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Human consumption of meat from roadkilled animals in the southwestern Amazon

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ABSTRACT

The harvest of meat from wild animals is essential for the nutrition of many human populations in the Neotropics. Specific techniques are used to access wild meat in this region, but collecting meat from road killed animals, or purposely run over animals to kill and consume the meat have not been documented so far. In this study we interviewed four residents of the state of Rondônia who claimed to consume roadkilled animals. Respondents cited only medium and large mammals (10 species in total) as the group from which wild meat is harvested, with one respondent claiming to intentionally run over the animals. The interviewees analyse the smell/putrefaction condition, swelling and exposure of viscera as criteria for not collecting the meat. The meat from roadkilled animals may pose a risk to the health of humans who consume it due to the foodborne diseases it may spread after the decomposition process. In addition, the practice of running over animals for consumption of their meat can cause potential impacts to the fauna and humans since it can reduce animal numbers and also cause serious accidents. Further investigations are needed to clarify whether this is widespread phenomenon occurring in other places of the Amazon and the Neotropics.

Keywords: Hunting; Bushmeat; Vehicle collision; Wild meat; Mammals.

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SIGNIFICANCE STATEMENT

This article presents an unprecedented record of consumption by humans of meat from roadkilled animals in the Neotropics. Consumers described the criteria used to choose the roadkilled animals they would consume, and cited mammals as the exclusive taxonomic group from which they collect the meat for consumption.

INTRODUCTION

Dependence on protein from wild animals is recorded in different human populations across the tropics; the harvest of wild animals is therefore essential to complement to the nutrition of these populations (Alvard et al. 1997; Alves and van Vliet 2018; Oliveira and Calouro 2019; Sena et al. 2021; Fa et al. 2022; van Vliet et al. 2022a,b). In the Neotropical region different hunting techniques and tools can be adopted to harvest wild animal sand acquire protein for human consumption (Fernandes-Ferreira 2014; Alves et al. 2016). For instance, in the Neotropics hunters employ firearms, traps, bladed weapons, and dogs, in different variations and combinations (Alves et al. 2009; Bezerra et al. 2012; Santos et al. 2022.; Santos-Fita et al. 2012), and the decision on which to use depends on the type of environment, available technologies and target species (Alves et al. 2018; Tavares et al. 2020; Oliveira et al 2022a; Oliveira et al. 2022b). Another way of acquiring wild-sourced protein is through purchase at open fairs, local markets or gain (van Vliet et al. 2014, 2015; Chaves et al. 2017; Souto et al. 2019; El Bizri et al. 2020). However, although anecdotally reported in different parts of the globe, literature records of consumption of wild animals victims of roadkills are to our knowledge non-existent for the Neotropics.

The consumption of roadkilled specimens is a common practice in temperate countries. In the US, 29 states allow the collection of roadkilled animals for consumption, including species such as deer, bear and elk. Each state has its own regulations and which animals can be collected (Noor 2019). In the city of Marlinton, in West Virginia in the USA, a culinary event called "Roadkill Cook-off" takes place annually. This festival brings together chefs from all over the country who compete for the best dishes using roadkilled animals. Different North American websites defend the consumption of animals that have been run over due to road safety, food sovereignty, ethics and the conservation of species.

According to the Urubu System (an interactive platform recording roadkills in Brazil based on citizen science), an animal is run over every 17 seconds on Brazilian highways, totalling 1,300 animals per day and 475 million per year. The same platform highlights that in the period from January to February 2023 (consultation performed on February 21), 8,776,700 medium- and large-sized animals were run over in Brazil, representing 9% and 1% of the total number of animals recorded, respectively. In the year 2022 alone, 63 species of mammals were roadkilled, distributed into 1227 individuals (Sistema Urubu 2023).

In the state of Rondônia, in the southwestern Amazon, 44 species have been recorded as hunted by humans (Gomes 2017; Ramos et al. 2020; Belfort et al. 2020; Oliveira et al. 2022c). Among the mammal species hunted, there is a record of roadkills of *Cuniculus paca*, *Dasypus novemcinctus*, *Euphractus sexcinctus*, *Hydrochaerus hydrochaeris* and *Tayassu pecari* (Turci and Bernardi 2009; Caries et al. 2019; Pommer-Barbosa and Oliveira 2022). The roadkill rate of these species in Rondônia state ranges from 0,0002 to 0,09 individuals roadkilled per kilometer traveled; *Dasypus novemcinctus* stands out with a record of 125 animals in 1320 kilometers traveled. (Caires et al. 2019). These data demonstrate the availability of meat of these species on the roadsides, which can be potentially collected for consumption by humans. Given this scenario, this study presents an unprecedent record of consumption of medium and large mammals from occasional or intentional roadkills in the southwestern Amazon.

