



# The Role of Religion, Wealth, and Livelihoods in the Hunting Practices of Urban and Rural Inhabitants in Western Amazonia

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## Abstract

Hunting by rural and urban populations is essential for securing access to protein and other nutrients throughout the tropics. The hunting patterns of urban hunters in Amazonia, and the similarities with those of rural hunters, are unclear, as are the social factors that influence hunting practices. We analyze the effects of socioeconomic and cultural factors on hunting frequency and composition of species hunted by urban and rural Amazonian hunters. We interviewed 49 urban hunters and 57 rural hunters within 10 municipalities in western Amazonia in Brazil. A total of 44 species were cited as hunted. Our analyses show that the probability of engaging in sport hunting (for recreation) is greater among urban hunters. Rural inhabitants, hunters with lower monetary incomes, and hunters who were non-practicing Christians and atheists hunted more frequently. The composition of species hunted was similar, regardless of the hunters' livelihood (rural or urban) or religion. We found that hunting frequency is influenced by hunters' socioeconomic and cultural backgrounds, but these factors do not affect the composition of the harvest. This similarity between urban and rural hunters might be related to species distribution and availability and could potentially impact the most hunted species if hunting grounds overlap. Understanding hunting patterns, especially those of urban hunters, allows for more effective hunting management strategies, improvements in law enforcement against illegal hunting, as well as development of more effective and sustainable conservation actions.

**Keywords** Bushmeat · Sport Hunting · Tropical Forests · Livelihoods · Amazon · Brazil

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## Introduction

Humans have hunted animals for food and other benefits from earliest recorded history (Fa et al., 2022). Consumption of wild meat is still an essential component of the diets of millions of rural, forest-dependent families throughout the tropics (van Vliet et al., 2011; El Bizri et al., 2020a). In Amazonia, hunting for wild meat is an essential practice to buttress food security and livelihoods of many Indigenous Peoples and rural communities (Nunes et al., 2019a, b). The rise in population numbers in cities and towns in Amazonia, often resulting from migration from rural areas, has led to a greater demand for wild meat (e.g., Chaves et al., 2021; Rebello et al., 2022).

In recent decades, urban areas in Amazonia have seen growing populations of a variety of rural peoples of different ethnic groups and socioeconomic backgrounds, in search of better access to health, education, and technology (Parry et al., 2010; Eloy et al., 2015; Sobreiro, 2015). The persistent connection between urban dwellers and rural culture (especially for those originating from the countryside) means that a considerable number of urban residents still hunt, though many not out of necessity (Chaves et al., 2019). Recent estimates of consumption of wild meat in urban centers in central Amazonia indicate that a minimum of 10,000 tonnes of meat is consumed per year, of which approximately 15% is hunted by urban hunters themselves (El Bizri et al., 2020b). Better access to firearms and ease of urban-rural transport also encourage urban residents to keep hunting (El Bizri et al., 2015; Ingram et al., 2021).

Hunting practices among Amazonian rural hunters are influenced by many factors, including socioeconomic, cultural, and environmental considerations. Studies have examined the impact of various factors on hunting practices, such as hunter's age (Barbosa et al., 2020; Knoop et al., 2020; Nunes et al., 2020), preferred hunting techniques (Tavares et al., 2020; Oliveira et al., 2022a), religious beliefs (Knoop et al., 2020), educational background (Barbosa et al., 2020), and the surrounding vegetation cover (Torres et al., 2021), primarily focused on rural communities living in remote regions, particularly within protected areas (Fernandes-Ferreira & Alves, 2017). However, to date, hunting by medium and large rural agricultural communities or by urban inhabitants is poorly represented in the literature.

Most studies of urban hunters have focused on low-income populations, which have a high dependence on hunting. van Vliet et al. (2015) confirmed the existence of hunting by urban hunters, mainly rural migrants, in the cities of Benjamin Constant and Atalaia do Norte in the state of Amazonas, Brazil. In these cases, hunting was practiced to supply local markets and to supplement income. However, recent studies show a high prevalence of sport hunting

of wild animals by urban dwellers that have higher incomes, access to modern weapons, do not depend on wild meat as a source of food, and who mostly hunt illegally for sport (El Bizri et al., 2015; Santos et al., 2022). Religion, like income, plays a significant role in the practice of hunting. The adoption of different religions and their taboos associated with the consumption of certain species can determine the animals which can be killed and consumed, or avoided (Luzar et al., 2012; Knoop et al., 2020; Lemos et al., 2021).

We investigated the effects of socioeconomic (age, income, and number of people in the household) and cultural (religion) factors on motivations and hunting patterns by rural and urban hunters (livelihoods) in the western Brazilian Amazon. Our central hypothesis was that livelihood, income, age, number of household residents, and religious affiliation influence hunting frequency, the composition of hunted species, and the likelihood of hunting for sport by rural and urban Amazonian hunters.

