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A COMPARISON OF ZOOTHERAPY PRACTICES BETWEEN URBAN AND RURAL HUNTERS IN THE SOUTHWESTERN BRAZILIAN AMAZON

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ABSTRACT

Wildlife plays an essential role in the feeding and traditional medicine of rural and urban populations throughout the Neotropics. However, crucial gaps in patterns of use can still be observed in the Amazon region, especially for urban and rural hunters. Faced with this scenario, this study aims to answer the following question: do urban and rural hunters have the same zootherapeutic practices? As such, 57 rural and 49 urban hunters were interviewed about their use of zootherapeutic practices in the state of Rondônia, located in the southwestern Amazon. The primary analyses used for group comparison were the species rarefaction curve, Relative Importance, Use Value Index, Value of Medicinal Applications, and Principal Coordinate Analysis. Of the total number of hunters interviewed, 56.6% reported the use of zootherapeutic practices, with nine hunting to specifically obtain zootherapeutic products. A total of 12 species were utilized of which nine body parts were used to treat 33 diseases, where the main species used in the zootherapeutic practices was *Cuniculus paca*. This predominance may be related to hunting preference and may introduce the potential for pharmacological research. The Relative Importance, Use Value Index, Value of Medicinal Applications, and Principal Coordinate Analysis showed no differences. Our results indicate a significant similarity in the use of zootherapeutic practices between the groups and that the geographic location of residence does not influence the choice of species.

KEYWORDS: bile, *Cuniculus paca*, fat, malaria, traditional knowledge.

COMPARACIÓN DE LAS PRÁCTICAS DE ZOOTERAPIA ENTRE CAZADORES URBANOS Y RURALES EN LA AMAZONIA SUROCCIDENTAL BRASILEÑA

RESUMEN

La vida silvestre juega un papel esencial en la alimentación y la medicina tradicional de las poblaciones rurales y urbanas en todo el Neotrópico. Sin embargo, todavía se pueden observar brechas cruciales en los patrones de uso en la región amazónica, especialmente para los cazadores urbanos y rurales. Ante este escenario, este estudio tiene como objetivo responder la siguiente pregunta: ¿los cazadores urbanos y rurales tienen las mismas prácticas zooterapéuticas? Para este fin, 57 cazadores rurales y 49 urbanos fueron entrevistados sobre su uso de prácticas zooterapéuticas en el estado de Rondônia, ubicado en el suroeste de la Amazonía. Los principales análisis utilizados para la comparación de grupos fueron la curva de rarefacción de especies, la importancia

relativa, el índice de valor de uso, el valor de las aplicaciones medicinales y el análisis de coordenadas principales. Del total de cazadores entrevistados, el 56.6% refirió el uso de prácticas zooterapéuticas, con nueve de ellos cazando para obtener específicamente productos zooterapéuticos. Se utilizaron un total de 12 especies, de las cuales nueve partes del cuerpo se usaron para tratar 33 enfermedades, donde la principal especie utilizada en las prácticas zooterapéuticas fue *Cuniculus paca*. Esta predominancia puede estar relacionada con la preferencia de caza y puede introducir el potencial para la investigación farmacológica. La importancia relativa, el índice de valor de uso, el valor de las aplicaciones medicinales y el análisis de coordenadas principales no mostraron diferencias. Nuestros resultados indican que hay una similitud significativa en el uso de prácticas zooterapéuticas entre los grupos y que la ubicación geográfica de residencia no influye en la elección de especies.

PALABRAS CLAVE: bilis, conocimiento tradicional, *Cuniculus paca*, grasa, malaria.

INTRODUCTION

Hunting is characterized not only as a source of animal protein for different populations throughout the Neotropics (Costa-Neto, 2005; Baía Júnior *et al*., 2010; Ferreira *et al*., 2012; van Vliet *et al*., 2015; Oliveira and Calouro, 2020) but also as a source of medicinal products (Alves *et al.*, 2016; Herrera-Flores *et al*., 2019; Albuquerque *et al*., 2020), whose exploitation may contribute to the extinction of target species (Ripple *et al*., 2016). According to Mishra *et al.* (2020), animals have traditionally been used as medicinal resources for various diseases worldwide. Geographical isolation and reduced access to the public health network, influence a system of highly complex and diverse zootherapeutic practices resulting in an increase of sharing practices among members of populations (Santos *et al*., 2012). Another aspect related to zootherapy is its commercial participation, which involves at least 200 species across Brazil (Pinto and Maduro, 2003; Ferreira *et al*., 2013), captured both to meet hunters' demands and local and international urban trade (Souto *et al*., 2018; Morcatty *et al*., 2020). In Brazil, this commercialization can be attributed to cultural factors, the effectiveness of medicines, and the economy (Alves and Santana, 2008).

Fauna plays a secondary role in traditional medicine compared with flora (Silva, 2008) and is restricted to the treatment of diseases in humans and domestic animals (Ritter *et al.*, 2012). The knowledge derived from these traditional practices, especially species that are frequently used, can help identify species with possible pharmaceutical applications (Barros *et al*., 2012; Ritter *et al*., 2012). Scientific evidence points to the efficiency of certain zootherapeutic medicines in popular medicine (e.g., Souza *et al*., 2017). Thus, studies involving zootherapeutic practices should include different target informants, especially urban and rural hunters and consumers, in order to identify different species and their uses.

