on the use of game and fish, and explanatory variables such as wealth, income, demography, and human capital. Variables related to human capital included the number of years of schooling completed by the subject.

The information we collected on the dependent variables—fish and game consumption per person—refers to the average for the entire household, but the information we collected for some of the explanatory variables, such as education, came from both the female and the male household heads. For the regressions (Table 2) we had to decide whose personal attributes to consider as independent variables. We could have included the attributes of the wife, the husband, or both. We tried all three permutations and found that our main conclusions reported did not change, although the results became statistically stronger when we included both household heads because the sample size doubled. When we included both household heads, many of the results that were on the verge of being statistically significant became significant at the 90% confidence level or above. To be conservative, we used information from only one household head. For arbitrary reasons we decided to use the personal attributes of the male household head in the regressions (Table 2).

Variables

The dependent variables were average kilograms of fish and game brought into the household per person during the week before the interview, estimated based on informant recall. Weekly consumption per person of bushmeat and fish from the sample averaged 1.52 kg of bushmeat (SD = 3.81) and 2.40 kg of fish (SD = 5.01). The variable for game consumption contained more missing values than the variable for fish consumption, weakening the elasticity estimates of game consumption.

Explanatory variables included income and wealth per person, household size, education of the male head of household, village prices for fish and domesticated animals (chickens, ducks, swine, and cattle), and dummy variables for villages and ethnic groups. Income included farm income from the harvest of maize, rice, and peanuts and cash income from the sale of farm products and forest goods (excluding wildlife) and from wage labor. Income also included remittances received. Wealth included the total value of one dozen diagnostic physical assets. Assets were valued with village prices. We transformed consumption, income, wealth, household size, education, and prices into natural logarithms.

Statistical Tests

We estimated Pearson partial correlation coefficients among independent variables. They generally fell below 0.50, except among the prices of cattle, ducks, and fish. Despite multicollinearity, we left those variables in the regressions because they matter for policy purposes.

We carried out and report the results of six regressions, three for fish and three for game. We ran a regression for the pooled sample and one for the top and bottom of the income distribution for fish and game. We used the median income to split the sample. For each of these groups and for the pooled sample, we tested for heteroscedasticity and for omitted-variable bias. We used the Cook-Weisberg test for heteroscedasticity and the Ramsey test for omitted variable bias. Most of the regressions did not have omitted variable bias. In the instances where the assumption of constant variance of the error term was violated, we ran the regressions with Huber-White robust standard errors.

Results and Discussion

Subject-Group Similarities and Differences

All the groups in the study rely on swidden cultivation and, secondarily, on foraging for subsistence. Both groups inhabit tropical rain forest, although the Chiquitano forest is more deciduous. Both groups clear approximately 1 ha each of old- and secondary-growth forest for agriculture each year. Hunting and fishing takes place within village lands, typically within 3–5 km of the village. All groups live in nucleated settlements, but village density varies widely within groups. All the groups have had centuries of contact with outsiders, although contact seems to have been strongest and more continuous among the Mojeño and the Chiquitano. Many of the groups have moved to inaccessible regions to avoid and minimize contact with outsiders. Except for the Mojeños and the Yuracaré, the groups face direct threats from encroachers.

People in all the cultures depend on the market to various degrees and need cash to buy school supplies or necessities, such as salt and metal tools. Cash becomes indispensable when misfortune strikes. To satisfy their need for cash, people in all the groups sell goods such as peanuts, rice, thatch palm, logs, wildlife, wild honey, and firewood. During the agricultural slack season they work as unskilled laborers on cattle ranches, in logging camps, in the farms of smallholders, and in nearby towns. Private merchants comb indigenous territories (except along the river Sécure), selling commercial goods, medicines, and farm inputs, buying crops and nontimber forest goods, and giving credit to people they know.