## Methods

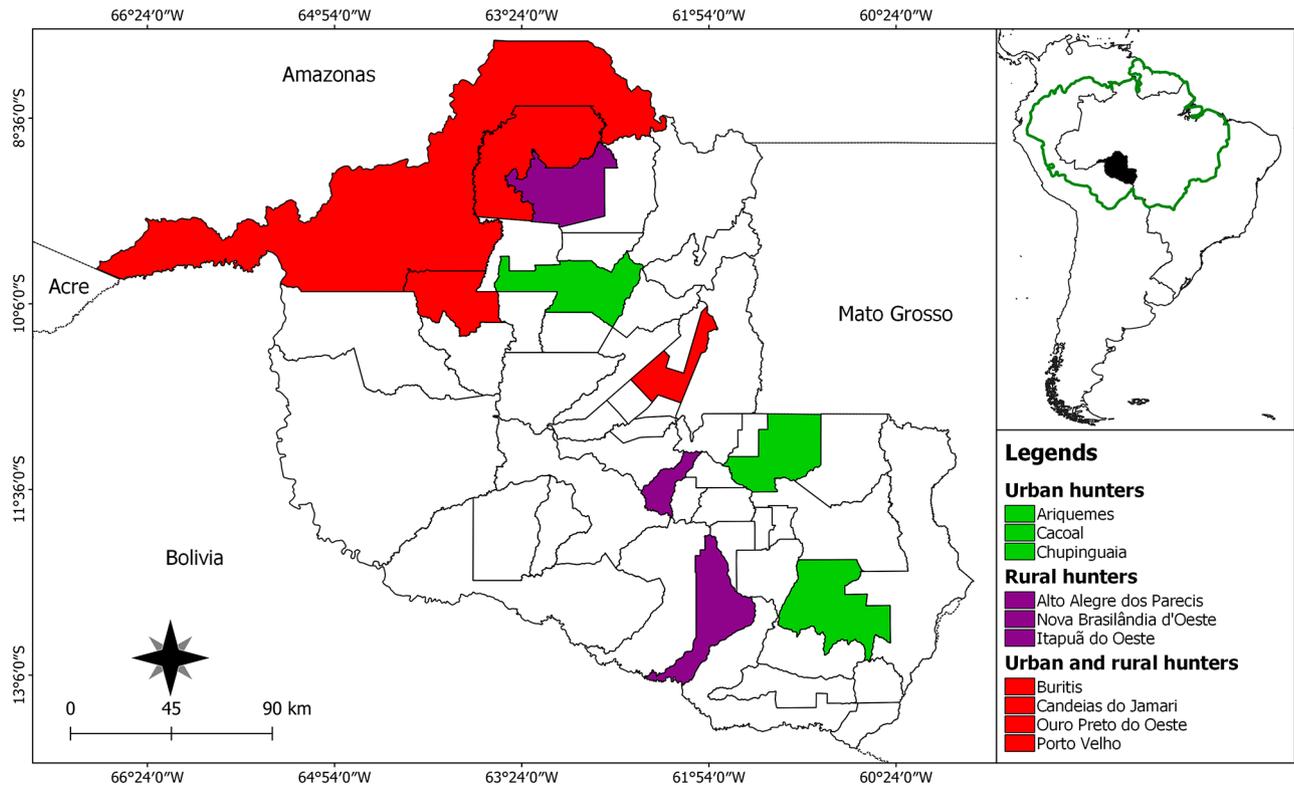
### Study Area

We conducted our study in the state of Rondônia, in southwestern Amazonia, Brazil. Rondônia occupies an area of 237,765.233 km<sup>2</sup> and has 52 municipalities (administrative divisions comprising rural areas and a capital city) and is the fifth least populated state (estimated population 1,777,225 inhabitants) in the country. The urban population (1,149,180 inhabitants) is almost three times larger than the rural population (413,229 inhabitants) (IBGE, 2017) (Fig. 1).

Colonization and migration in Rondônia state began in the seventeenth century, driven by different economic and development cycles: mining, slavery, rubber production, railway development, hydroelectric dams, and, more recently, immigration of international refugees. These migration waves involved a wide variety of internal migrants and immigrants from various nationalities (Cotinguiba & Cotinguiba, 2015), and have created a multicultural population (Amaral, 2018), where 57.7% are non-native inhabitants (IBGE, 2015).

### Data Collection

We interviewed a total of 106 hunters (49 urban and 57 rural) in 10 municipalities from October 2018 to February 2020 (Table 1). Following Oliveira et al. (2022b), we classified the hunters according to their livelihood as: (1) urban: hunters who lived in a city or town within the municipality but traveled to the countryside to hunt; and (2) rural: hunters who lived in rural areas of the municipalities but



**Fig. 1** Map of the state of Rondônia in the southwestern Amazon, indicating the 10 municipalities where we conducted interviews with rural and urban hunters. The green polygon indicates the boundaries of the Amazon basin

**Table 1** Number of hunters interviewed, total area extension, and number of inhabitants of the municipalities in the state of Rondônia surveyed in this study

Municipalities	Rural	Urban	Area (km <sup>2</sup> )	Inhabitants
Alto Alegre dos Parecis	1	-	3,958.30	13,940
Ariquemes	-	1	4,426.57	90,353
Buritis	1	2	3,265.81	32,383
Cacoal	-	1	3,792.89	78,574
Candeias do Jamari	4	1	6,843.87	19,779
Chupinguaia	-	1	5,126.72	8,301
Itapuã do Oeste	5	-	4,082.58	10,641
Nova Brasilândia d'Oeste	2	-	3,265.81	21,592
Ouro Preto do Oeste	1	1	1,969.85	37,928
Porto Velho	43	42	34,090.95	428,527
Total	57	49	70,823.36	729,472

were not members of any traditional community (i.e., riverine or Indigenous People) and did not inhabit protected areas. All rural hunters were small to large rural agricultural producers.

The median size of the sampled municipalities was 4,082.58 km<sup>2</sup>, and the median number of inhabitants in a municipality was 26,988. Informants were selected using the snowball sampling method (Goodman, 1961). This

selection process consisted of identifying the first hunters within the study area, who subsequently suggested other interviewees who also recognized themselves as hunters and were willing to participate in the study. Participants had to be over 18 years of age and should have resided in the state of Rondônia for at least six months (Fig. 1). We used this 6-month threshold due to the various migration waves the state has experienced over the last 10 years. This allowed us to restrict the study to individuals who were already established and had some form of interaction with the local environment.

We employed semi-structured interviews to gather socio-economic and cultural information as well as data on participants' hunting profiles. The questions included municipality of residence, livelihood (urban/rural), age (in years), religious affiliation (open-ended question), and average monthly income (in Brazilian Real). The average monthly income was converted into US dollars using the exchange rate for 27 January 2021 (USD\$1.00 = BRL R\$5.39), based on the general price index for Brazil estimated by the Getúlio Vargas Foundation. Religious affiliation identified in this study was classified as: Catholic, Evangelical (any evangelical denomination), atheist (no religion or belief in

God), and non-practicing Christian (believing in a Christian God but not attending services or meetings).

We asked participants to describe their main motivation for hunting (sport, subsistence, or trade), frequency of hunting (in days per month), species hunted (freelist), and preferred species to hunt and their justification for this preference (i.e., palatability, abundance, and body size). We added another 12 unstructured interviews applied to Evangelical and Catholic participants to understand and discuss the influence of religious precepts on hunting activities. These consisted of an open-ended question on why their religion influenced hunting, with an emphasis on the frequency of hunting trips.

In instances where the local species names provided by the informants were not sufficient to unequivocally catalog the species, we used the genus or family. For species classification, we followed the methods proposed by Abreu et al. (2022) for mammals, Pacheco et al. (2021) for birds, and Costa et al. (2021) for reptiles. We classified the conservation status of the identified taxa at the species level according to the International Union for Conservation of Nature and Natural Resources Red List version 2022-2 (IUCN) (IUCN, 2023) at the international level, and according to the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) List of species threatened with extinction (MMA, 2022) at the national level.

All hunters were informed of the objectives of the project, and we assured them that their names would not be disclosed, as determined by CNS resolution 466/12 on research involving human subjects. This study was approved by the research ethics committee (CEP) of the Aparício Carvalho University Center (protocol: 2.661.332).

## Data Analysis

We use descriptive statistics (mean, standard deviation, and percentage) to report the socioeconomic profiles and hunting patterns of the participants. To verify if the frequency of hunting of the interviewees is influenced by the socioeconomic factors included in the study, we performed a generalized additive mixed model (GAMM) with the Gamma family of distribution. We tested whether hunting frequency (response variable) varied according to the interviewees' livelihood, age, religious affiliation, monthly income, and the number of people living in the household (fixed predictor variables). We tested both linear and non-linear effects for the frequency of hunting according to the monthly income. For that purpose, we tested the fit of non-linear effects using penalized P-splines (pb) and cubic splines (cs) smoothers. To check whether the effect of income on hunting frequency differs between rural and urban hunters,

we also tested a model with interaction between monthly income and livelihoods.

To assess the probability of hunting for sport (response variable: 0 for no and 1 for yes) (response variable) according to the interviewees' livelihoods and monthly income (fixed predictor variables), we used a GLMM with a Binomial family of distribution. We also performed a GLMM with the ZAGA family (Zero-adjusted Gamma) to verify if the percentage of citations of species mentioned as preferred to be hunted by interviewees (response variable) is related to the percentage of citations of hunted species and interviewees' livelihoods (predictor variables).

To account for different sample sizes from different municipalities in the state of Rondônia and the possible effect of factors at the municipality level not considered here, we included municipalities as a random factor in all models. To build the models, we first checked for collinearity among variables; no collinearity was found. We compared combinations of predictor models, from the simplest (null model, no effect of any predictor variable) to the most complex model (effect of all predictor variables). Final models were selected based on the Akaike information criterion (AIC), considering all models with good support as those with delta AIC values smaller than two in relation to the model with the smallest AIC (see Burnham & Anderson, 2004). We considered that non-linear models and or the model with interaction should be selected over a linear model or the one with no interaction only if the increase in fit is substantial enough to overcome the penalty (see below). In cases where more than one model was best fitted, we selected the model with the smallest number of parameters (simplest model with fewest degrees of freedom). To assess the effect of variables, we considered  $p < 0.05$  as significant.

Finally, we assessed the difference in hunted species and hunting preference between urban and rural hunters and by religious affiliation using principal coordinate analysis (PCoA), with the Gower similarity coefficient as a measure of proximity. Additionally, we performed a permutational multivariate analysis of variance (PERMANOVA) with 9999 permutations to validate the PCoA results. In these analyses, we considered that the number of citations of a taxon would reflect the proportion with which it is hunted, as demonstrated by Oliveira et al. (2022b). We used R software (ver. 3.3.3) (R Core Team, 2017) and the *gamlss* (Rigby & Stasinopoulos, 2005) and *vegan* (Oksanen et al., 2018) R packages for the analyses, and the *GGally* (Schloerke et al., 2021) R package for the collinearity test.