The use of zootherapeutic practices by urban populations is still concentrated in studies referring to public urban markets (Pinto and Maduro, 2003). Ferreira *et al.* (2013), highlight that integrating urban-rural environments benefit the constant exchange of information, spreading traditional medicine practices, such as zootherapeutic practices. Silva (2008) and Barboza *et al.* (2014) suggest that the loss of some of this popular knowledge is due to migrations to cities and consequently, greater accessibility to industrialized medicines and health clinics. As a result, this type of knowledge is concentrated in the older individuals of populations (Herrera-Flores *et al*., 2019). Rapid urbanization, the mastery of allopathic medicine, and the acculturation of populations can contribute to the disappearance of this knowledge, highlighting the importance of studies on these practices (Ritter *et al*., 2012). In different contexts of miscegenation, Amazonian inhabitants have unique local knowledge with promising zootherapeutic potential (Barros and Azevedo, 2014), of which little is understood (Guimarães *et al*., 2019). New studies promote a better understanding of

the dynamics and use of natural resources by different populations, in addition to providing subsidies for biodiversity conservation and management strategies (Alves and Santana, 2008; Barros and Azevedo, 2014).

Zootherapy research is exceptionally scarce in the Brazilian Amazon (Costa-Neto and Alves, 2010; Belfort *et al*., 2020; Ramos *et al*., 2020), especially when compared to the Caatinga (e.g., Fernandes-Ferreira *et al*., 2012; Souto *et al*., 2018, Silva-Policarpo *et al*., 2019a). The few existing studies are mainly associated with studies on hunting (e.g. Lemos *et al*., 2018). In the state of Rondônia, only two studies register the use of zootherapeutic practices by hunters. Ramos *et al*. (2020), registered the use of eight species by hunters from a peri-urban village, whose inhabitants are collectors of recyclable materials, to treat 10 diseases, highlighting the use of *Cuniculus paca* by products. Belfort *et al*. (2020), studied hunters from riverine communities of Baixo Madeira, and counted three species used for treating nine diseases, where the main species used was *Tapirus terrestris*. This reinforces the need for descriptive and systematized investigations about these practices. From the conservationist point of view, this research can provide insights into the negative impacts of zootherapeutic activities and practices on fauna resources and subsidize the implementation of management and conservation techniques of the species used (Silva-Policarpo *et al*., 2019b).

Thus, this article aims to contribute to the understanding of zootherapeutic practices of urban and rural hunters in the state of Rondônia, identifying the species used, forms of treatment, related diseases, and the differences between groups. The guiding question of this study is: do urban and rural hunters have the same zootherapeutic practices?

METHODS

Study area. The state of Rondônia is located in the southwestern portion of Northern Brazil. It occupies a territorial area of 237,765.233 km², distributed across 52 municipalities. The estimated population is 1,777,225 inhabitants, where the urban population (1,149,180 inhabitants) is almost three times larger than the rural population (413,229 inhabitants) (IBGE, 2017). About 50% of the resident population are non-native inhabitants of the state (IBGE, 2007). One hundred six interviews were conducted in 10 municipalities in the State of Rondônia. The concentration of interviewees in Porto Velho was due to the method used, which requires the construction of a trusting relationship between interviewer-interviewee and consequently time and interpersonal contact, which made it impossible to obtain a greater number of reliable interviews in other locations (Figure 1 and Table 1).

For he data survey, individual semi-structured interviews were conducted with each interviewee (Albuquerque *et al*., 2014). The following questions were asked: age, sex, whether they used zootherapeutic products from wildlife, whether they hunted for medicinal purposes, species of game used in zootherapeutic practices, parts used, forms of preparation, and diseases treated. Each interview was considered as an independent event. The informants' answers were collected through an adaptation of the Snowball Sampling method proposed by Goodman (1961). The interviews were conducted using different means: telephone, WhatsApp, in person, or through the training of an informant, who was usually a hunter or consumer of game meat, due to the difficulty of obtaining these data due to illegal hunting activity in Brazil (Alves *et al*., 2010). The hunters were invited to participate in the survey and were informed about the project's objectives, free participation, and the guarantee of anonymity. The Research Ethics Committee (Federal University of Rondônia) approved this study under the number 2,661,332. The criteria for inclusion in the research were: people who were self-declared hunters, over 18 years old and residents of Rondônia. The hunters were classified as urban and rural, using residence as inclusion criteria for each group. Hunters whose residences were located within the urban perimeter of the municipality were categorized as urban, and those who had residences in the rural area were categorized as rural, regardless of where (urban or rural) they carry out their hunting activity. In conjunction with this, all hunters

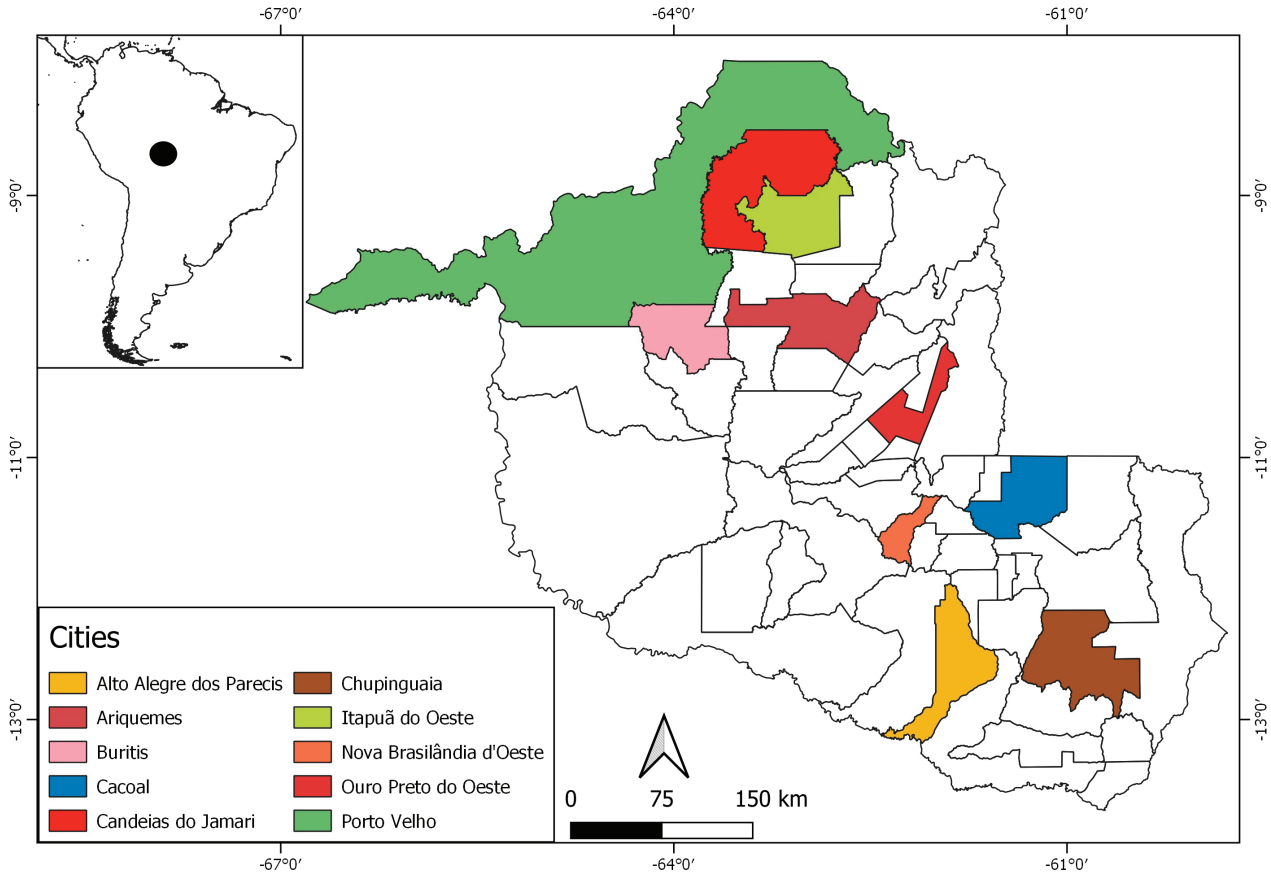

Figure 1. Municipalities in the state of Rondônia with sampled hunters.

Table 1. The number of interviewees by grouping and municipalities sampled.

MUNICIPALITIES	RURAL	URBAN
Alto Alegre dos Parecis	1	-
Ariquemes	-	1
Buritis	1	2
Cacoal	-	1
Candeias do Jamari	4	1
Chupinguaia	-	1
Itapuã do Oeste	5	-
Nova Brasilândia	2	-
Ouro Preto do Oeste	1	1
Porto Velho	43	42

were asked whether they considered themselves to be urban or rural hunters. The conservation status of each species was consulted in the list found in the Red Book of Endangered Brazilian Fauna organized by the Chico Mendes Institute for Biodiversity Conservation (ICMBio, 2018) and the International Union for Conservation of Nature version 2020-2 (IUCN, 2020). The interviews were conducted from October 2018 to February 2020.

Data analysis. For the data referring to the interviewees' ages, the mean and standard deviation were calculated for each grouping. For the evaluation statement regarding medicinal products between the groups and on performing hunting activities to acquire medicinal products, a Pearson's Chi-square test was used.

The interpolation and extrapolation rarefaction curves of the mentioned zootherapeutic species were constructed to compare each hunter group. The curves were calculated and compared based on the sample size using the iNEXT package (Hsieh *et al.*, 2020). The rarefaction and extrapolation curve had a 95% confidence interval for 100 repetitions using the Bootstrap resampling method. With the same package, the extrapolated wealth was calculated.

The Relative Importance (RI) was used to verify which species have greater cultural importance within each grouping (Bennett and Prance, 2000; Silva-Policarpo *et al.*, 2019a):

$$RI = NBS + NP$$

Where NBS = number of body systems (disease categories according to ICD), which is given by the number of body systems treated by a particular species (NBSS) divided by the total number of body systems treated by the most versatile species (NBS = NBSS / NBSVS) and where NP = number of properties, which is given by the number of properties assigned to a given species (NPS) divided by the total number of properties assigned to the most versatile species (NPVS) NP = NPS / NPVS. The higher the registered IR value, the more critical that species is for the grouping.

The Use Value Index (UV) was used to determine the relative importance of the medicinal species of each grouping (Phillips and Gentry, 1993) using the following formula:

$$UV = \frac{\sum_{I=1}^{N} UV_{is}}{N}$$

where: UV = value of species' use; UVis = number of citations per species per informant; N = number of informants. The UV index thus varies from 0 to 1. When it is low or close to zero, the knowledge about the species is not generalized across informants. When close to 1, the species is known in the locality by almost all informants. To classify the values found, the following criteria were adopted: values between 0.01 and 0.39 were considered as a low knowledge generalization, from 0.4 to 0.69 average knowledge generalization, from 0.7 to 0.99 high knowledge generalization and values that reached 1 very high knowledge generalization.

The Value of Medicinal Applications (VAM) index was used to demonstrate the proportion of medicinal use categories that informants claim to be treatable by a given species, measuring its versatility (Barros *et al.*, 2012). The VAM index of an s-species was calculated as the number of categories of the International Statistical Classification of Health-related Diseases and Problems version 11 (ICD-11) (ICD, 2020) that informants claim to be treatable by the s-species (Ds), divided by the total number of ICD categories (Dt):

$$VAM_s = \frac{D_s}{D_t}$$

The VAM index varies between 0 and 1. Values closer to zero indicate that the species is used to treat only one or very few diseases, suggesting that its therapeutic properties are quite specific. In cases where the values were close to or equal to one, the species is used to treat many different diseases, suggesting that its therapeutic properties are quite versatile. The classification of the values obtained followed the pattern used in the UV. The categories used followed the ICD-11 classification.