The groups vary in population size, from a low of 3339 (Yuracaré) to a high of 69,590 (Chiquitano). They also vary in household composition and human capital. Total household size ranges from 5.01 for the Tsimane' to 6.2 for other groups. The people surveyed have little formal schooling, averaging only about 2 years, but the Chiquitano have twice as much formal schooling than the rest. The groups fall into two clusters in their knowledge of Spanish. Among the Tsimane' only 55% of household heads are fluent in Spanish, but among the other groups almost all are.

The groups vary in distance to the nearest market. The Yuracaré and the Mojeño of the river Sécure are the most isolated; their villages lie, on average, about 123 km from the nearest town. The land of the people along the river Sécure lies outside the direct threat of coca cultivators and other encroachers, but the same cannot be said of the land of the Tsimane' or of the Chiquitano. Logging firms have perforated the territory of the Tsimane', taking out logs regularly and with impunity.

The cultures under study have experienced different shocks in recent years. The floods of 1992–1993 affected the Tsimane', Yuracaré, and Mojeño. Their territory was a pit stop for drug traffickers during the 1980s. Drug trafficking has declined in recent years owing to a stronger program of drug interdiction. Although the production and the distribution of coca and cocaine has affected most aspects of the Bolivian economy, it does not directly affect, at present, the household economy of the groups we studied.

Finally, the groups differ in how they are linked to the market. The Yuracaré and the Mojeño are well linked to the market through the sale of labor, but not through the sale of crops or through the use of chemicals or credit. The Tsimane' are poorly linked to the outside economy through the market for farm inputs, but they seem well linked through the markets for labor and rice. The Chiquitano are tied to the outside economy chiefly through the sale of labor.

Household surveys showed that a large share of households did not consume fish (59.08%) or game (60.46%).

Income Elasticities

Fish seems to be an inferior good, with an income elasticity of consumption for the pooled sample of −0.15 ($p = 0.051$; Table 2). An increase in income was a much stronger curb on fish consumption in the bottom half (elasticity −0.28; $p = 0.046$) than in the top half of the income distribution, where the elasticity was indistinguishable from zero (elasticity for top half, 0.023; $p = 0.911$). On the other hand, bushmeat was a necessity in the pooled sample (elasticity 0.056; $p = 0.727$) and in the bottom half of the income distribution (elasticity 0.04; $p = 0.906$), but it was an inferior good in the top half of the income distribution (elasticity, −0.137; $p = 0.712$). Because the income elasticities of consumption for bushmeat were around zero and were statistically insignificant at the 90% confidence level or above, one could tentatively conclude that bushmeat is a necessity bordering on being an inferior good.

These results are echoed by other results obtained from a panel estimation of 32 households of Tawahka Amerindians in the rainforest of eastern Honduras that were monitored over 2.5 years, from June 1994 until December 1996 (Godoy 2000). The income elasticity of consumption for fish was indistinguishable from zero and was not statistically significant (−0.01; $p = 0.849$) in a multivariate random-effect estimation. As in Bolivia, bushmeat was a necessity in the pooled sample (elasticity of 0.19 in the random-effect estimation; $p = 0.089$) and in the bottom half of the income distribution (elasticity of 0.50; $p = 0.003$), but it was an inferior good in the top half of the income distribution (elasticity −0.6; $p = 0.741$).

Own-Price Elasticities

Because we did not have a village price for bushmeat but did have the village price of fish, the only own-price elasticity we could estimate with accuracy was that for the consumption of fish. If one assumes, however, that the price of fish and the price of bushmeat move in unison, then the price of fish could be used as a proxy for the price of bushmeat, which is the assumption we made in estimating the own-price elasticity for bushmeat. Care should be taken in interpreting the own-price elasticity for bushmeat consumption (Table 2) because those estimates refer to changes in the consumption of bushmeat produced by a change in the price of fish, not of bushmeat.

