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Illegal bushmeat hunting and trade dynamics in a major road-hub region of the Brazilian Mid North

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This study was conducted to characterize the illegal bushmeat hunting and trade in Floriano region (Piauí State), an import road hub between Amazon and Northeast regions of Brazil. This is the first study that assesses bushmeat hunting in Mid North of Northeast Brazil. Our main hypothesis is that hunting has completely changed from a purely subsistence scenario to another under multiple demands and with the incorporation of technological resources. We collected data from August 2015 to July 2016 throughout semi-structured questionnaires with 82 hunters and rapid survey at markets. Our study revealed that 14 wild vertebrates are usually hunted in studied areas as source of meat and zootherapeutics. Hunting for subsistence was the main purpose reported by interviewees, nonetheless we detected that virtually all hunters sell wild meat and zootherapeutic products. We found that local hunting is mainly as a nocturnal activity. Our results show that bushmeat hunting and trade are facilitated by modern technologies and these activities turned into a black way supported by very diverse purposes besides subsistence. We suggest more comprehensive conservation strategies, including alternatives to supply urban demand for game meat, environmental education to mitigate involvement in hunting and improved intelligence efforts by environmental agencies.

Keywords: Bushmeat market chain, Ethnozoology, Hunting in Brazil, Loss of traditional hunting, Wildlife trade, Wildlife conservation.

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Hunting is one of the oldest activities performed by humans, constituting a successful way to extract wild resources[1]. Reasons for consumption of wild meat and other wildlife products in recent times are quite diversified across the tropics. In addition to the loss of alternatives, people may have preferences based on cultural traditions, by considering wild meat as an item of superior quality or by reasons of familiarity with taste and prestige of the bushmeat consumption[2,3]. However, bushmeat species are used by urban and peri-urban for different ends, such as medicinal purposes, as an income source, as trophies and even as building items[4-6].

Mostly studies about wildlife use and trade in Brazil has focused in Amazon region or in Eastern parts of Northeast Brazil (NE Brazil)[6-9]. This certainly occurred due to several reasons. First, bushmeat is a crucial resource for Amazon inhabitants, playing an important role in the subsistence for several communities and means for generating income to purchase commercially available foodstuffs, beverages, processed products, or hunting supplies[5,7,9]. Amazon region also encompasses numerous indigenous groups (traditional people) who have hunted legally for subsistence in their lands[10]. In turn, illegal bushmeat hunting in East parts of NE Brazil (Caatinga (semi-arid) or Atlantic Forest domains) have been performed for subsistence, as a sport or entertainment, and even as a profession[1,4,8]. Both Amazon region and most populous parts of NE Brazil have an intensive, dynamic and complex hunting and trade of wild vertebrates for medicinal purposes[1,8,11], with zootherapeutic products representing a major source of income for salesman and hunters, in addition to an

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key-medicinal alternative for all people involved in market chain of animal-derived remedies[11].

Here, we assesses the general aspects of hunting and bushmeat trade products for food and medicines in an road-rub region of the Brazilian Mid North (geographic transition between the Northeast and Amazonian (North) regions) and we verified the influence of socioeconomic aspects on hunting. The present study is the first about bushmeat hunting scenario in Mid North of Brazil. Our main hypothesis was that hunting has completely changed from a purely subsistence way to another under multiple demands and with the incorporation of technological resources. We consider the implications of our findings within the context that new strategies to support conservation initiatives and management of exploited species are needed.

Methods

Study sites

Our study was carried out from August 2015 to July 2016 in urban and peri-urban areas of two municipalities (Floriano (FLO) and Rio Grande do Piauí (RGD)) and in a small community from microrregion of Floriano, South of Piauí State (Interstate community of Manga) (Fig. 1). The total population of FLO was ~ 59,000 inhabitants, with 85% living in the urban area[12]. RGD has approximately ~ 6,300 residents; ~ 65% of them living in urban RGD town[12], and the interstate community of Manga (two sister villages, Manga-Piauí State and Manga-Maranhão State, 55 km traveling distance from Floriano) has a total population of ~ 700 residents according to Association of the Residents of Manga community (2016, estimate, unpublished data).