MATERIAL AND METHODS

Porto Velho municipality is the capital of the state of Rondônia and the third largest city in northern Brazil. It has a population of 548,952 inhabitants, with a population density of 12.57 inhabitants per km^2 and with a fleet of 313,097 vehicles, 40% of which composed by small cars. The municipality of Candeias is located 22 kilometers from Porto Velho and has a population of 26,693 inhabitants and a demographic density of 3.9 inhabitants per km^2 and with a fleet of 8,331 vehicles, 25% of which are small cars. BR 364 is the main highway to both municipalities (IBGE 2017) (Figure 1).

We used semi-structured interviews to investigate the consumption of roadkilled animals in Rondônia (Albuquerque et al. 2014). Interviewees were selected through referrals from other hunters and consumers of wild meat. From each interviewee we requested information on their sex, age, and place of residence of the informant, whether they hunt or not, the roadkilled species from which they collect meat (free list), and the criteria for deciding on whether or not to consume the meat from the animals. The interviewees indicated seven other people who collect and consume roadkill animals, but these people declined to be interviewed.

The interviews were carried out between December 2019 and February 2020. This work was approved by the Research Ethics Committee (CEP) of the Centro Universitário Aparício Carvalho under protocol number 2661332. We classified the conservation status of the identified taxa down to the species level at the international level according to the International Union for Conservation of Nature Red List (version 2021-1 IUCN) (IUCN 2021), and at the na-

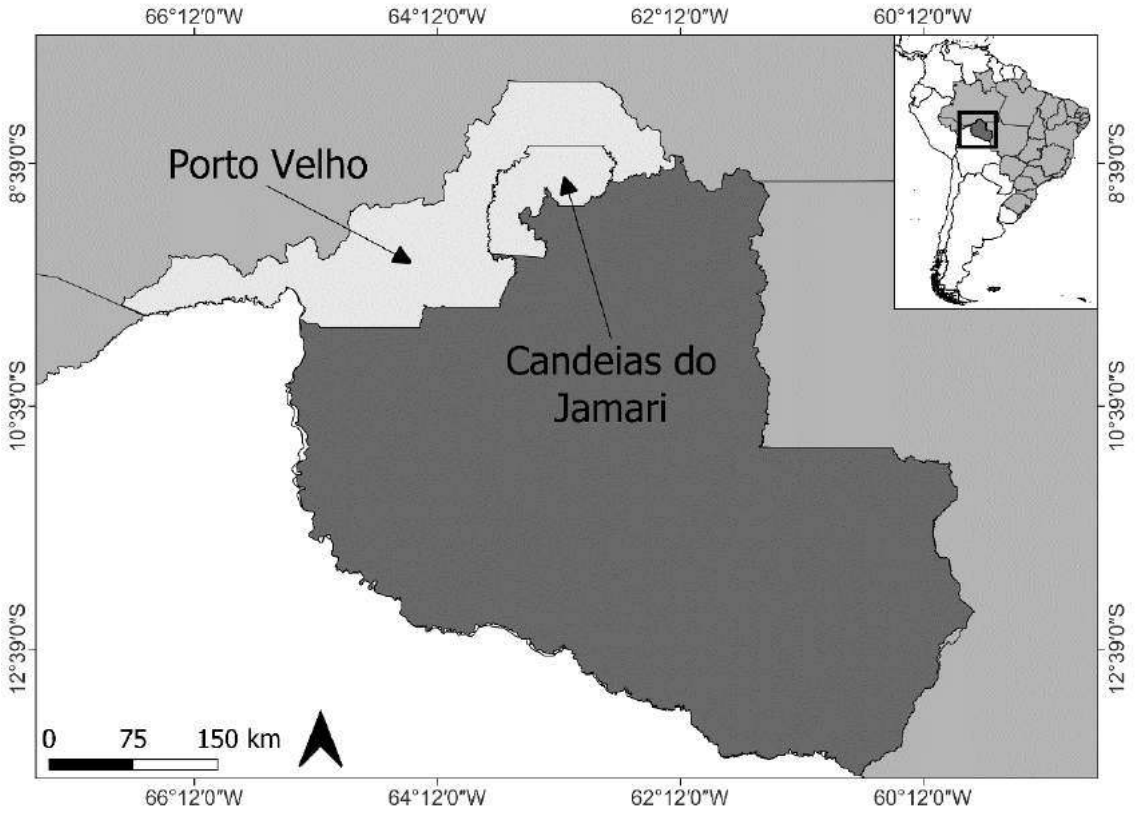

Figure 1. Location of the municipalities of residence of the interviewees that consume roadkilled wild animals in Rondônia, southwestern Amazon.

tional level according to the Instituto Chico Mendes de Conservação da Biodiversidade's (ICMBio) List of Endangered Species (MMA 2022).

According to the interviewee that intentionally roadkills animals, priority is given to running over medium-sized (e.g. collared peccary) over large-sized mammals due to potential damage to the car and the risk of overturning that large animals can pose. The roadkills are usually performed at night to avoid being detected by environmental officers or police. Regarding running over animals, the respondent stated that he avoids head-on collisions with animals. A frontal collision can damage the structure of the car radiator, damage the vehicle's paintwork, cause the animal to be crushed, in addition to increasing the risk of rollover. Thus, the collision should prioritize the most lateral regions of the car, close to the headlights. When asked about the collection criteria, this informant stated that he only collects animals that he intentionally runs over.

RESULTS

Four interviews were carried out in total. All informants were male, three were residents of rural areas (one from Porto Velho and two from Candeias do Jamari). The age of consumers ranged from 37 to 56 years. All respondents stated that they are not dependent on wild meat to meet their dietary needs. All respondents were born in the state of Rondônia and reported having consumed wild meat since childhood. One interviewee declared himself to be a hunter. This hunter lives in the urban area of Porto Velho but has lived in the countryside for 17 years. He claimed to use conventional techniques such as firearms to harvest animals, but also reported intentionally running over animals to obtain their meat. Two consumers reported that consumption of wild meat from roadkilled animals is a family custom that they learned from their parents, and that other family members, such as siblings, also consume roadkilled animals. One respondent stated that his habit is recent, which started less than five years ago after watching a TV program and following different videos on YouTube about the collection and consumption of roadkilled animals.

All respondents reported consuming exclusively roadkilled mammals (Table 1). One of the interviewees justified the exclusive consumption of mammals due to the perception that this group takes longer to enter a state of decomposition, and thus is safer for

consumption. All respondents stated that medium-sized animals (e.g. paca) can be collected whole and transported home. In the case of large species (e.g. tapir), transport becomes unfeasible, so parts of the animals are removed and taken home, especially meat from the region of the hind limbs.

The three consumers-only of the meat declared they did not travel roads with the aim of killing or finding roadkilled animals. The collection is carried out mostly on the roads close to their houses, especially after observing the presence of vultures flying in circles or during displacement to carry out their daily activities. None of the interviewees were able to precise the frequency of meat collection and roadkills. In the case of consumers, collection depends on the availability of animals on the track, which is independent of their effort. Consumer collectors highlighted three main aspects to be observed when collecting the animal: smell/putrefaction conditions, swelling and exposure of the viscera, which together are taken into consideration for decision making (Figure 2). Only one consumer pointed out that if vultures are observed pecking at the animal, the meat is not collected.

DISCUSSION

In this study we present the unprecedented record of the collection of roadkilled wild animals for consumption of their meat. The large mammals mentioned as collected are among the species with the greatest harvest rates by hunters in the state of Rondônia (Belfort et al. 2020; Ramos et al. 2020; Oliveira et al. 2022c), and in other locations in the Neotropics (Lopes and Ferrari 2000; Alves et al. 2016; Barboza et al. 2016). The relatively large size of these animals reduces the chance of being crushed or compressed due to being run over, with a greater possibility of using the meat.

In general, modern hunting techniques mainly involve the use of firearms for capturing animals (Souza and Alves 2014), which is efficient in capturing individuals of a range of body sizes (Braga-Pereira et al. 2020). Although the introduction of firearms represents a potential source of animal over-exploitation due to their high efficiency, the practice of running over can cause potential impacts on fauna by adding mortality of individuals in the population. Different means of locomotion can be used to access hunting areas. In the Amanã Sustainable Development Reserve, located in the state of Amazonas, Brazil, Valsecchi and Amaral (2009) recorded the use of motorized or non-motorized canoes to capture white-lipped peccary, but there is no record of the direct use of the vehicle itself as a weapon to kill animals.

The species mentioned by the interviewees are not among the most roadkilled in the Neotropics, although the lack of sampling in the Brazilian Amazon is evident (Medrano-Vizcaíno et al. 2022; Pinto et al. 2022). In the Urubu System, from 2014 to 2023, 17 species and 109 roadkilled individuals were recorded in the state of Rondônia. Of the species cited as consumed in this study, *Hydrochoerus hydrochaeris* (16), *Dasypus novemcinctus* (11) and *Euphractus sexcinctus* (6) were recorded as roadkilled in that platform, 30.28% of the total number of registered mammals (Sistema Urubu 2023). The species with the highest number of records in the system was *Tamandua tetradactyla* ($n = 29$, 26.61%), a species not consumed by hunters in the state (Gomes 2017; Ramos et al. 2020; Belfort et al. 2020; Oliveira et al. 2022c). Species with a more generalist diet, such as the opossum *Didelphis marsupialis* (Medrano-Vizcaíno et al. 2022), present higher roadkill rates, but are not targeted by hunters or consumers of roadkilled meat.

Intentional running over may not result in an effective capture due to the potentiality of only injuring the animal, which may escape and die far from the road (Pinto et al. 2022). Associated with this issue is the presence of different pathogens. Many of the animals cited as consumed are potential hosts of zoonotic pathogens such as different fungi species (Richini-Pereira et al. 2010; Navas-Suárez et al. 2021), *Leishmania* spp. (Richini-Pereira et al. 2014) and adenoviruses (Lial et al. 2022). These microorganisms pose risks to human health, and the consumption of these animals is a potential route of entry for zoonoses. Consumption of wild meat is essential for the food sovereignty of different human populations and culturally embedded in the Neotropics (Booth et al. 2021). Therefore, access to this product must occur with guaranteed food safety, including the assessment of zoonotic risks.

Of the 10 species mentioned, three are considered Vulnerable to extinction: *Tayassu pecari*, *Tapirus terrestris* and *Panthera onca*. For these species, different threats lead to a reduction in their populations: hunting, deforestation, unsustainable agriculture and livestock, conflicts with domestic animals, pollution, forest fires, among others (Keuroghlian et al. 2018; Medici et al. 2018; Morato et al. 2018; Lima et al. 2020). The intentional collision of animals with transportation vehicles can be a new threat to these species, favouring the loss of biodiversity in the Neotropics. The presence of the carcasses along the highways can attract other animals to consume them, exposing these animals to these roads and increasing the risk of vehicle collisions (Santos et al. 2022). The state of Rondônia presents a particularly negative scenario in relation to the conservation of its natural resources, with a 20% increase in deforestation rates over the years 2000 to 2017 (Ranieli et al. 2020), in addition to constant invasions and loss of vegetation cover within

Table 1. Species of medium and large mammals that can potentially be consumed in case of road kills in the state of Rondônia.

Taxon	Common name	N citations	IUCN Red List	ICMBio Red List
Dasypus novemcinctus	Nine-banded Armadillo	4	LC	-
Dasypus beniensis	Greater long-nosed armadillo	4	-	-
Euphractus sexcinctus	Yellow Armadillo	2	LC	-
Cuniculus paca	Paca	4	LC	-
Dasprocta sp.	Agouti	2	-	-
Hydrochoerus hydrochaeris	Capybara	1	LC	-
Dicotyles tajacu	Collared peccary	4	LC	-
Tayassu pecari	White-lipped peccary	4	VU	VU
Tapirus terrestris	Tapir	4	VU	VU
Panthera onca	Jaguar	1	NT	VU
Total		**30**		

Figure 2. Adult *Tapirus terrestris* individual stricken in the state of Rondônia in considered ideal conditions for meat collection.

protected areas (Cardozo et al. 2017). In a more fragmented and human-modified environment, collisions, whether intentional or not, may become more frequent.

CONCLUSION

Our findings demonstrate that the capture of wild animals for consumption can be done using different means in addition to traditional hunting methods, such as through the consumption of roadkilled species. The most frequently mentioned species coincide with the most preferred hunted species among hunters in Rondônia, reinforcing that wild meat harvest is not a random event, but rather targeted at a limited bulk of species. Intentional roadkill of animals can be an occasional practice with high associated risks both to the animal populations and the human health. Attempting to run over the animal can increase the risk of accidents on the highways. Furthermore, there is the potential that the animals may not be killed on impact, leaving them injured and more vulnerable to death.

New studies should be conducted to better understand this phenomenon, looking for information from a new set of consumers, the rates of consumption, most

collected species, the frequency of intentional roadkills and capture success. In addition, it is important to verify the quality of the meat, in relation to both sanitary aspects and the presence of diseases. These new investigations would help understand whether this is a local or a widespread phenomenon in the Neotropics.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: MAO, RAPB, HREB, RRNA, MRM, CRCD.
Carried out the experiment: MAO, RAPB.
Carried out the data analysis: MAO, RAPB.
Wrote the first draft of the manuscript: MAO.
Review and final write of the manuscript: MAO, RAPB, HREB, RRNA.
Supervision: MRM, CRCD.

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