## Results

### Socioeconomic Characteristics of Hunters and their Relationship with Hunting Motivations and Frequency

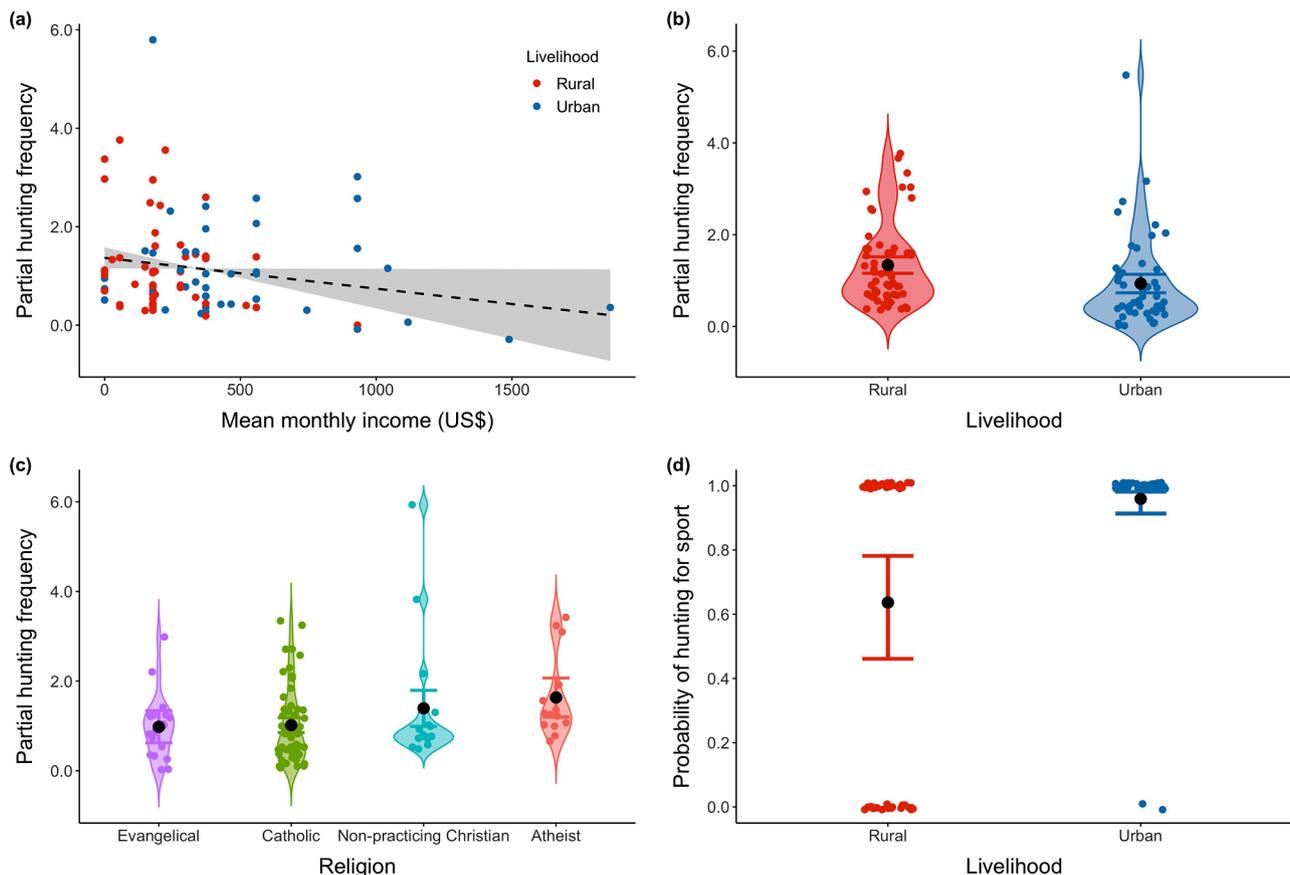
The mean age of urban hunters was  $34 \pm 12$  years and of rural hunters was  $37 \pm 15$  years. The number of household residents was also similar,  $3.23 \pm 1.53$  and  $3.58 \pm 1.98$  for urban and rural hunters, respectively. Hunting frequency was significantly influenced by the average monthly income; the lower the income, the higher the hunting frequency (Fig. 2A). Rural hunters hunted at a higher frequency than urban hunters (Fig. 2B). Religious practices also influenced hunting frequency: non-practicing Christian and atheist informants hunted more frequently than Catholics and Evangelicals (Fig. 2C; Table 2). Models with interaction or non-linear relationships did not improve the overall fit. Hunter age, number of residents in the household, and length of hunting practice did not influence hunting

frequency. No hunter reported using animals for religious or ritualistic purposes.

The probability of hunting for sport was related to the livelihood of the hunter but not to the average income (Fig. 2D). The main motivation for hunting among the urban population was for sport (88.68%). In contrast, among rural hunters, sport and subsistence hunting had an approximate number of citations corresponding to 50.79% and 44.44%, respectively.

### Composition of Hunted Taxa

A total of 44 species were recorded as hunted in 609 citations. Urban hunters cited 33 species as hunted, with seven species cited exclusively by this group. Rural hunters cited 36 species, 10 of which were exclusive (Table 3; Fig. 3). Regarding hunting preference, 17 species were cited (34.69% of the total species hunted cited), with 13 cited by urban hunters and 14 cited by rural hunters. The justification for preference in all citations recorded for both groups



**Fig. 2** (A) Relationship between hunting frequency and the hunters' average monthly income. (B) Mean monthly frequency of hunting as a function of the interviewees' livelihood (urban vs. rural). (C) Mean monthly hunting frequency as a function of religion declared by hunters. (D) Probability of engaging in sport hunting as a function of place of residence. Y-axis are ln transformed in graphs A, B and C,

and points represent normalized partial residuals. Shaded grey area in graph A and whiskers in graphs B, C and D represent the confidence intervals. Black dot in graphs B, C, and D represent the mean. Violins (B, C) represent distribution and density of the data at different values across different categories

**Table 2** Details of the generalized linear models for the probability of hunting for sport according to livelihood, and for the effects of livelihood, religion, and income on the hunting frequency of rural and urban hunters in Rondônia state, southwestern Amazonia, Brazil. Reference Classes - Livelihood: Rural; Religion: Atheist. \* $p < 0.05$

Response variable	Predictor variable	Estimate	Std. Error	t-value	p-value
Probability of hunting for sport	Intercept	0.56	0.28	2.00	0.049*
	Livelihood (Urban:Rural)	2.60	0.77	3.35	0.001*
Frequency of hunting	Intercept	2.04	0.26	7.93	< 0.001*
	Livelihood (Urban:Rural)	-0.40	0.20	-2.01	0.047*
	Income	-0.0006	0.0002	-2.69	0.0085*
	Religion (Catholic:Atheist)	-0.62	0.27	-2.31	0.023*
	Religion (Evangelical:Atheist)	-0.65	0.31	-2.09	0.039*
Hunting preference	Religion (Non-practicing Christian:Atheist)	-0.24	0.33	-0.73	0.468
	Intercept	0.41	0.20	2.09	0.039*
	Hunting rate	0.20	0.02	7.19	1.49e-10 *

of hunters was palatability. Only two urban hunters and six rural hunters indicated no hunting preference. Mammals were the most cited group as hunted (79.09% for urban and 84.78% for rural), followed by birds and then reptiles. The same pattern was observed for preference, with mammals being the group with the highest number of citations (83.33% for urban and 86.51% for rural) (Table 3).

Hunting preference was significantly related to the species cited as hunted, where the species with the highest number of citations were the most preferred, regardless of hunters' livelihoods (Fig. 4; Table 3).

The PCoA showed strong similarities between rural and urban hunters with respect to the composition of hunted (PERMANOVA  $F=0.0349$ ;  $p=0.5$ ) and preferred species (PERMANOVA  $F=0.0412$ ;  $p=0.5$ ) (Fig. 5A, C). Religious affiliation was also not an influencing factor for the composition of hunted species (PERMANOVA  $F=0.0784$ ;  $p=0.3$ ) (Fig. 5B). The 12 Catholic and Evangelical hunters participating in the unstructured interview reported a preference for participating in religious activities, such as worship services and meetings, rather than conducting hunting activities. When asked if there was any religious moral or ethical code that prevented or limited hunting, all were emphatic in stating that they were allowed to hunt because animals were created by God to satisfy human needs.

## Discussion

Our study is one of only a few to assess hunting patterns of urban inhabitants in the Amazon, in addition to investigating the factors that influence hunting practices. Urban and rural hunters show great similarity in the composition of hunted species and preference for each species, with the most frequently hunted species generally being those preferred for their taste. The relationship between species off-take and preference is not necessarily intuitive, as in many

cases the species that hunters prefer are not available to be hunted, are rare, or are difficult to catch. A non-matching relationship in some cases can reflect a depletion of the population of preferred species, such as the case of freshwater chelonians in Central Amazonia (see El Bizri et al., 2020a). Oliveira et al. (2022b) demonstrated that hunters in Rondônia captured 60% of the total species cited as hunted during a freelisting interview, and five species were the most targeted (52.7% among urban hunters and 61.6% among rural hunters). Hence, it is possible to affirm that hunting effort is not random but directed at some specific preferred and highly available species.

Preference for palatability is an important feature for the consumption of several species (Rosa et al., 2019). In our study, palatability plays a strong role even for sport hunters. This is because most urban hunters in Brazil usually eat the meat they obtain in their hunts and are probably consuming the meat themselves and rather than selling it (see El Bizri et al., 2015). This preference was directly reflected in hunting records, where the paca (*Cuniculus paca*) was the main species cited as hunted by urban and rural hunters as well as the most cited preferred species. In agreement with our results, paca has the highest capture record in different regions of the Amazon and is one of the most preferred species in terms of palatability (Valsecchi & Amaral, 2009; El Bizri et al., 2015; Ramos et al., 2020; Torres et al., 2021; de Paula et al., 2022; Griffiths et al., 2022; Mayor et al., 2022). Hunters also present a wealth of knowledge about baits for successfully attracting and catching this species (Oliveira et al., 2023b). The prevalence of paca in hunter off-take has been also likely increasing with the adoption of new technologies that facilitate its capture at night, such as LED flashlights (Bowler et al., 2020) and the reduction in the populations of larger-sized mammals such as the white-lipped peccary (*Tayassu pecari*) due to overexploitation, trade, or natural seasonal fluctuations (Fragoso et al., 2022; Mayor et al., 2022). The high consumption of pacas has

**Table 3** Number of citations of species hunted and catch preference of urban and rural hunters in Rondônia state, southwestern Amazonia, Brazil. VU = vulnerable, EN = endangered

Taxon	Popular name	Citation			Preference			IUCN	ICMBio
		Urban	Rural	Total	Urban	Rural	Total		
<b>Mammalia</b>									
<b>Didelphimorphia</b>									
<i>Didelphis marsupialis</i>	Common opossum	-	2	2	-	-	-	-	-
<b>Cingulata</b>									
<i>Dasyus novemcinctus</i>	nine-banded armadillo	29	40	69	4	2	6	-	-
<i>Dasyus beniensis</i>	greater long-nosed armadillo	15	4	19	3	3	6	-	-
<i>Euphractus sexcinctus</i>	yellow armadillo	3	2	5	-	-	-	-	-
<i>Cabassous unicinctus</i>	southern naked-tailed armadillo	2	3	5	-	-	-	-	-
<i>Priodontes maximus</i>	giant armadillo	4	3	7	-	-	-	VU	VU
<b>Primates</b>									
<i>Alouatta puruensis</i>	Purus red howler monkey	1	2	3	-	-	-	VU	-
<i>Ateles chamek</i>	black-faced black spider monkey	1	3	4	-	-	-	EN	VU
<i>Leontocebus weddelli</i>	Weddell's saddle-back tamarin	1	-	1	-	-	-	-	-
<i>Saimiri ustus</i>	golden-backed squirrel monkey	1	-	1	-	-	-	-	-
<i>Sapajus apella</i>	black-capped capuchin	1	1	2	-	-	-	-	-
<b>Rodentia</b>									
<i>Hydrochoerus hydrochaeris</i>	capybara	10	18	28	2	3	5	-	-
<i>Cuniculus paca</i>	paca	47	47	94	38	37	75	-	-
<i>Dasyprocta</i> spp.	agouti	11	22	33	2	1	3	-	-
<i>Coendou longicaudatus longicaudatus</i>	long-tailed porcupine	-	2	2	-	-	-	-	-
<i>Hadrosiurus spadiceus</i>	southern amazon red squirrel	-	1	1	-	-	-	-	-
<b>Carnivora</b>									
<i>Nasua nasua</i>	south american coati	-	3	3	-	-	-	-	-
<i>Puma concolor</i>	puma	2	5	7	-	-	-	-	-
<i>Panthera onca</i>	jaguar	1	6	7	-	-	-	-	VU
<b>Perissodactyla</b>									
<i>Tapirus terrestris</i>	tapir	14	20	34	-	4	4	VU	VU
<b>Cetartiodactyla</b>									
<i>Mazama americana</i>	red brocket	18	17	35	2	7	9	-	-
<i>Passalites nemorivaga</i>	amazonian brown brocket	8	12	20	-	-	-	-	-
<i>Ozotoceros bezoarticus</i>	pampas deer	1	-	1	-	-	-	-	VU
<i>Dicotyles tajacu</i>	collared peccary	33	29	62	5	7	12	-	-
<i>Tayassu pecari</i>	white-lipped peccary	24	31	55	4	13	17	VU	VU
<b>Aves</b>									
<b>Tinamiformes</b>									
<i>Tinamus solitarius</i>	solitary Tinamou	7	3	10	1	-	1	-	-
<i>Tinamus guttatus</i>	white-throated tinamou	-	1	1	-	-	-	-	-
<b>Anseriformes</b>									
<i>Dendrocygna</i> spp.	whistling-duck	2	-	2	-	-	-	-	-
<i>Cairina moschata</i>	muscovy Duck	4	3	7	2	-	2	-	-
<b>Galliformes</b>									
<i>Penelope jacquacu</i>	Spix's guan	11	13	24	-	-	-	-	-
<i>Ortalis guttata guttata</i>	speckled chachalaca	-	1	1	-	-	-	-	-
<i>Pauxi tuberosa</i>	razor-billed curassow	14	11	25	-	4	4	-	-
<b>Cathartiformes</b>									
<i>Sarcoramphus papa</i>	king Vulture	-	1	1	-	-	-	-	-
<b>Gruiformes</b>									
<i>Psophia viridis</i>	green-winged trumpeter	1	-	1	-	-	-	VU	VU
<b>Psittaciformes</b>									
<i>Ara</i> sp.	macaw	-	1	1	-	-	-	-	-
<b>Columbiformes</b>									
<i>Patagioenas</i> spp.	pigeon	3	-	3	-	-	-	-	-
<i>Leptotila</i> spp.	dove	1	-	1	-	-	-	-	-

**Table 3** (continued)

Taxon	Popular name	Citation			Preference			IUCN	ICMBio
		Urban	Rural	Total	Urban	Rural	Total		
Cuculiformes									
<i>Crotophaga major</i>	greater Ani	-	1	1	-	-	-	-	
Piciformes									
<i>Ramphastos</i> spp.	toucan	-	1	1	-	-	-	-	
Reptilia									
Squamata									
<i>Boa constrictor</i>	common boa	1	-	1	-	-	-	-	
<i>Eunectes murinus</i>	green anaconda	1	1	2	-	-	-	-	
Crocodylia									
<i>Melanosuchus niger</i>	black caiman	7	8	15	6	4	10	-	
<i>Caiman crocodilus</i>	common caiman	8	3	11	3	2	5	-	



**Fig. 3** Species captured by hunters living in urban and rural areas in Rondônia state, southwestern Amazonia, Brazil: (A) nine-banded armadillo *Dasybus novemcinctus*, (B) White-lipped peccary *Tayassu*

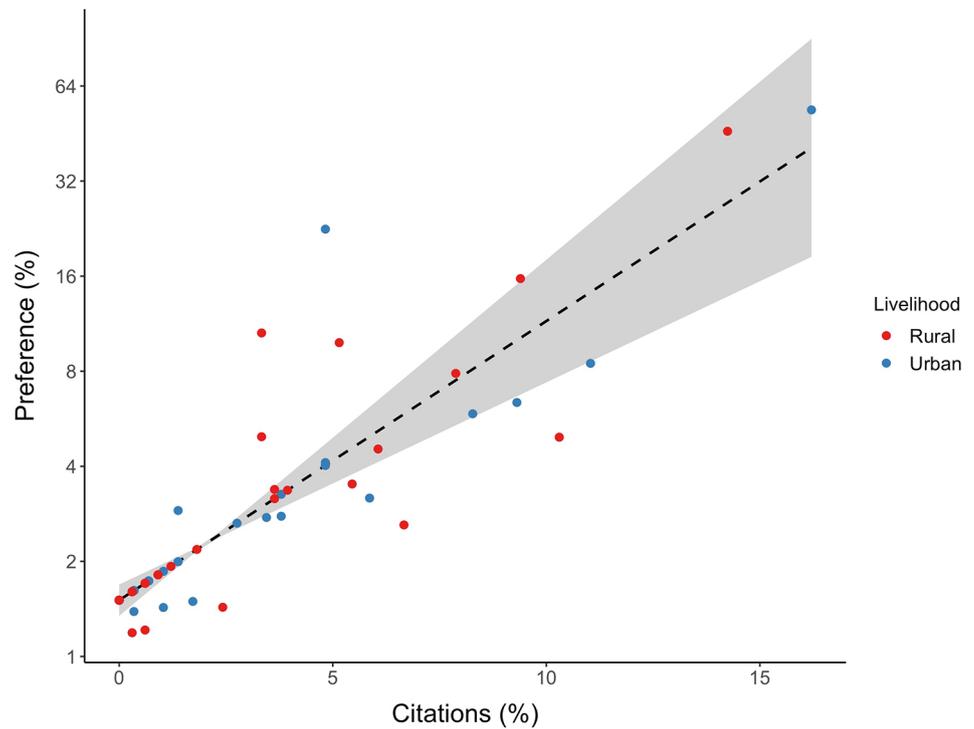
*pecari*, (C, E, and H) paca *Cuniculus paca*, (D) tapir *Tapirus terrestris*, (F) capybara *Hydrochoerus hydrochaeris*, and (F and G) common caiman *Caiman crocodilus*

important implications for the health of Amazonian people, since this species is involved in the cycle of pathogens causing life-threatening zoonotic diseases such as polycystic echinococcosis (San-José et al., 2023).

Urban and rural hunters in Rondônia share the same consumption pattern of taxonomic groups similar to that observed in other regions of the Amazon. The preference for mammals over birds and reptiles is observed in Indigenous

(Knoop et al., 2020; Shaffer et al., 2017), rural (Mesquita et al., 2018; Ramos et al., 2020), riverine (Belfort et al., 2020; Valsecchi & Amaral, 2009), and extractivist (Lemos et al., 2018; Nunes et al., 2020) populations. Although the spectrum of hunted species is wide, hunting is concentrated within a specific group of species, represented almost exclusively by mammals, presenting high selectivity similar to that reported by de Paula et al. (2022). Species hunted and

**Fig. 4** Relationship between the citation frequency of hunted species and the citation frequency of hunting preferences. Y-axis is plotted as original values at a log (ln) scale



cited exclusively by each hunter group had a maximum of three citations, representing less than 5% of the total number of citations.

Although other studies indicate the killing of felines aimed at control or retaliation (Lima et al., 2020), we observed that the capture of these animals was motivated by both retaliation and consumption. Consumption of the meat of large cats is a behavior that is rarely recorded in the Amazon (Srbek-Araujo, 2015; Oliveira et al., 2023a) and in other areas of the world (Braga-Pereira et al., 2021).

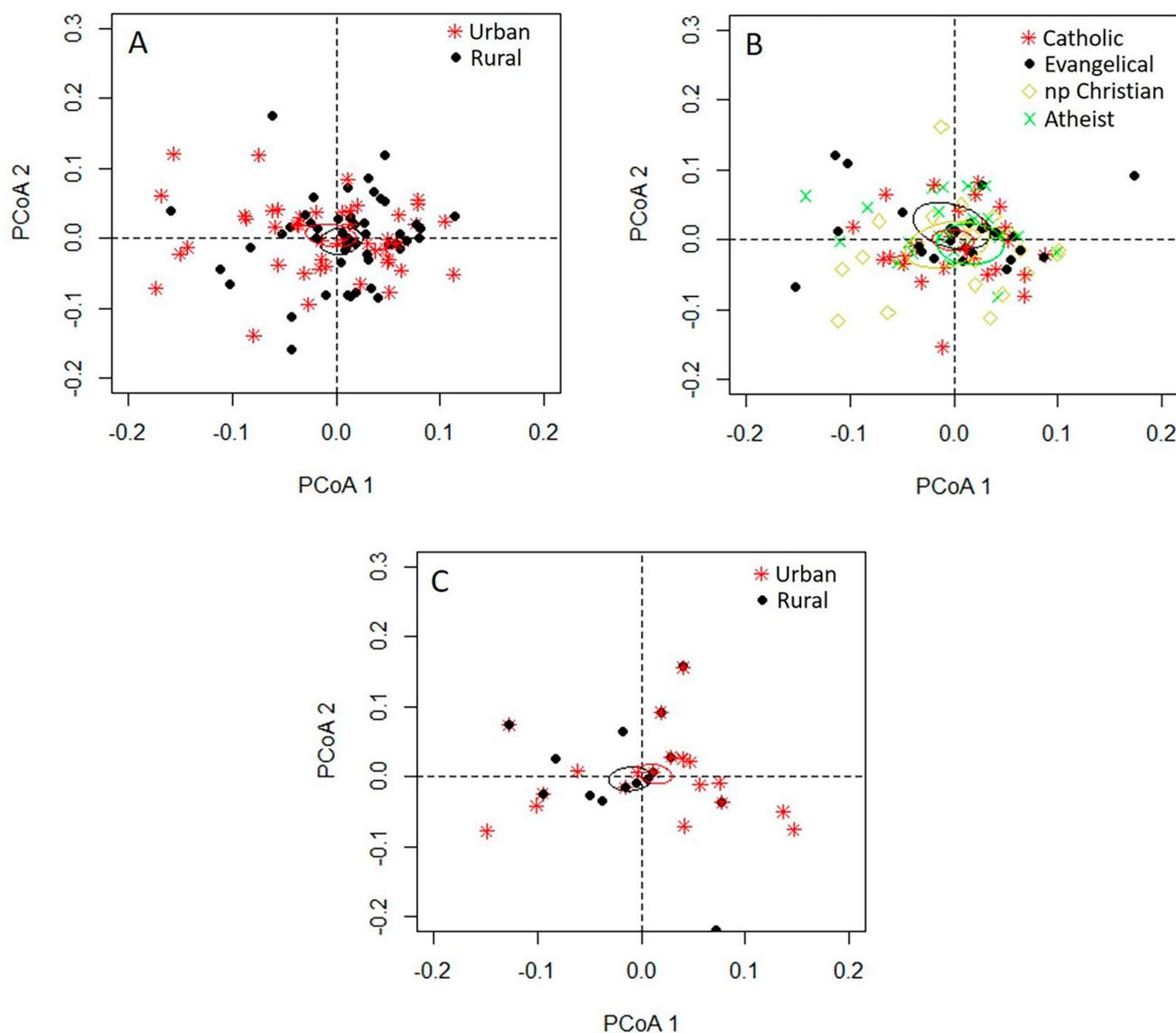
Regarding hunting motivation, the predominance of hunting linked to sport/recreational practices by urban hunters, and a high prevalence of this type of motivation among rural hunters, is an unprecedented record in the Brazilian Amazon. Sport hunting in Brazil is widespread (Alves et al., 2009; Castilho et al., 2019), including video sharing and acceptance by the online media consuming public (El Bizri et al., 2015). A study analyzing more than 8,000 comments on videos about sport hunting on social networks showed that only 1.03% of these presented positions that were not in favor of sport hunting in Brazil (El Bizri et al., 2015). The motivation of sport hunters is linked to their emotions and the thrill of chasing animals, although hunters usually consume the meat.

Recreational hunting in Brazil is only legally allowed for controlling populations of invasive species (Carvalho et al., 2019). This activity is still surrounded by considerable debate regarding its impact on target populations and whether it is possible to reconcile it with conservation goals.

In the United States, for example, a proportion of the funds obtained from the sale of hunting licenses and taxes on equipment used for hunting are used towards species conservation. In this situation, a lower engagement in hunting would result in a lower financial contribution to conservation actions (Bakner et al., 2022). Regardless of the debate, all measures (either to suppress or legalize hunting) must be supported by evidence, which highlights the need for further research on this subject in Brazil.

A factor that should be highlighted regarding the existence of urban hunters is related to desire to consume wild meat in urban areas. Studies conducted in the Amazon clearly indicate the existence of demand for wild meat in urban settings, often motivated by the flow of people from rural to urban areas. In the central Brazilian Amazon, rural migrants continue to consume wild meat after moving to urban areas (Chaves et al., 2021). In Iquitos, in the Peruvian Amazon, the increase in wild meat sales has kept pace with urban population growth from 1973 to 2018 (Mayor et al., 2022). Thus, urban demand may affect the stock of game species that can be accessed by the rural population living in remote areas, which is dependent on this resource (Morsello et al., 2015). Hunting grounds accessed by urban hunters should be investigated to verify the existence of an overlap with rural hunter territories.

Our results show that income influences hunting frequency; hunters with lower monthly incomes hunt more frequently, regardless of their place of residence. Although the motivations of rural hunters are similar, the relationship



**Fig. 5** Principal coordinate analysis (PCoA) illustrating the composition of hunted taxa according to livelihood (A), religious affiliation (B), and composition of preferred species according to livelihoods (C)

between income and frequency highlights the importance of wild meat in the diet of low-income populations (Mayor et al., 2007). Wild meat plays an important role in subsistence, and its replacement by other protein sources, especially domesticated ones, is not feasible given the high cost compared to the average income of this population (Nunes et al., 2019a). Our results regarding income corroborate those reported by Parry et al. (2014), demonstrating that lower-income families practice hunting for meat. On the other hand, Torres et al. (2021) in rural communities of Santarém, Belterra, and Mojuí dos Campos (Pará-Brazil) and Souza et al. (2022) with residents of the urban and rural areas of Crisópolis (Bahia-Brazil) found that wild animal hunting and consumption are independent of family income, and

that increasing family income will have little or no impact on wild meat consumption. In these localities, hunting plays an important role in the informal economy, used as a means of exchange, as well as an element to strengthen social relations and essential to the subsistence of the populations studied.

In addition to income, religious affiliation influenced hunting frequency but was not a determinant of the composition of hunted species. Knoop et al. (2020) in their study with Maraguá Indigenous Peoples in the lower Madeira River (Central Amazon) recorded that Adventist hunters have restrictions on the consumption of certain game species, limiting the consumption mainly to deer, tinamids, curassows, and jacamins, a pattern not observed among

non-Adventist hunters. Lemos et al. (2021) reinforces the results of Knoop et al. (2020), highlighting the dietary restriction of Adventists to a restricted group of species. Dietary restrictions based on religious beliefs are common (Luzar et al., 2012); however, the influence of religion on hunting frequency in Amazonia has not yet been documented.

Here, we observed that practicing religious people hunted at a lower frequency than non-practicing religious and non-religious people. This frequency may be influenced by the other activities of religious practitioners, especially on weekends when more time would be available for hunting. Although it was not possible to quantify the effect of religious activities, the utilitarian view presented by the interviewees, in which animals were created for human benefit, demonstrates that possible factors involving ethics and morals can be discarded in view of the beliefs of these people. This utilitarian relationship was presented by Lemos et al. (2021), who recorded the avoidance of primate meat by people in central Amazonia because of their belief that primates were not animals created by God for consumption as food. Future studies should verify how the frequency of religious activities influences hunting, in addition to the views on the use of fauna in different religions.

Hunting is illegal in Brazil (Law n° 9.605 of February 12, 1998), with some exceptions for Indigenous peoples and local people in need for food. However, hunting is a widespread activity in several parts of the country, including the state of Rondônia. This can be attributed to several factors, including cultural traditions, lack of enforcement of wildlife protection laws, and poverty. Therefore, it is crucial to address the issue of illegal hunting, as it has significant impacts on biodiversity conservation and the sustainable use of natural resources in Brazil. Policies such as creation of protected areas, hunting bans, and community-based natural resource management must be implemented to address this issue. Additionally, raising awareness about the importance of biodiversity conservation and the negative impacts of illegal hunting can also play a crucial role in changing attitudes and behaviours towards wildlife. Studies such as ours investigate the root causes of hunting and are important to furnish information for higher effectiveness of conservation interventions.

## Conclusion

Income and religion are important predictors of hunting frequency, regardless of whether the hunters are urban or rural dwellers. The similarity in the composition of and preference for hunted species between urban and rural hunters reflects species distribution and availability, as well

as cultural factors. Areas that, in principle, would only be accessed by local hunters in the rural environment may now be open to urban hunters, thus increasing extraction and, consequently, potentially affecting the stocks necessary for the subsistence of rural populations.

Although illegal, sport hunting is a widespread and culturally accepted activity in Brazil and the state of Rondônia, demonstrating the need to create appropriate policies to address the issue. In this scenario, an understanding of the hunting pressure provoked by urban hunters, in conjunction with other anthropogenic pressures currently occurring in the Amazon, such as habitat loss and fragmentation, is needed for an in-depth understanding of the impacts of this activity to help design sustainable long-term management and conservation strategies.

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**Data Availability** The data can be directly requested with the correspondence author.

## Declarations

**Ethical Approval** This study had the prior informed consent of the hunters, authorizations from the National Research Ethics Council (CONEP) (protocol: 2.661.332).

**Competing Interests** The authors declare no competing interests.

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