The study area is located in the Parnaíba River Basin and Itaueira River Sub-basin[13,14]. Floriano and Manga are on the banks of the Parnaíba River[15] and they depend economically on this river for water supply, fishing resources and maintenance of agricultural irrigation projects (WMSS, personal obs.). In particular, FLO is a major *road hub* of Western part of NE Brazil due to the convergence of roads and services availability. The Municipal Market of FLO (hereafter, MMF) provide directly or indirectly food, industrialized and luxury items for 500,000 inhabitants distributed between several parts of Piauí and Maranhão States (Government of Floriano, unpublished data).

Data collection

Such as Barboza et al.[4], we conducted semi-structured interviews, complemented by open interviews and participant observation of hunting journeys, with hunters opportunistically selected in all surveyed localities. The main informations obtained of hunters were: socioeconomic data, which species are hunted by them, bushmeat hunting dynamics, trade aspects and motivations for hunting. Only individuals who reported to capture wild animals and agreed to participate of our research were

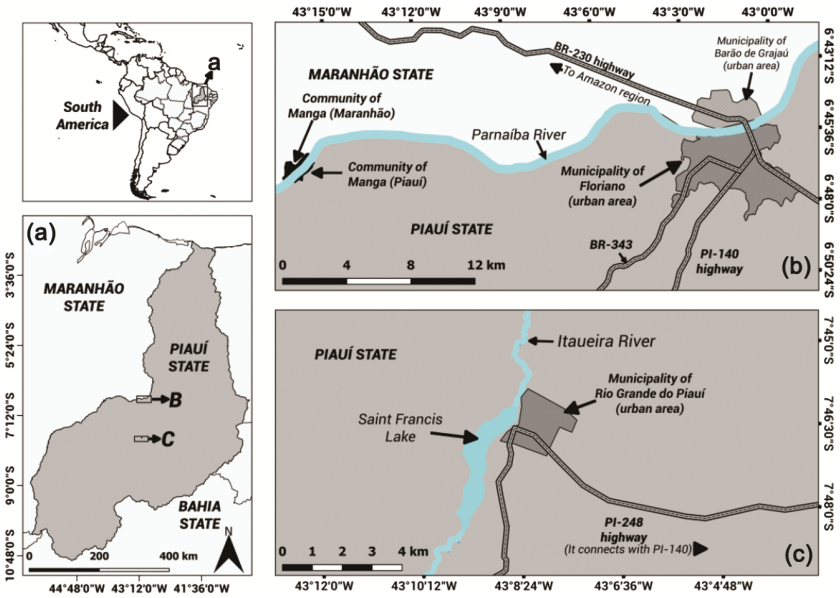

Fig. 1 — Study areas in Mid North of NE Brazil

included in the sample. The total sample was 82 hunters: FLO – 33, Manga – 28, RGD – 21. The total population involved with hunting is virtually impossible to estimate given the clandestine nature this activity in the study area. The questionnaire directed to hunters had as purpose to obtain general information about the hunting, specially: (1) Socioeconomic aspects of hunters and their parents, (2) which target-species are hunted, (3) techniques and strategies for hunting, (4) purposes for hunting; (5) whether the hunter is involved in bushmeat trade; (6) prices of bushmeat; (7) transportation ways for wildlife areas; other aspects of hunting.

We also recruited two local residents to voluntarily check whether bushmeat was sold at MMF or the relationship of this market with the trade chain of bushmeat species. Volunteers performed four visits (December 2015, February, April and July 2016) at the MMF. Volunteers asked local sellers where they (volunteers) could acquire specimens or find wild animals traders. Such as performed by Souto et al.[15], the information obtained of the market traders was compared with data provided by interviewed trappers in order to elucidate the local trade chain (e.g., types of customers, kinds of bushmeat sale unity (kg, entire carcass, others), prices of bushmeat and where find bushmeat products and dishes).