Bearing this caveat in mind, we inferred that both fish and bushmeat are much more elastic in the top than in the bottom half of the income distribution (Table 2). For instance, the own-price elasticity of consumption for fish in the bottom half of the income distribution was only −0.426 ($p = 0.001$), but it was −2.632 ($p = 0.058$) in the top half. The pattern was the same with bushmeat. The own-price elasticity of bushmeat consumption in the bottom half was only −2.175 ($p = 0.051$) but rose to −5.852 ($p = 0.053$) in the top half. The high own-price elasticity of consumption (particularly at higher levels of income) suggests that indigenous people may have many sources of animal protein available to them, a finding with positive and negative implications for conservation.

Cross-Price Elasticities

Our results suggest that chickens and pigs are substitutes for fish (Table 2). In the pooled sample, an increase in the price of chickens and pigs resulted in greater consumption of fish. The pooled cross-price elasticities between fish consumption and the price of chickens and pigs was 4.316 ($p = 0.001$) for chickens and 2.184 ($p = 0.001$) for pigs. In the top half of the income distribution, pigs continued to be a substitute for fish (elasticity 2.988; $p = 0.054$) and cattle were a complement (elasticity −1.089; $p = 0.056$). Bushmeat consumption did not, however, respond to changes in the price of domesticated animals.

Conclusions and Policy Implications

The results of this study suggest that (1) an increase in income reduces consumption of fish in the pooled sample and in the bottom half of the income distribution; (2) an increase in income causes consumption of bushmeat to increase, but the effect is modest, suggesting that bushmeat is a necessity, bordering on being an inferior good in the top half of the income distribution; (3) consumption of bushmeat and fish responds to changes in their price, in that people consume less at higher prices—a trend more marked among better-off households, and (4) a decrease in the price of meat from domesticated animals is associated with a large decline in the consumption of fish but not of bushmeat.

Given that consumption of fish and bushmeat appears sensitive to changes in income and prices, and assuming that consumers in other poor tropical forested nations behave like Amerindians in Bolivia and Honduras, then at least three admittedly tentative lessons for policymakers and donors can be drawn from the study. First, economic development might result in enhanced wildlife conservation if household incomes rise fast enough and high enough to shift bushmeat from a necessity to an inferior good (Fig. 1). Second, given the high own-price elasticity of demand for bushmeat among wealthier households, any factor that lowers the marginal cost of hunting (i.e., more efficient foraging technology) is likely to increase hunting effort and its effect on wildlife. But any activity that raises the price of bushmeat or the direct or opportunity costs of hunting, such as fines associated with enhanced law enforcement, higher farm wages, or more lucrative off-farm jobs in the countryside, could counterbalance the negative effects of new technologies. Finally, our analysis suggests that demand for fish may be reduced and conservation of fish may be enhanced by promoting access to cheaper alternative sources of animal protein, such as pork and chicken. Access to cheaper substitutes may not, however, reduce demand for bushmeat.

The effect of changes in household income on bushmeat consumption implied by the results of our preliminary study will depend on the shape of the bushmeat demand curve for any given set of consumers (Fig. 1), and on the location of individual households along the income axis (Ferraro & Kramer 1997). For example, given relatively high initial incomes fuelled by money from petrochemical development, a decline in household livelihoods associated with the devaluation and structural adjustment in Cameroon is believed to have increased demand for bushmeat in the capital Yaoundé (Fig. 1). The opposite has happened in Kinshasa, Democratic Republic of Congo, since the start of the civil war in 1996, when household income continued to fall from an already low level (T. Trefon, personal communication).

Our results are suggestive rather than conclusive; researchers need to validate our finding that the demand for fish and bushmeat in other tropical forest regions of the world is as responsive to the price of substitutes and to income as it appears to be among Amerindians. Given the severity of the threat posed by bushmeat hunting to wildlife conservation in the tropics, even these tentative results suggest that donors and governments should continue to support and expand initial efforts to encourage or coerce multinational logging and oil companies to halt illegal commercial bushmeat hunting in their concessions, thus constraining the major source of supply of bushmeat to urban consumers and increasing the costs of hunting.

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