To evaluate if there were differences in the composition of species, parts used, the form of preparation and diseases cited as being zootherapeutic by rural and urban hunters, we used the Principal Coordinate Analysis (PCoA), in which we used the Gower coefficient of similarity as a measure of proximity between respondents based on the composition of species reported. The following groupings were made based on the body parts used: the body system of origin was used as a criterion comprising bones, skin (and derived structures), teeth, fat, and bile. The preparation forms were grouped according to the main form of preparation: drying, roasting, frying, and packaging in alcohol. We performed a Similarity Analysis (ANOSIM), using Grower's similarity coefficient, to test each grouping (composition of species, parts used, the form of preparation and diseases treated) to obtain the statistical significance of the PCoA dissimilarities/similarities. The diseases were grouped according to ICD-11.

The statistical analyses were performed using the R 3.5.3 software (R Core Team, 2019), employing a 5% significance level. A Wilcoxon test was used to compare the UV, VAM, and RI indexes of each grouping. The quotation of the dollar from November 2, 2020, was used for the transformation of the values, where R$5.74 was equivalent to US$1.00.

RESULTS AND DISCUSSION

We interviewed 106 hunters, of which 49 lived in urban areas and 57 lived in rural areas, with an average age of 34±12 and 37±15 years, respectively. There was a predominance of males (98.08%) and most of the interviewed urban hunters (53.63%) and rural hunters (63.27%) were from the state of Rondônia.

Of the total number of hunters interviewed, 56.6% declared to use zootherapeutic practices. The results indicated that rural hunters do not use zootherapeutic products or perform targeted hunting significantly more compared to urban hunters (X=2.77, df=1, p=0.09 - X=0.49, df=1, p=0.47). Of the 49 urban hunters, 23 claimed to use zootherapeutic practices, and two hunters reported that they capture species to obtain medicinal products. Among the 57 rural hunters, 37 claimed to use medicinal products of wild animal origin, and seven reported that they hunt to capture animals in order to obtain medicinal products. The results indicate a low motivation of hunting to directly obtain medicinal products, and the collection of zootherapeutic products can generally be considered as sources of food complementation among rural hunters (Guimarães *et al*., 2019; Ramos *et al*., 2020). However, there is a need for research into the motivation of urban hunters and the marketing of natural products.

To understand the absence of differences in the use of zootherapy as a source of disease treatment between urban and rural hunters, it is necessary to further investigate the use of these products in the daily routines of each group. Potential, synergistic hypotheses with different flow intensities may explain the results. The integration with cities, the urban-rural connection, and health clinics can contribute to the loss of habits and customs through incentives and easy access to medicines (Barboza *et al.*, 2014). Another possibility is that hunting for medicinal products by urban hunters may indicate how traditional practices adapt to changing contexts rather than disappear (van Vliet *et al.*, 2015). Further evaluation of traditional-industrial medicinal preparations and the substitution of each cluster should be included in future studies.

The use of 11 species by urban hunters and 10 by rural hunters was recorded, totaling 12 species captured, nine parts used, and 33 diseases treated, distributed across 51 statements from urban hunters and 75 from rural hunters. *C. paca* comprised 46.4% of the hunters' responses to species captured, bile and fat totaled 81.6% of the sources of parts used and drying accounted for 54% of preparation methods (Table 2).

The data indicate that most of the species used as sources of medicinal products are hunted primarily as sources of food s (Castillo and Ladio, 2019), which enhances the versatility of this resource (Alves *et al*., 2013) and highlights species that are usually killed for control purposes or due to conflict (Castillo and Ladio, 2019; Albuquerque *et al*., 2020; Lima *et al.*, 2020). The similarities observed in this study for hunter groups are likely due to the fact that all the hunters are residents of the same state and are therefore, exposed to significant faunistic, cultural, and social diversity similarities (Ferreira *et al.*, 2013). Another critical factor is that the state of Rondônia presents an extraordinary convergence of immigrants from diverse origins and cultural backgrounds, which has contributed to this homogenization.

Mammals represent the majority of species used in zootherapeutic practices and this pattern has already been observed in Caatinga, as reviewed by Alves *et al.* (2016). This may reflect hunting pressures as mammals comprise the primary biomass captured during hunting activities (Gomes, 2017). Our results demonstrate that the study hunters reported the utilization of a more limited range of species than other areas in Brazil (Silva-Policarpo *et al.,* 2019a, b) and even other localities in the northern region of Brazil (Silva, 2008; Barros *et al.*, 2012; Santos *et al.*, 2012). The forms of preparation varied according to the body part used and disease treated, as also observed by Castillo and Ladio (2019).

ICD 1 and 15, which comprise parasitic and musculoskeletal system diseases, respectively, totaled 40% of the registered citations. For the treatment of respiratory system diseases (ICD12), six species were cited, representing 54.5% of the total taxa cited (Table 3).

Table 2. Declared zootherapics, including parts used, forms of preparation, condition of use, and treat diseases, by urban and rural hunters in the state of Rondônia, Brazil.

TAXON	POPULAR NAME	PART USED	METHOD OF PREPARATION	DISEASES	UB	RU	FOOD
Alligatoridae	Caiman	Osteoderm	Roasts directly in the fire. After this process, it scrapes the material and adds it to the food or drink.	Rheumatism	-	1	Ub/Ru
				Various verminous	1	2	
				Blood-related problems	1	-	
		Fat	Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Hemorrhoid	2	-	
Crotalus sp.	Rattlesnakes	Fat	Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Column pain	1	-	No
Eunectes murinus	Green anaconda	Fat	Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Cicatrizant	4	4	Ub/Ru
			Fries the fat until it melts. After that, it is packed in a bottle. Take a tablespoon daily.	Several inflammations	1	-	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster on the chest.	Asthma	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. Add the drink.	Reduce catarrh	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Column pain	2	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Muscle distention	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Muscle contusion	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Pains in general	-	2	
			Fries the fat until it melts. After that, it is packed in a bottle. Add the drink.	Pneumonia	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	General burns	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Rheumatism	1	1	

Table 2. Cont.

TAXON	POPULAR NAME	PART USED	METHOD OF PREPARATION	DISEASES	UB	RU	FOOD
Boa constrictor	Common boa	Fat	Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Cicatrizant	-	1	Ub/Ru
				Column pain	1	-	
				Muscular pain in general	-	1	
Coragyps atratus	Black vulture	Bile	Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Cancer	-	1	No
Tapirus terrestris	Tapir	Penis	Bake on low heat until dry. Scrape off the dry penis and add dust to food.	Male impotence	2	-	Ub/Ru
		Fat	Fry the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and puts it on the chest.	Bronquite	-	1	
		Hull	Roasts directly in the fire. After this process, it scrapes the material and adds it to the food.	Psychological disorders in women	-	1	
		Mane fat	Fry the fat until it melts. Take one tablespoon of the dissolved product.	Intestinal diseases	1	-	
				Liver diseases	1	-	
Hydrochoerus hydrochaeris	Capybara	Fat	Fry the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Column pain	1	1	Ub/Ru
				Rheumatism	-	2	
				Thrombosis	1	-	
				Arthritis	1	-	
			Fries the fat until it melts. Take a tablespoon of the thawed product or add it to an herbal tea.	Asthma	1	1	
		Mandible	Roasts directly in the fire. After this process, it scrapes the material and adds it to the food or drink.	Rheumatism	4	5	
			Roasts directly in the fire. After this process, it scrapes the material and adds it to the drink or over the wound.	Leishmaniosis	-	2	
Didelphis marsupialis	Common opossum	Fat	Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Asthma	-	1	
			Fries the fat until it melts. After that, it is packed in a bottle. For use, take one tablespoon daily.	Risk pregnancy	1	-	
Cuniculus paca	Paca	Bile	Leave to dry naturally. After this process, it can be cut into pieces and added to food or drink.	Malaria	4	16	Ub/Ru
			Leave to dry naturally. After this process, it can be cut into pieces and added to food or drink.	Problems related to blood	-	1	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Several inflammations	1	3	

Table 2. Cont.

TAXON	POPULAR NAME	PART USED	METHOD OF PREPARATION	DISEASES	UB	RU	FOOD
				Asthma	-	1	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink or food or scraped and placed over the wound.	Cicatrizant	1	2	
				Diabetes	-	2	
			Leave to dry naturally. After this process, it can be cut into pieces and added to food or drink.	Intestinal diseases	1	-	
			It removes the liquid and passes in the legs.	Kidney pain	1	-	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Plantar fasciitis	-	1	
			Leave to dry naturally. After this process, the material is scraped, and the powder is placed over the place.	Assist in the thorns removal process	1	3	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Stomach diseases	1	-	
			Leave to dry naturally. After this process, it can be cut into pieces and added to food or drink.	Liver diseases	6	5	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the food or scraped and the powder added over the affected area.	Several inflammations	1	2	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	General infections	-	1	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Leishmaniosis	1	-	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Snakebite treatment	-	1	
			Leave to dry naturally. After this process, it can be cut into pieces and added to the drink.	Rheumatism	-	1	
			It removes the liquid and passes in the legs.	Thrombosis	1	-	
			Leave to dry naturally. After this process, it can be cut into pieces and added to food or drink.	Various verminous	-	1	
		Penis	Roasts directly in the fire. After this process, it scrapes the material and adds it to the food.	Male impotence	1	-	
Nasua nasua	Coati	Fat	Fries the fat until it melts. After that, it is packed in a bottle. For use, it prepares a plaster and applies it over the target area.	Pains in general	1	-	No
		Baculum	Roasts directly in the fire. After this process, it scrapes the material and adds it to the food or drink.	Male impotence	1	1	

Table 2. Cont.

TAXON	POPULAR NAME	PART USED	METHOD OF PREPARATION	DISEASES	UB	RU	FOOD
Dasypus spp.	Armadillo	Tail	Roasts directly in the fire. After this process, scrapes the dust into the ear.	Ear pain	1	-	Ub/Ru
Tayassu pecari	White-lipped peccary	Canine tooth	Roasts directly in the fire. After this process, it scrapes the material and adds it to the drink.	Pneumonia	1	1	Ub/ Ru

Table 3. ICD-11 categories and diseases cited by urban and rural hunters in the state of Rondônia, Brazil.

ICD-11 CATEGORY	DISEASES/ HEALTH PROBLEMS CITED	URBAN SPECIES	RURAL SPECIES	TOTAL SPECIES	URBAN CITATIONS (%)	RURAL CITATIONS (%)	TOTAL CITATIONS (%)
01 Certain infectious or parasitic diseases	Malaria, leishmaniasis, and verminous	*Cuniculus paca*	Alligatoridae, *Cuniculus paca* and *Hydrochoerus hydrochaeris*	3	6(11.76)	18(24)	24(35.76)
02 Neoplasias	Cancer	-	Coragyps atratus	1	-	1(1.33)	1(1.33)
03 Diseases of the blood or blood-forming organs	General blood problems	-	Alligatoridae and *Cuniculus paca*	2	-	2(2.67)	2(2.67)
05 Endocrine, nutritional or metabolic diseases	Diabetes	-	*Cuniculus paca*	1	-	2(2.67)	2(2.67)
06 Mental, behavioral or neurodevelopmental disorders	Psychological disorder in women	-	*Tapirus terrestris*	1	-	1(1.33)	1(1.33)
10 Diseases of the ear or mastoid process	Ear pain	*Dasypus* spp.	-	1	1(1.96)	-	1(1.96)
11 Diseases of the circulatory system	Thrombosis and hemorrhoid	Alligatoridae, *Cuniculus paca* and *Hydrochoerus hydrochaeris*	-	3	4(7.84)	-	1(7.84)
12 Diseases of the respiratory system	Asthma, pneumonia, cough with catarrh and bronchitis	*Hydrochoerus hydrochaeris* and *Tayassu pecari*	*Eunectes murinus, Tayassu pecari, Tapirus terrestris, Hydrochoerus hydrochaeris, Cuniculus paca* and *Didelphis marsupialis*	6	2(3.92)	8(10.67)	10(14.59)
13 Diseases of the digestive system	Stomach, intestinal, and liver diseases	*Cuniculus paca* and *Tapirus terrestris*	*Cuniculus paca*	2	10(19.61)	5(6.67)	15(26.28)

Table 3. Cont.

ICD-11 CATEGORY	DISEASES/ HEALTH PROBLEMS CITED	URBAN SPECIES	RURAL SPECIES	TOTAL SPECIES	URBAN CITATIONS (%)	RURAL CITATIONS (%)	TOTAL CITATIONS (%)
14 Diseases of the skin	Burn	-	*Eunectes murinus*	1	-	1(1.33)	1(1.33)
15 Diseases of the musculoskeletal system or connective tissue	Rheumatism, back pain, general muscle pain, muscle strain, plantar fasciitis, and arthritis	*Eunectes murinus, Crotalus* sp., *Hydrochoerus, hydrochaeris* and *Cuniculus paca*	*Eunectes murinus,* Alligatoridae, *Cuniculus paca, Nasua nasua* and *Hydrochoerus hydrochaeris*	6	12(23.53)	16(21.33)	28(44,86)
16 Diseases of the genitourinary system	Kidney pain	*Cuniculus paca*	-	1	1(1.96)	-	1(1.96)
17 Conditions related to sexual health	Sexual impotence	*Tapirus terrestris, Cuniculus paca* and *Nasua nasua*	*Nasua nasua*	3	4(7.84)	1(1.33)	5(9.17)
18 Pregnancy, childbirth, or the puerperium	Risk pregnancy	*Didelphis marsupialis*	-	1	1(1.33)	-	1(1.33)
22 Injury, poisoning, or certain other consequences of external causes	Cicatrizant, thorn pulling, muscle bruising, and snakebite	*Eunectes murinus and Cuniculus paca*	*Eunectes murinus, Boa constrictor* and *Cuniculus paca.*	3	7(13.73)	12(16)	19(29.73)

Fat is one of the main body components used in the production of zootherapeutic medicines (Barros *et al.*, 2012; Santos *et al.*, 2012; Martinez *et al.*, 2013; Castillo and Ladio, 2019; Mishra *et al.*, 2020), although in the present study it was the second most cited part, which may be associated with hunting preference. The significant diseases treated, referring to ICD1 and ICD15, have strong links with activities carried out in rural areas. Malaria and leishmaniasis are tropical diseases with a high incidence in the region, especially in rural areas (Lapouble *et al.*, 2015). Regarding ICD15, rural workers make repetitive movements and adopt forced postures, such as rubbing and capping, which present a high risk of injury or occupational diseases (Costa *et al.*, 2011), highlighting one of the main categories of conditions related to the trade of zootherapeutic products in Brazil and other countries (Ferreira *et al.*, 2013). Even urban hunters are more susceptible to these diseases due to their presence in forested areas and the nature of hunting activities.

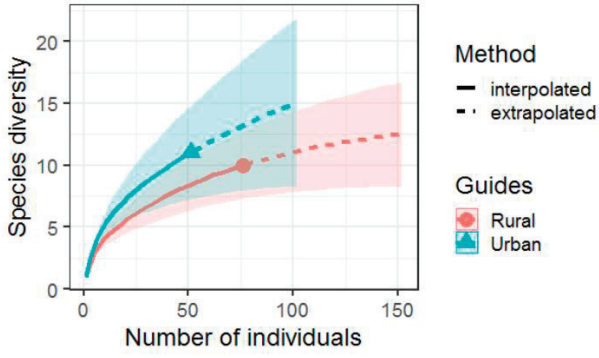

Figure 2. Rarefaction curve of the diversity of zootherapic species cited by rural and urban hunters in Rondônia, Brazil.

The rarefaction curves demonstrate that an increase in the quantity of interviews would result in an increase of reported species (Figure 2). The extrapolation of several rural species indicates that an increase of 37 interviews would result in the registration of two more species. For urban hunters, an increase of two species would require an increase of 52 interviews.

The curves demonstrate the absence of differences in species diversity reported by urban and rural hunters,

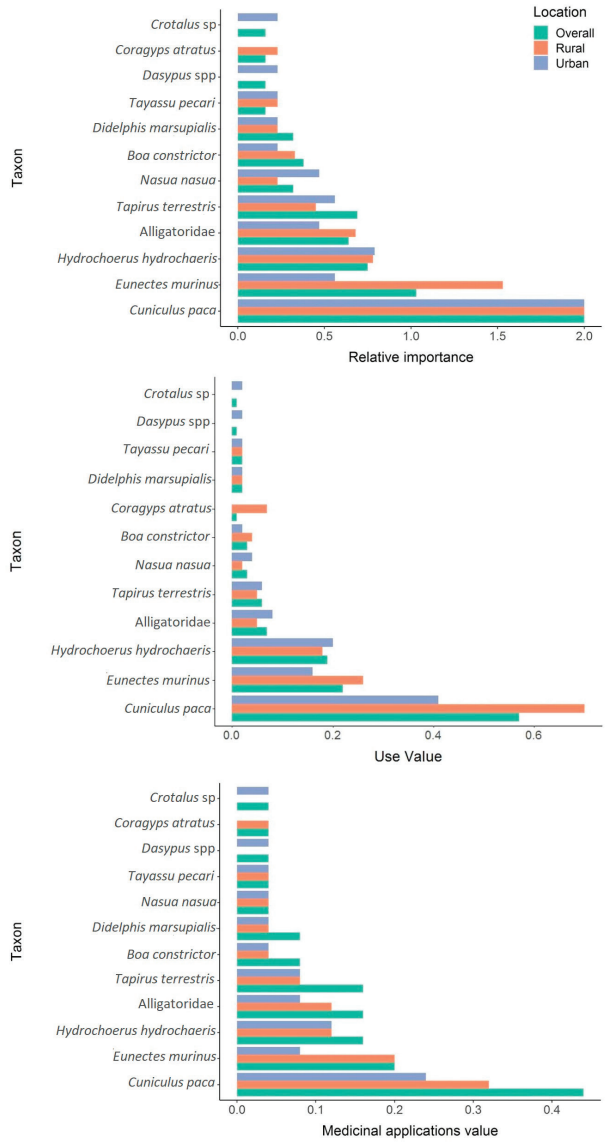

Figure 3. Values of the Indices of Relative Importance, Value of Use and Value of Medicinal Application cited by rural and urban hunters in Rondônia, Brazil.

due to the overlapping confidence intervals. An increase in sampling effort would allow for an increase in the registration of new species and, consequently, the registration of new treatments and diseases. This is especially important for endangered species and would therefore, provide insight into the factors that affect the conservation statuses of these species. It is possible that the potentialities of these species are being increasingly lost (Albuquerque *et al.*, 2020).

The RI rates of urban and rural hunters were similar (U=-69.4 ; p=0.90) and *C. paca* stood out as the largest IR species in both groups. The UV indices of the species used in both groups presented great similarity (U= 71 ; p=0.97). The species, *C. paca,* showed the highest UV index values for both groups and is generally considered to be of average knowledge generalization among urban hunters and high generalization for rural hunters. The remaining species were classified as low knowledge generalization between both groups. The VAM indices of the species used in both groups showed significant similarity, showing no statistical difference (U= 70.5 ; p=0.95). The species *C. paca* presented the highest VAM index values for both groups and in general. All species were considered to have low versatility, such as medicines of excellent specificity, except for *C. paca* when its VAM index was analyzed in the general set of hunters (Figure 3).

The PCoA performed for species, parts, form of preparation and diseases did not show differences between groups (variability: 75.1%, 98.7%, 95.3% and 66%, respectively) and showed that rural and urban hunters have similar patterns of zootherapeutic practices use (ANOSIM R: 0.075, p =0.078; R=-0.06, p=0.94; R=0.027, p=0.23; R=0.019, p=0.29, respectively) (Figure 4).

Souto *et al.* (2018), indicate that cultural factors and hunter preference can influence the choice of zootherapeutic species. Thus, the similarity of index values and the absence of differences for the PCoAs and ANOSIM can potentially be explained by cultural sharing, availability of species in hunting territories, preference for food consumption, and frequency of species capture. Although the species have low UV and VAM values, this indicates that they have high specificity in treating the cited diseases.

Cuniculus paca is characterized as one of the most preferred species for hunting and/or capture among Amazonian mammals (Mesquita and Barreto, 2015; Nunes *et al.*, 2019; El Bizri *et al.*, 2020), and this relationship with hunting may potentially explain the higher values of the indices found and emphasizes that the slaughter of these individuals is not only related to food (Santos Teixeira *et al.*, 2020). This reinforces Silva-Policarpo

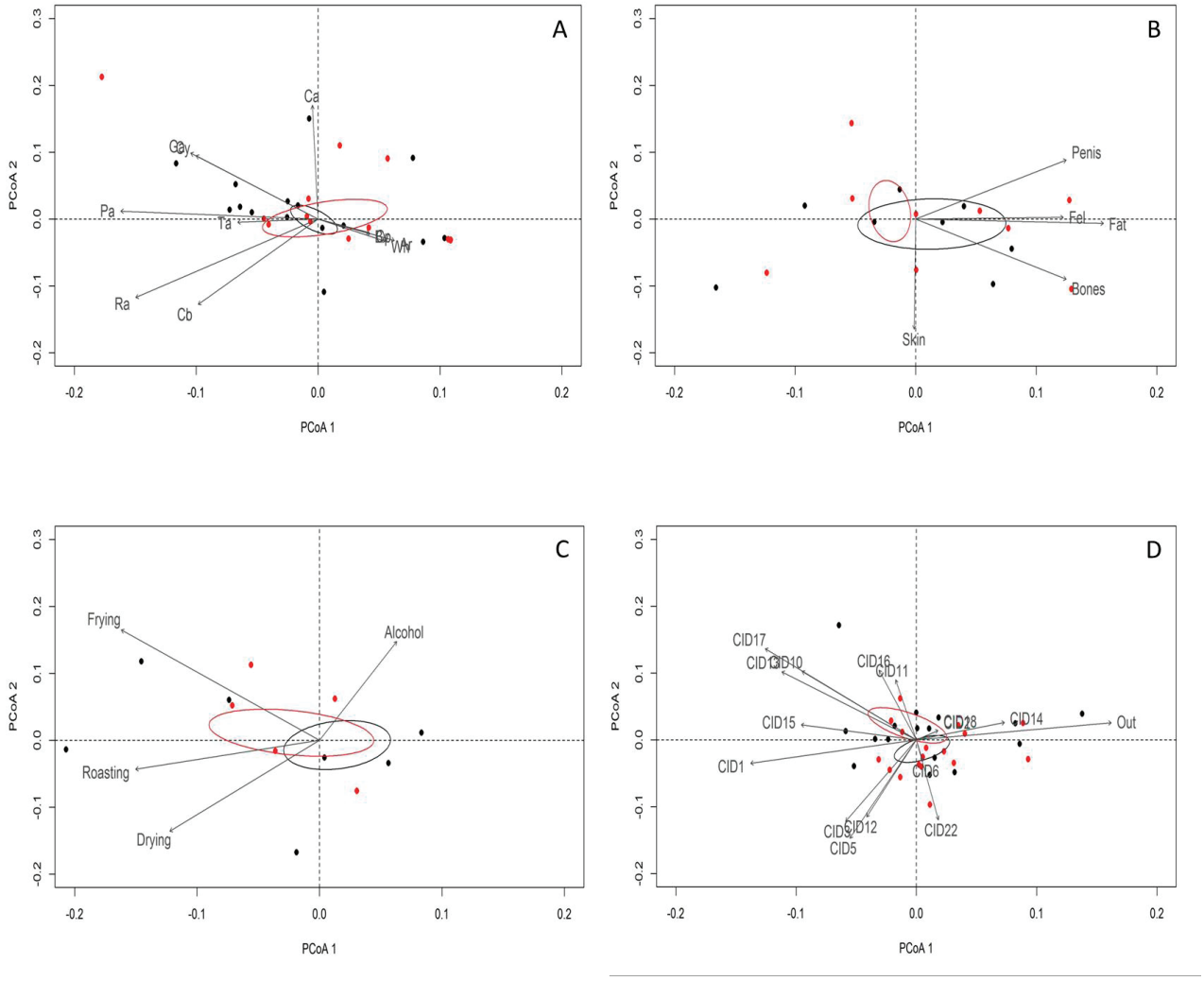

Figure 4. Principal coordinates analysis (PCoA) of the use of zootherapics according to the location of the hunter. Black points indicate that urban and red points indicate rural. The gray arrows represent the rates (A), parts (B), forms of preparation (C), and groups of diseases cited (D), while the black and red circles represent the 95% confidence interval. Plot A: Co= coati (*Nasua nasua*); Ta= tapir (*Tapirus terrestris*); Ra= rattlesnakes (*Crotalus* sp); Wh= white-lipped peccary (*Tayassu pecari*); Cb= common boa (*Boa constrictor*); Ca= caiman (Alligatoridae); Cy= capybara (*Hydrochoerus hydrochaeris*); Ga= green anaconda (*Eunectes murinus*); Ar= armadillo (*Dasypus* spp); Bv= black vulture (*Coragyps atratus*); Cp= common opossum (*Didelphis marsupialis*); Pa= paca (*Cuniculus paca*).

et al. (2019a) statement, that the environment directly influences the choice of zootherapeutic resources and that medicinal use represents a resource optimization strategy. Besides the factors related to hunting practices, the high similarity of IR, VAM, and UV may be associated with the passing down of knowledge through generations, since these practices are likely being regularly repeated and transmitted by members of the groups, as pointed out by Santos *et al*. (2012).

According to the interviewed hunters, the commercial value of these products can vary greatly. The value of the green anaconda's fat varies according to the purity, which is defined by the color: the lighter it is the more pure it is. The green anaconda's fat can reach a value of US$ 4.35 per liter (Figure 5a,b). Although it was not possible to further research this aspect, these results indicate the occurrence of these practices and also provide information related to demand criteria for products. This lack of knowledge is observed throughout the Brazilian Amazon (Ferreira *et al*., 2013).

In the case of the tapir penis, although only one user was reported, the value can reach US$ 52.64 per unit

Figure 5. A) Removal of the fat of an adult individual from the green anaconda; B) Processed green anaconda fat for sale.

due to its rarity, both of the species and of the hunters who perform this type of slaughter. As well as its use for treating sexual impotence, the penis powder is also used to prevent diseases of the female reproductive system, although the hunters could not specify which diseases were prevented. As with the treatment of sexual impotence, the powder is added to food and can be consumed daily by women. The preparation process is as follows: the penis is roasted over a low heat for approximately 5 hours (Figure 6). It is then stored in the refrigerator to prevent deterioration.

Other uses have been reported in addition to medical uses, each with a single record coming from rural hunters. The skin of capybara is boiled and passed over the plantation to scare off other capybaras, acting as an attack control on the crops. In the case of paca bile (Figure 7), there was a record of the use of this product on dogs not used for hunting to become hunters and the use of tapir bile for cockroach control. These uses, although occasional, reinforce the multiple functions and services of hunting byproducts.

CONCLUSIONS

Urban and rural hunters present similar zootherapy use patterns, demonstrating that the rural-urban-rural connection strongly influences this practice, and endangered species are not among the main species used. The exploited species recorded in this study presented low and medium knowledge generalization. Species can be defined as highly specific for the treatment of specific diseases or groups of diseases. The paca (*Cuniculus paca*) was the most exploited species, and malaria was the primary condition treated with its bile, increasing the capture pressure of this species. Aspects related to bioprospection and management should be directed towards this species. The maintenance of populations of this species, in the long term, has a significant relationship with the food sovereignty of dependent people and as a medicinal source. The frequency of use, the transmission of knowledge, and efficacy/efficiency of the products and aspects related to hunting activity should be further investigated in order to understand the importance of these products for each group, as well as the motivations for their use, since the geographical location of residence does not influence the practice of zootherapy.

Figure 6. Tapir penis in preparation.

Figure 7. Paca gallbladder ready for use.

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