The ethical approval for the study was obtained from the Ethics Committee of the Federal University of Piauí (CAAE number 47887015.9.0000.5214). Prior to each interview, the study participants were asked to sign a Free Consent and Understanding Agreement (TCLE).

Species identification and conservation aspects

The wild animals were identified as follows: (1) through the analysis by researchers (Wedson Souto, Breno Sousa) of specimens held by hunters, (2) photographic records of specimens during guided tours with interviewees and during monitoring of hunting events. Specialized literature[16,17] and reliable digital source[18] was employed as additional resource for taxa identification. The Catalogue of Life website (version 2017)[19] was consulted for the classification and nomenclature used. Additionally, the International Union for Conservation of Nature Red List of Threatened Species version 2017-3 (IUCN Red List)[20] was used to verify the conservation status of the species recorded in the present study.

Data analysis

Species richness was estimated by estimators based on incidence data, namely CHAO 2 and Jackknife 2[11]. EstimateS v. 9.10 was used to calculate both Chao 2 and Jackknife 2[21]. We calculated the use-value (UV)[22] for each species. UV was calculated as follows: $UV = \Sigma U/n$, where U is the number of citations per species and n is the number of informants. We used univariate non-parametric statistics to assess which social factors influence locally in the hunting scenario. All statistical tests were performed with the help of PAST(c) Software version 3.20[23].

Results and Discussion

Hunters' socioeconomic general profile

The most of the hunters resides in urban areas (n=54; 65.85%). The average age of respondents was 49.42±16.19. Interviewees were typically male (n = 62; 75.61%), with low schooling level and income. However, the participant hunters usually were owners of motor vehicles. Table 1 summarizes the social and economic aspects of the sample. Mobile phones (or smartphones) ownership, access to tap water and electricity were universal among the interviewees, and are not itemized in Table 1. The presence of women playing role of hunter is a new record among non-indigenous people in Brazilian Mid North. However, hunting for food and medicine performed by women, nonetheless, is a widespread activity throughout the tropics[see 24,25].

Bushmeat species exploited and sampling effort

A total of 14 terrestrial vertebrates species were reported by hunter as source of wild meat and zootherapeutic products (Table 2). Chao 2 predicted 14.33±0.92 species exploited by hunters and jackknife 2 estimated 16 bushmeat species. Our sample effort can consequently be considered very high.

The number of species hunted by residents from microrregion of Floriano was lower than other parts of the Brazilian Northeast semi-arid. For instance, at least 42 wild terrestrial vertebrates were source of meat and 15 species were exploited by hunters as medicines in two municipalities of Paraíba State[26]. As highlighted in several studies[e.g.,1,4,5] about bushmeat hunting, the species richness locally exploited for human needs can to reflect aspects of the faunal composition, accessibility and hunters' prefererences. Our results are in line with these perspectives, since while there is a diversity of small-

Table 1 — Hunters' socioeconomic aspects

Socioeconomic aspect	n	%
Locality		
Community of Manga	28	34.15%
FLO	33	40.24%
RGD	21	25.61%
Residence zone		
Urban	54	65.85%
Peri-urban	28	34.15%
Age group		
Less than 30 years old (y.o.)	10	12.20%
≥ 30 and < 50 y.o.	31	37.80%
≥ 50 y.o.	41	50%
Gender		
Female	20	24.39%
Male	62	75.61%
Schooling		
A – Very low (Illiterate, Semi-literate)	40	48.78%
B – Low (Incomplete or complete elementar school "ensino fundamental")	25	30.49%
C – Medium-High (Incomplete or complete secondary school "ensino médio" or university)	17	20.74%
Personal income		
A – Low		
≤ Minimum wage (BRL 788 (USD 242.46) at the data collection)	45	54.88%
B – Medium-high	20	24.39
> 1 e ≤ 2 Minimum wages	16	19.51%
> 2 Minimum wages	4	4.88%
C - Not reported	17	20.73%
Motorized vehicle(s) at home		
Yes	52	63.41%
Motorcycle	42	51.22%
Car	6	7.32%
Both	4	4.88%
No	30	36.59%

bodied game species in semi-arid *stricto sensu* of NE Brazil and local people rely on several different species to guarantee the supply of wild animal parts for subsistence or commercial purposes[1,4,27], other tropical areas with large-bodied species or abundant animal populations may enable local residents to primarily exploit – at least while available - a more limited repertoire of vertebrates with meat or other parts in greater quantity[24,28]. Consequently, the ecotone Caatinga – Cerrado in FLO region clearly differs from other areas of the NE Brazil (mainly semi-arid zones) and it show a hunting scenario closer to tropical rainforest areas in terms of species richness.

The importance of mammals as major target-group by hunters in studied areas can be observed in terms of the most frequently mentioned species. The five species hunted for meat consumption with higher UV were mammals: the nine-banded Armadillo *Dasypus novemcinctus*, the Six-Banded Armadillo *Euphractus sexcinctus*, the seven-banded Armadillo *Dasypus septemcinctus*, the gray-brocket *Mazama gouazoubira*, and the collared anteater *Tamandua tetradactyla* (Table 2). Species hunted for medicinal use primarily were the same animals target for food; except by *Anhima cornuta* and *Pecari tajacu*, which were reported as meat source only, and by *Nyctibius griseus*, mentioned exclusively for zootherapeutic uses. Such as the use of wildlife for food purposes, the most important species source of animal-based remedies were mammals: *Euphractus sexcinctus*, *Mazama gouazoubira*, *Dasypus novemcinctus* and *Dasypus septemcinctus* (Table 2).

The general perception by interviewed hunters was that armadillos are the tastiest of all kinds of wild meat, especially bushmeat of *Dasypus novemcinctus* whose meat is comparable to taste of local chicken dishes. The hunters' preference by armadillos is also indirectly related to the ease of commercialization of these animals and the sporting nature of hunting with dogs to catch armadillos. According to hunters, armadillos are rarely stocked, and the selling to third parties usually occurs only a few hours after capture, especially when buyers are from urban areas. Barboza et al.[29] highlighted the undissociated aspect of armadillo hunting as a fast source of complementary income and leisure for hunters. There is an intrinsic aspect of prestige for hunters linked to armadillo hunting because some species, mainly *Dasypus* spp., are considered fast and difficult to capture in NE Brazil[29]. Overview analysis of illegal sport hunting videos posted on YouTube™ by Brazilians detected Dasypodidae species, medium-large size wild rodents (e.g., *Dasyprocta* spp. and lowland paca) and the collared peccary as most frequent target by urban sport hunters[30]. The coincidence of popular species detected in our study with other parts of Brazil and in different contexts reinforces the perception that not only social and economic aspects, but also cultural ones, act as synergistic drivers of hunting for food and medicine in Brazil[1,29].

Table 2 — Wild animals hunted for food or medicine purposes in Floriano region, Mid North of Brazil

CLASS/ Order/ Family/ Species – local name (Portuguese), English name	UV meat	UV medicinal purposes	IUCN Red List 2017-3	Price (as food)	Price (as zootherapeutic)
REPTILIA					
Crocodylia					
Alligatoridae					
Caiman crocodilus (Linnaeus, 1758) – Jacaretinga ou jacaré, Common Caiman	0.02	0.01	LC	"Low price per kilogram" (< BRL 10 / USD ~ 3)"	Sell as food. Customer extract zootherapeutic part.
AVES					
Galliformes					
Cracidae					
Penelope superciliaris Temminck, 1815 – