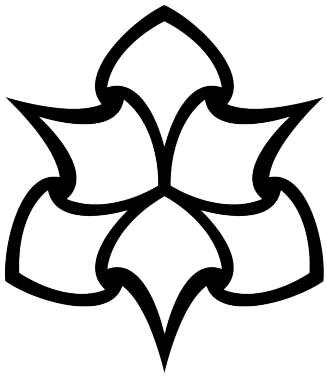

Urban wild meat consumption and trade in central Amazonia

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Article Impact Statement: In central Amazonia, wild meat is widely consumed by urban residents; its trade generates as much as the mineral and timber industries.

Abstract

The switch from hunting wild meat for home consumption to supplying more lucrative city markets in Amazonia can adversely affect some game species. Despite this, information on the amounts of wild meat eaten in Amazonian cities is still limited. We estimated wild meat consumption rates in 5 cities in the State of Amazonas in Brazil through 1,046 door-to-door household interviews conducted from 2004 to 2012. With these data, we modeled the relationship between wild meat use and a selection of socioeconomic indices. We then scaled up our model to determine the amounts of wild meat likely to be consumed annually in the 62 urban centers in central Amazonia. A total of 80.3% of all interviewees reported consuming wild meat during an average of 29.3 (CI 11.6) days per year. Most wild meat was reported as bought in local markets (80.1%) or hunted by a family member (14.9%). Twenty-one taxa were cited as consumed, mostly mammals (71.6%), followed by reptiles (23.2%) and then birds (5.2%). The declared frequency of wild meat consumption was positively correlated with the proportion of rural population as well as with the per-capita gross domestic product of the municipality (administrative divisions) where the cities were seated. We estimated that as much as 10,691 t of wild meat might be consumed annually in the 62 urban centers within central Amazonia, the equivalent of 6.49 kg/person/year. In monetary terms, this amounts to US$21.58 /person/year or US$35.1 million overall, the latter figure is comparable to mineral and timber production in the region. Given this magnitude of wild meat trade in central Amazonia, it is fundamental to integrate this activity into the formal economy and actively

develop policies that allow the trade of more resilient taxa and restrict trade in species sensitive to hunting.

## Introduction

Wild meat contributes to the diet of millions of people worldwide, making up 20-70% of all protein intake, particularly in isolated tropical forest regions, where domestic meat is scarce (Fa et al. 2015). Increased urbanization within the tropics has resulted in a greater demand for wild meat from cities and large towns; these population centers are supplied from the rural areas where wildlife occur. Thus, many rural peoples have shifted from being strictly traditional subsistence hunters to selling wild meat in cities (e.g. Dounias 2016). Whilst the sale of wild meat provides an important income source for many, uncontrolled trade to large urban markets is a conservation problem in many tropical countries (Nasi et al. 2011).

Until recently, the only published references to urban wild meat consumption in the Amazon were from studies in 1 city, Iquitos, Peru (Bodmer & Lozano 2001). Based on this, urban wild meat consumption in Amazonia was regarded for some time as negligible (Rushton et al. 2005, Nasi et al. 2011). However, recent studies suggest there are significant city markets in the region where a large number of wild animals are sold for human consumption. For example, well-established wild-meat markets exist in Abaetuba, Brazilian Amazon (Baía-Júnior et al. 2010), and in 2 prefrontier cities in southern Brazilian Amazonia, where around 80% of interviewed households regularly consumed wild meat (Parry et al. 2014). About 473 t of wild meat were estimated as traded annually in cities in the Amazonian trifrontier (Brazil, Colombia, and Peru) (van Vliet et al. 2014).

Because most of these studies are descriptive, restricted to relatively short sampling periods, and on a local scale, there is still a need to determine the levels of wild meat use and the volumes traded in Amazonian cities in much larger areas. Although factors affecting wild

meat consumption and trade in African cities are relatively well known (Fa et al. 2009), these are still largely undescribed for Amazonia. A few studies have been conducted on how the economic and cultural background of consumers in Amazonian cities can affect how much wild meat is eaten (Morsello et al. 2015; Chaves et al. 2017); however, studies that can predict the volume of wild meat consumed in urban centers at a regional level are still absent.

We estimated wild meat consumption rates in 5 cities in the State of Amazonas in Brazil. From these data, we developed statistical models to determine the relationship between wild meat use and a number of socioeconomic indices obtained from government sources and scaled up our model to estimate the amounts of wild meat likely to be consumed annually in urban centers throughout central Amazonia, an area representing about one-third of the entire Amazon biome. We also calculated the monetary value of the wild meat trade in this region. The results of our study can be useful to understand the extent of urban demand for wild meat in the Amazon as a whole and generate insights that may inform conservation efforts and policies to ensure the sustainable use of wildlife.

## Methods

### *Study sites*

This study was conducted in Amazonas state, the largest state by area in Brazil (1,571,000 km²). The state is almost entirely covered by moist broadleaf forest and encompasses about 29% of the Amazon Basin.

Brazilian states are divided into administrative municipalities that contain natural areas and urban and rural human settlements. Each municipality has a city that is the seat of the area's administration; these seat cities are not specified in law according to a minimum population size, area, or facilities. Amazonas state contains 62 municipalities with around 3.4 million inhabitants, of which around 2.7 million (79.4%) live in cities (IBGE 2018).

Because most cities in the state are far apart, accessible after long hours of travel by boat or plane, we chose those closest to our main research base in Tefé. Among these more accessible cities, we selected those within municipalities that would be representative of the range of socioeconomic variables we wanted to consider: rural and urban human population, human development index (HDI), and gross domestic product (GDP) (Supporting Information). We sampled households in the seat cities of 5 municipalities: Alvarães (14,080 inhabitants) and Tefé (61,399 inhabitants), at the confluence of the Tefé and Solimões Rivers; Coari (75,909 inhabitants), between the Urucu and Solimões Rivers; Maraã (17,364 inhabitants) on the lower Japurá River; and Fonte Boa (22,659 inhabitants) on the Solimões River (Table 1; Supporting Information). The economy of these municipalities is based around small-scale industries and farming (IBGE 2018).

*Data collection*

Data on wild meat consumption and trade were obtained through household surveys conducted from April 2004 to May 2012 (Table 1). Depending on the time available for research in each city, we randomly selected at least 50% of neighborhoods within which we had a minimum of 2 interviews per neighborhood (Table 1). We asked heads of households (women and men) the following questions: is wild meat consumed in the house (*yes* or *no* response), how often is wild meat consumed (number of days per week, month, or year), which species are eaten, how is the consumed wild meat obtained (hunting, buying, or as a gift), if purchased, where is it purchased, and what price is paid for each species and what is the selling unit (e.g., kilograms, entire animal or half the animal specimen).

Although consumption and trade of wildlife is forbidden by law in Brazil (Law 5.197/1967) (Antunes et al. 2019), local wildlife management authorities tend to persecute hunters and traders, not consumers. Therefore, consumers do not perceive they are acting illegally and do not fear persecution. Given this, we did not use indirect questioning methods;

rather, we applied direct questioning, as used in previous studies of wild meat consumption in the region (e.g., Parry et al. 2014; van Vliet et al. 2015; Chaves et al. 2017). Participants were made comfortable with our interview process by informing them of the study aims prior to the interview. Respondents were free to participate in the study and were informed that we would not disclose their identity. Of a total 1085 visited households, 96.4% (1,046 households) agreed to be interviewed, an indication that most people felt comfortable participating (Table 1). We followed the Guidelines for Applying Free, Prior and Informed Consent in Buppert and McKeehan (2013).

*Data analyses*

The overall amount of wild meat consumed ($B$) in each city was estimated using the following formula:

$$B = F_c * P_c * D_c \ , \qquad (1)$$

where $F_c$ is the mean frequency of consumption reported by the interviewees expressed as the number of days wild meat was consumed per person per year and $P_c$ the total potential consumers in the city based on the percentage of informants declaring that they consumed wild meat in our survey multiplied by the number of urban inhabitants. Because actual daily amounts of wild meat consumed by Amazonian urban dwellers is not currently available, we used 0.18 kg/person/day (CI 0.07) (obtained from a study of 13 indigenous communities [Ojasti 1996]) as an average amount of wild meat consumed per person per day ($D_c$).

For each city, we estimated the amount of meat consumed of each taxon from the percentage of times the taxon was mentioned (hereafter referred to as citations) and the overall amount of wild meat consumed ($B$). We estimated the number of individuals consumed per taxon per year by dividing the estimated biomass consumed of each taxon by the body mass of eviscerated specimens of the species (García et al. 2004).

All taxa were classified according to the International Union for Conservation of Nature (IUCN) Red List threat categories (vulnerable, endangered, critically endangered) (IUCN 2018). If the local names provided by informants did not allow an unequivocal classification to species, we used genus or family.

We calculated the average selling price for each taxon by adjusting for the inflation rate for the different years during which each city was sampled based on the General Price Index for Brazil estimated by the Getúlio Vargas Foundation. We used the exchange rate for 1 June 2018 to convert Brazilian reais (R$) into U.S. dollars (R$3.85 = US$1.00). Hereafter all monetary units are U.S. dollars.

We built generalized additive models for location, scale, and shape (GAMLSS) to assess drivers of the 3 response variables: frequency of consumption (reported number of days of wild meat consumption per year), taxa citations, and price per kilogram. As predictor variables, we used socioeconomic indices compiled by the Brazilian Government for each municipality (IBGE 2018): total population (number of inhabitants), percent rural population (rural population/total population), HDI, and the per capita GDP in dollars per individual. Data from 2010 was used as reference for the first 3 variables because no information was available for the specific years when our interview data were collected. Per capita GDP values were available for each sampling year. We considered the gross body mass (noneviscerated weight in kilograms) and habitat type (terrestrial, arboreal, and aquatic) for each taxon as biological drivers for the models in relation to the taxa citations and price per kilogram. We also included taxa as a random factor due to differences in the number of citations among cities and the price per kilogram as a predictor variable for the taxa citations. Gross body mass of all mentioned species was obtained from García et al. (2004) and Robinson and Redford (1986). To avoid overestimating the number of people consuming wild meat due to low sample sizes in some cities, we calculated the potential number of

consumers ($P_c$) by using the same variables of the municipalities as predictors in multiple logistic regressions (Supporting Information).

To build the models, we tested combinations of predictor variables in linear and nonlinear forms with different distribution families. We checked for collinearity among variables. Because the percentage of rural population was negatively correlated with the total population ($r^2$=0.99) and HDI ($r^2$=0.94), these variables were never included in the same models and were tested separately. Final models were selected based on the Akaike information criteria (AIC); all models with good support were those with ΔAIC values <2 in relation to the model with the smallest AIC. In cases when >1 model was a best fit, we selected the model with the smaller number of parameters.

Based on our best-fit models and variables, we used the function gamlss.predict to predict the current frequency of wild meat consumption, the amount of consumed wild meat (corrected by the percentage of consumers among urban dwellers), and the monetary value generated by wild meat for the entire central Amazonia region, and calculated these parameters for all 62 cities in the Amazonas state with the most updated values for the predictor variables available from the government statistics (Supporting Information). We used R version 3.3.3 (http://www.R-project.org/) and the gamlss R-package for generalized linear and additive mixed models and predictions and GGally R-package for the collinearity test. For the variables effects, we assumed significance when $p$ <0.05.

Results

Sampled municipalities were representative of the 62 municipalities in the state of Amazonas. Average per capita GDP ($2,835.34 [SD 2,540.01]) (and average percentage of the rural population (36.06% [11.88]) in our 5 sampled municipalities were not statistically different from the averages for the remaining 57 municipalities (average GDP $2,463.56

[1396.36], $t = 0.53$, df = 60, $p = 0.65$; rural population \$44.95 [14.30], $t = 1.45$, df = 60, $p = 0.15$) (Supporting Information).

*Consumption and procurement of wild meat*

All interviewees in Maraã (20/20) and Fonte Boa (22/22), 90.8% (139/153) in Alvarães, 85.0% in Coari (51/60), and 76.9% (608/791) in Tefé declared consuming wild meat; overall average was 80.3% (Table 2). Respondents declared consuming wild meat during 29.3 (CI 11.6) days per year (Table 2). An average of 80.1% of interviewees reported buying wild meat, and 14.9% of consumers reported hunting wildlife (Table 3). The estimated mean annual wild meat biomass consumed per capita was 4.60 kg/person/y (SD 1.87), a total of 500,497.56 kg (CI 203 - 254.42).

*Taxa consumed*

Twenty-one taxa were mentioned as eaten by respondents. As many as 40% (6 of 15) of the taxa identified to species are threatened with extinction (Supporting Information). Among the 2,067 citations, mammals were the predominant group (*n*=1,480, 71.6%), followed by reptiles (*n*=479, 23.2%) and birds (*n*=108, 5.2%). In terms of biomass, white-lipped peccary (*Tayassu pecari*) (37,955.30 kg), tapir (*Tapirus terrestris*) (23,362.72 kg), lowland paca (*Cuniculus paca*) (21,303.39 kg), and yellow-spotted river turtle (*P. unifilis*) (10,840.29 kg) were the most representative, making up together 67% of the total (Fig. 1). A total of 95,772 (CI 38,893) animals were estimated as consumed annually; 4 species, *P. sextuberculata*, *P. unifilis*, agouti (*Dasyprocta fuliginosa*), and *C. paca*, represented 76.6% of this total (Supporting Information).

*Traded biomass*

Of the total biomass estimated as consumed, 403,311 kg (80.6%) were estimated as purchased in urban markets. People declared they usually bought wild meat in only 1 place (*n*=605, 94.4%), although some informants declared buying in two (*n*=27, 4.2%) or 3

different places (*n*=9, 1.4%). Informants reported that wild meat is mainly obtained at local fairs (*n*=313, 46.1%), followed by hawkers (*n*=208, 30.2%), private residences (*n*=69, 9.2%), directly in rural communities (*n*=63, 9.3%), and from riverboats (*n*=33, 5.2%).

Information on prices was reported by informants for 17 taxa: mean price was $3.82/kg (SD 1.60). The sale of these taxa was estimated to generate $1,522,412/year (CI 240,919). The commercialization of 4 taxa alone, 2 chelonians (*P. unifilis* and *P. sextuberculata*) and 2 mammals (*T. pecari* and *T. terrestris*), were responsible for 68.9% of this amount. Curassows (mean price $8.39/kg) and the 3 freshwater turtles (mean prices $7.67/kg for *P. unifilis*, $6.49/kg for *P. sextuberculata*, $6.01/kg for *P. expansa*) were the most expensive taxa (Supporting Information).

*Drivers of and overall wild meat consumption in central Amazonia*

The reported frequency of wild meat consumption per person increased significantly relative to the percent rural population in the municipality (2.504e-02 [SE 5.597e-03], $t$=4.4, $p$ <0.001) (Fig. 2a) and as per capita GDP increased (1.393e-04 [1.573e-08], $t$=8855.1, $p$<0.001) (Fig. 2b). The gross body mass positively influenced the taxa citations (0.077 [SE 0.007], $t$=10.0, $p$< 0.001) (Fig. 2c). Prices per kilogram presented a nonlinear relationship with the taxa's gross body mass (-0.001 [SE 0.0001], $t$=-10.7, $p$< 0.001) (Fig. 2d) and increased as the percentage of rural population in the municipality increased (0.005 [ 0.0005], $t$=8.7, $p$< 0.001) (Fig. 2e).

Using the models obtained from these relationships, we estimated that 10,691,103 kg (CI 4,342,101) of wild meat was consumed annually in the 62 cities (2,755,756 urban inhabitants) within central Amazonia (Supporting Information). This translates to a mean annual per capita consumption of 6.49 kg/person/year (CI 2.64) and amounts to a total monetary value of $35,112,904/year (CI 14,260,811) (average of $21.58 /person/year [CI 8.76]). The cities with the largest estimated amounts of wild meat consumed per year were

along the western part of the state, and few were located in the central part of the Amazon River basin. The cities with a greater estimated per capita wild meat consumption were located along the northwestern portion of the state (Fig 3).

## Discussion

A very large proportion of interviewees in our study reported eating wild meat, corresponding to 1 day of wild meat eaten for every 12.47 days consuming domestic meat in a year. These results correspond with Parry et al.'s (2014) study in the southern Brazilian Amazon, which shows that as many as 80% of the inhabitants consumed wild meat at least once per year.

Data on daily wild meat consumption in Amazonian urban centers are largely unavailable. The average per capita wild meat consumption we used to estimate overall consumption volumes is necessarily a working value only, but it is heuristically useful for estimating the amount of meat consumed in wild meat-based meals and for extrapolating to the entire study region. There is no doubt that more precise information on amounts consumed per individual or household in urban centers is required, and we suggest this should be a priority for future work.

We acknowledge that some respondents could have underreported how much wild meat they consumed. Because we did not apply indirect questioning techniques to determine the level of underreporting, our consumption estimates must be treated as a minimum. We also believe underreporting rates were probably similar among cities because sampled cities are culturally similar and under the same enforcement regimes.

Data collection for the different cities was spread out over 7 years, and data for some socioeconomic indices were not available for the same years of data collection. This may have affected our results because consumption rates and socioeconomic indices may have varied over time. In addition, the most recent values of socioeconomic statistics were not

obtained at the same time by the government (last available GDP values are from 2016, whereas last census of population was conducted in 2010). However, temporal changes in the 2 variables (rural population, per capita GDP) we used varied differently. The GDP changed substantially over the short-term (i.e., some studied municipalities' GDPs more than doubled from 2010 to 2016), whereas the proportion of rural population changed by only -1.0% on average from 2000 to 2010 (IBGE 2001). Despite these shortcomings, our estimation of 3.49 kg/person/year for Tabatinga, a city in the Brazil-Colombia-Peru frontier, was very similar to the 3.40 kg/person/year van Vliet et al. (2015) derived from direct observations at for the same site. In addition, our predicted per capita frequency of wild meat consumption for Tapauá (39.1 days/year) was also comparable to estimates of Chaves et al. (2017) (38.4 days/year) in the same city. We argue that, despite the limitation posed by the lack of some governmental statistics, these observations support the robustness of our model (Supporting Information).

Our results clearly showed that urban wild-meat markets are well established in Amazonas state. In all surveyed cities, most interviewed urban dwellers reported buying wild meat, and most of them declared purchasing meat from the same salesmen, vendors in local fairs and hawkers, an indication of constancy in supply. Parry et al. (2014) show that the poorest urban households hunt to obtain wild meat, whereas wealthier residents buy wild meat. This is because hunting is the cheaper option for poorer people in cities, but also because the lack of formal employment, which is more common among this group, allows them to spend more time in this activity. Although we have not systematically collected data on this, some informants who declared hunting wild meat for consumption in our study informally declared selling part of their quarry. In the Amazonian trifrontier between Brazil, Colombia, and Peru, hunters profit from the sale of up to 96% of their game to closed markets, whereas fewer hunters hunt to eat and occasionally sell a proportion of the meat to

supplement household income (van Vliet et al. 2015). The low number of urban people declaring hunting wild meat shows that rural hunters supply city markets. Hunters from rural areas in Amazonia are mainly subsistence hunters, but may sell part of their hunting yields, likely to obtain money to buy urban goods, such as clothes and foods (Antunes et al. 2019). For instance, in the Peruvian Amazon, Bodmer and Lozano (2001) found that rural hunters sell around 7% of mammals hunted, whereas Morcatty and Valsecchi (2015) found that around 21% of yellow-footed tortoises (*Chelonoidis denticulatus*) harvested by rural hunters in Amazonia were traded in urban wild-meat markets.

The main groups (mammals and chelonians) and species cited as consumed and traded in our study cities were similar to those traded in other Amazonian localities (Bodmer & Lozano 2001; van Vliet et al. 2014). These species are commonly hunted for subsistence and trade by rural populations throughout Amazonia (e.g., Peres 2000, Lopes et al. 2012) and in other Neotropical regions (El Bizri et al. 2015). In particular, tapir and white-lipped peccary were among the top 3 species cited in our surveys. Both species are listed as vulnerable, following IUCN Red List criteria, and hunting is one of the main threats. Both species are declining in central Amazonia (Parry & Peres 2015). Other highly cited species, such as lowland paca, are also affected by hunting in Amazonia (e.g. Valsecchi et al. 2014, El Bizri et al. 2018), but are listed as least concern by IUCN.

In central Amazonia, governmental statistics for each municipality are useful to predict wild meat consumption at large scales. We found that the proportion of rural inhabitants within a municipality was correlated with the proportion of inhabitants that declared consuming wild meat in cities, the reported frequency of consumption, and the prices per kilogram in the market. This pattern may be a result of the economic connectivity between urban and rural sectors in these municipalities. Thus, in municipalities where the rural population is larger, urban people are able to buy wild meat more frequently from rural

people who hunt. Because these small cities are often isolated and only accessible by boat, domestic and processed products become more expensive due to higher transportation costs. As a consequence, wild meat prices are higher in small cities, where rural inhabitants outnumber urban ones, because trading in wild meat is one of the most prevalent and cost-effective activities in localities where the sale of agricultural commodities do not have a large local market and are uncompetitive due to the high costs and long transportation times (Wilkie et al. 2016). Moreover, we argue that the price of the wild meat may also be anchored to the price of domestic meat or other important products for local inhabitants, such as oil.

The relationship between price and species' body mass reflects the fact that smaller species, although more abundant and easier to capture, are sold at a higher price because they yield less meat. Conversely, large-bodied species, although more profitable in terms of meat obtained, are less abundant and therefore more difficult to capture. This explains the U-shaped curve in this relationship and shows that hunters meeting urban demand do not kill prey randomly, but consider prey profitability when choosing which prey to kill and how to price it (Rowcliffe et al. 2004). Our results also indicated that larger species are generally more consumed than smaller species, and this relationship may be caused partially by price differences. However, considering that fewer game taxa were cited as consumed than in rural areas in Amazonia (e.g. 30 species [Vieira et al. 2015], 27 species [Kirkland et al .2018]), the range of species reaching urban markets may be limited by consumer taste and taboos.

Studies reporting the contribution of wild meat to local economies indicate a large informal sector, often as large as formal sectors, such as timber harvesting or agriculture (Lescuyer & Nasi 2016). Because wild meat trade in Brazil is prohibited, the harvest and selling of this product is excluded from official statistics. Nevertheless, the wild meat market was predicted to generate a great deal of money in central Amazonia ($35.0 million). Compared with other products, it is similar to mineral ($27.3 million) production and only

slightly lower than fish ($40.1 million) and timber production ($39.9 million) in the Amazonas state (SEPLANCTI/DEPI 2018). However, considering that a large proportion of these economic activities, including the wild meat trade, are carried out illegally, these numbers must be considered an underestimate. Most municipalities in the Amazonas state have >40% of their populations living on less than half minimum wage (IBGE 2018); thus, wild meat represents an important product for the income of several rural and urban families in the region. Hunters are not the only ones who generate income from wild meat; rather, several different actors involved in the commodity chain generate income for themselves. In Peru commercial hunters can supply wild meat directly to wholesalers, restaurants, or market traders, who in turn supply meat to the customers; price of the meat increases at each step (Fang et al. 2008). The same has been observed for the trade of tortoise meat in 4 cities in Amazonia, where intermediaries between hunters and urban vendors benefit significantly and obtain high profits (Morcatty et al. 2015). This highlights the necessity of finding solutions to regulate this sector in Amazonia and to reduce the impacts of wild meat trade in urban centers on Amazonian wildlife.

Our maps provide the first large-scale estimation of the amount of urban wild meat consumption for the Amazon, from which one may determine hotspots of wildlife extraction and where implementation of conservation strategies are more urgent. The high consumption rates of wild meat predicted for large cities, such as Coari and the capital Manaus, where there is an offer of domestic meat, signal that wild meat consumption is not strictly related to dietary necessity or poverty, but possibly a maintenance of the rural heritage and the thrill of local dwellers for diversifying their diet (Wilkie et al 2016). Many cities in the western Amazon, which are more accessible due to their location downstream on Amazon River, were predicted to have both per capita and total wild meat consumption at relevant levels, likely because of the combination of high GDP and surrounding rural populations. Therefore,

the replacement of the wild meat by domestic meat at a more accessible price, which is a very common suggested strategy to reduce wild meat demand in cities (Rushton et al. 2005), may not be sufficient to solve the problem. In addition, law enforcement and surveillance actions face several barriers in the Amazon, especially due to the large extent of the territory and difficult access. Accordingly, the current prohibition on wildlife commerce in most areas of the Amazon has been driving a hidden market that hampers control. Furthermore, captive breeding of wild species, although suggested as an alternative to keep wild meat consumption at sustainable levels (Nogueira-Filho et al. 2011), may not produce enough individuals to supply the demand at an affordable price (Wilkie 2016).

Given the magnitude of the trade of wild meat we found, we suggest the regulation of this unconstrained activity is a fundamental and urgent matter to resolve. Plans that support the sustainable management of wild meat in the surrounding forests should bring regulated wild meat trade into the formal economy and promote the improvement of rural livelihoods. Wildlife trade regulations could include policies designed to allow the trade of more resilient species and to protect or restrict the trade of those more sensitive to hunting. Some of these more resilient species are already among the most consumed taxa in the region, so acceptance of this policy is most likely. This strategy would generate income for those involved in the market chain and adequately control (unclear how restrictions provide monitoring) harvests of wildlife species while guaranteeing conservation of threatened species.

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Figure 1. Average percentage of citations (bars) and overall wild meat biomass estimated as consumed (line) per taxon in 5 cities in central Amazonia. Scientific names are in Supporting Information.

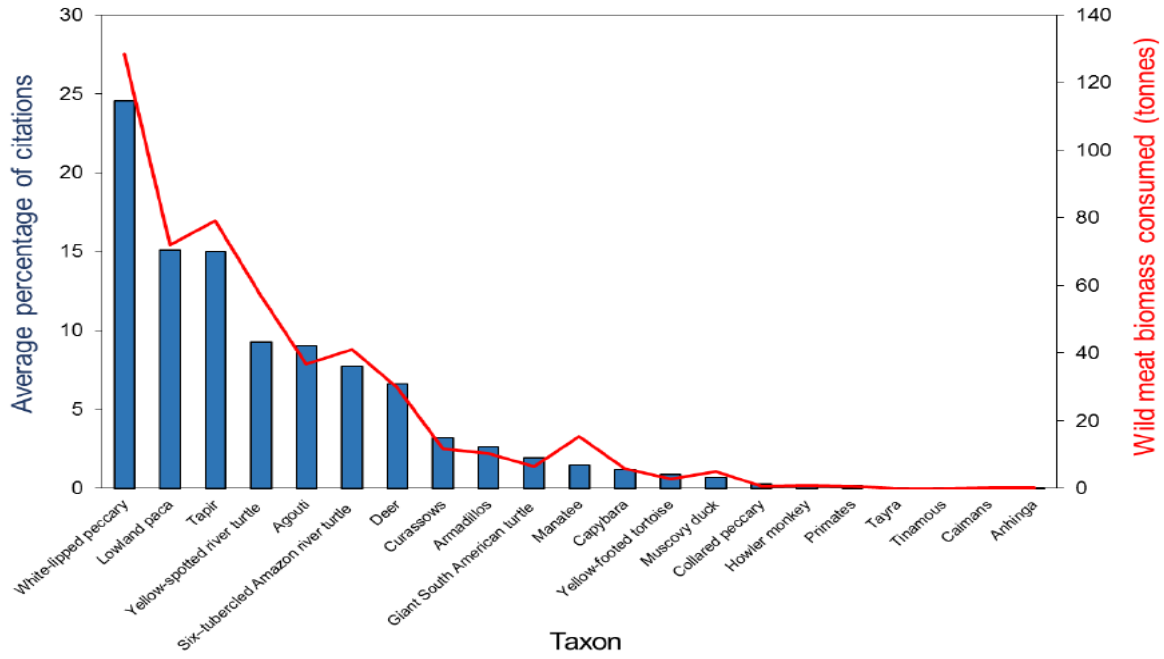

Figure 2. Relationships between (a) percentage of rural population and (b) per capita gross domestic product of the municipalities with the declared frequency of consumption of wild meat; between (c) gross body mass with the percentage of citations of each taxon; and between (d) gross body mass and (e) percentage of rural population of the municipalities with the price of each taxon in 5 cities of central Amazonia. Only taxa cited in at least 3 cities were considered for the model (c) (gray shading, 95% CI; y-axis values are partial residuals for each variable retained in the models). Model details, such as families of distribution, link functions, and *p* values, are in Supporting Information.

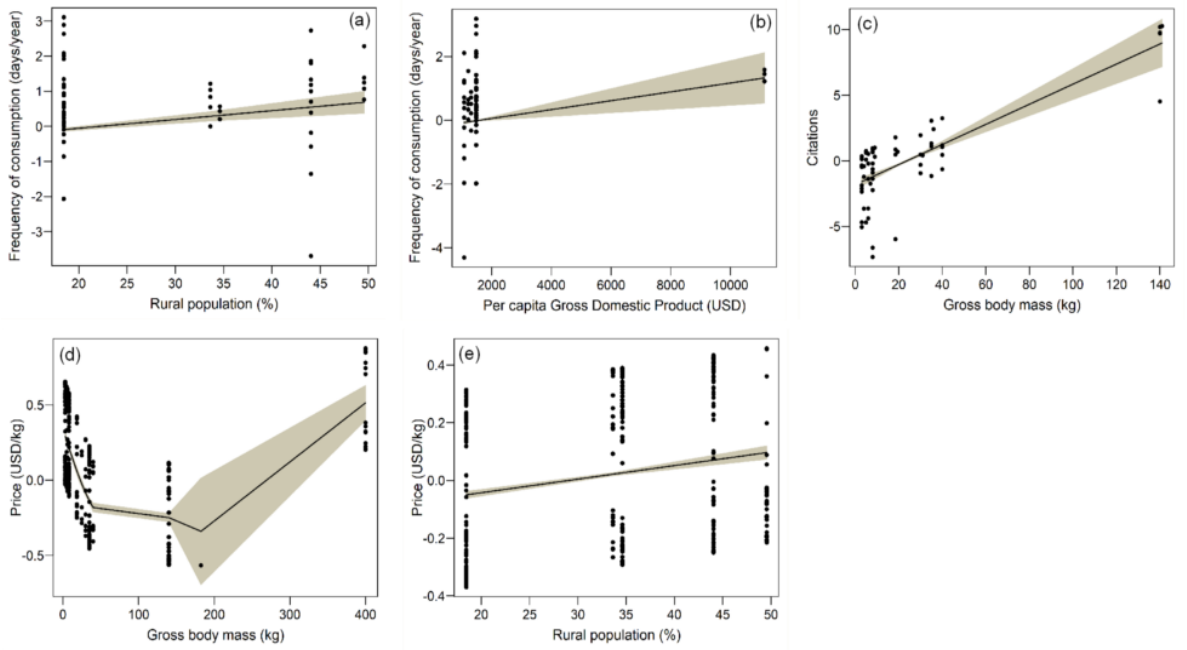

Figure 3. Two maps portraying the predicted per-capita wild meat consumption (top) and annual amount of wild meat consumption (bottom) in the cities of 62 municipalities in central Amazonia. The municipalities surveyed for modeling were Alvarães (24), Coari (29), Fonte Boa (19), Maraã (21), and Tefé (26). Names and details of the other municipalities are available in Supporting Information.

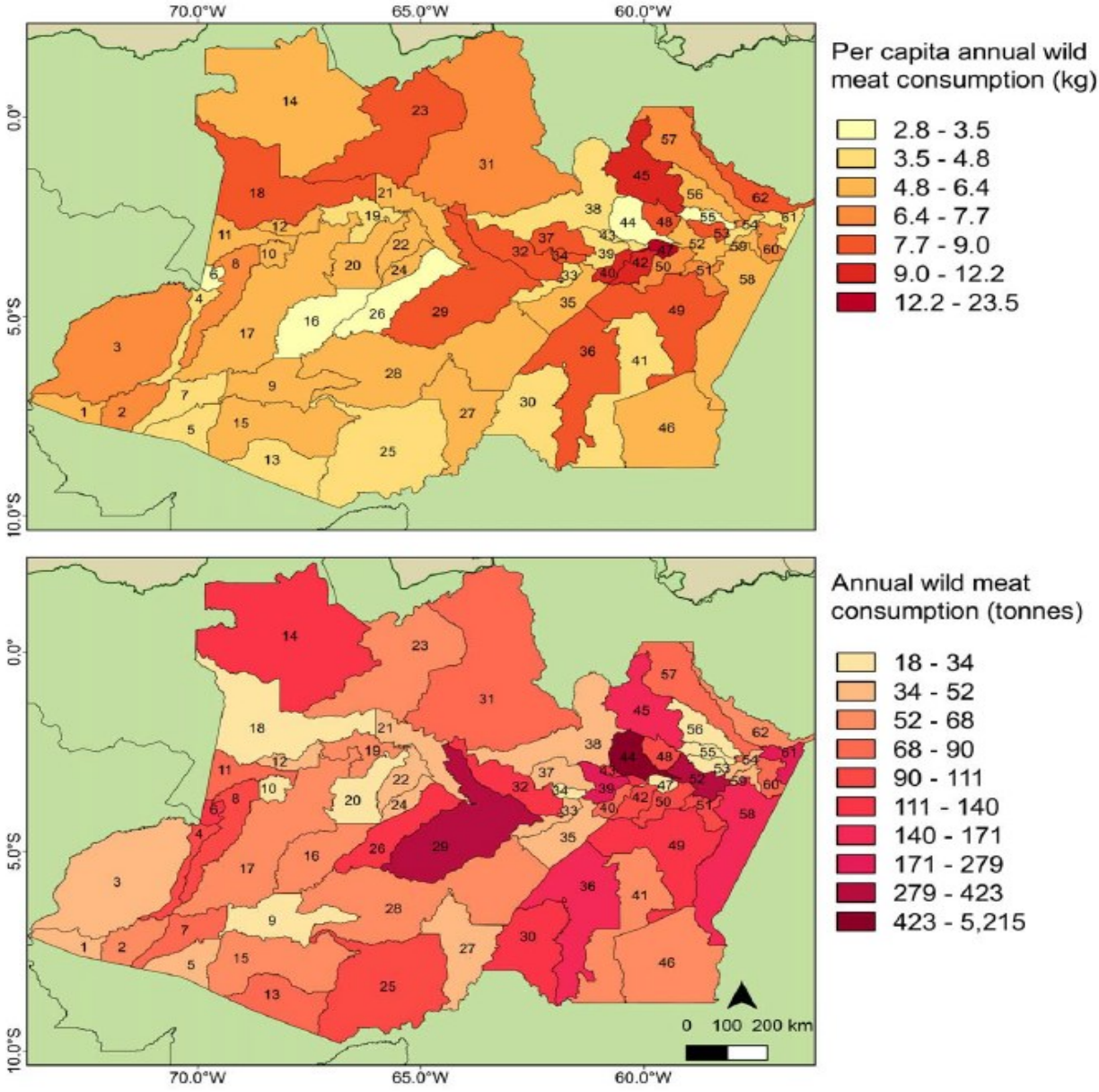

Table 1. Details on cities in Amazonas where surveys on wild meat consumption were conducted.

| City | Coordinates | Area ($km^2$) | Total inhabitants, urban inhabitants (%)* | Population density (ind/km²)* | Temporal range of interviews | Number of urban households | Households interviewed (%) | No. of neighborhoods (no. interviewed) |
|---|---|---|---|---|---|---|---|---|
| Alvarães | 03º 13' 15" S, 64º 48' 15" W | 5,923.46 | 14,080, 7,878 (55.95) | 2.38 | Jul - Aug 2007 | 1,362 | 153 (11.2) | 5 (5) |
| Coari | 04º 05' 06" S, 63º 08' 29" W | 57,970.77 | 75,909, 49,638 (65.4) | 1.31 | Oct 2011 – May 2012 | 10.380 | 60 (0.6) | 15 (8) |
| Fonte Boa | 02º 30' 50" S, 66º 05' 30" W | 12,155.43 | 22,659 (15,039; 66.37) | 1.86 | Nov 2011 | 2,791 | 20 (0.7) | 10 (6) |
| Maraã | 01º 51' 22" S, | 16,830.83 | 17,364 (8,759; | 1.03 | Oct 2011 | 1,393 | 22 (1.6) | 8 (8) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 65º 34' 52" W | | 50.44) | | | | | |
| Tefé | 03º 21' 15" S, 64º 42' 41" W | 23,692.22 | 61,399 (50,072; 81.55) | 2.59 | Apr – Nov 2004 Aug 2005 – Mar 2006 | 10,014 | 791 (7.9) | 20 (17) |
| Total | - | 116,572.71 | 191,411 | - | - | 25,940 | 1,046 | 58 (44) |

*Based on the last survey carried out in 2010 by the Brazilian government (IBGE 2018).

Table 2. Details on the estimated consumption of wild meat in 5 cities in central Amazonia.

| City | No. that consumed wild meat (%) | | No. of potential consumers (%)[a] | Average frequency of consumption, days person$^{-1}$ year$^{-1}$ (CI) | Overall wild meat consumption, kg year$^{-1}$ (CI range)[b] | Per capita urban wild meat consumption, kg person$^{-1}$ year$^{-1}$ (CI range) |
|---|---|---|---|---|---|---|
| | yes | no | | | | |
| Alvarães | 139 (90.8) | 14 (8.2) | 7,258.81 (92.1) | 32.83 (11.07) | 41,887 (24,876 - 58,897) | 5.32 (3.16 - 7.48) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Coari | 51 (85.0) | 9 (15.0) | 43,715.73 (88.1) | 29.33 (5.70) | 225,546 (133,951 - 317,141) | 4.54 (2.70 - 6.39) |
| Fonte Boa | 20 (100.0) | 0 (0) | 13,167.44 (87.6) | 24.77 (12.58) | 57,383 (34,079 - 80,686) | 3.82 (2.27 - 5.37) |
| Maraã | 22 (100.0) | 0 (0) | 8,223.41 (93.9) | 42.67 (26.04) | 61,713 (36,651 - 86,775) | 7.05 (4.18 - 9.91) |
| Tefé | 608 (76.9) | 183 (23.1) | 38,545.36 (77.0) | 16.81 (2.51) | 113,969 (67,686 - 160,252) | 2.28 (1.35 - 3.20) |
| Total | 840 (80.3) | 206 (19.7) | 110,910.75 | 29.28 (11.58) | 500,498 (297,243 - 703,752) | 4.60 (2.73 - 6.47) |

[a] Calculated with logistic regressions to obtain the likely percentage of people consuming wild meat within the entire population of each city (see Supporting Information).

[b] Calculated by summing average wild meat amount.

Table 3. Declared means by which urban consumers obtained wild meat in 5 cities in central Amazonia.

| City | No. buying (%) | No. hunting (%) | No. buying or hunting (%) | No. receiving gifts (%) | Total |
|---|---|---|---|---|---|
| Alvarães | 100 (75.8) | 18 (13.6) | 14 (10.6) | 0 (0.0) | 132 |
| Coari | 42 (82.4) | 4 (7.8) | 3 (5.9) | 2 (3.9) | 51 |
| Fonte Boa | 16 (80.0) | 4 (20.0) | 0 (0.0) | 0 (0.0) | 20 |
| Maraã | 19 (86.4) | 2 (9.1) | 1 (4.5) | 0 (0.0) | 22 |
| Tefé | 463 (75.9) | 146 (23.9) | 0 (0.0) | 1 (0.2) | 610 |
| Total (average %) | 640 (80.1) | 174 (14.9) | 18 (4.2) | 3 (0.8) | 834 |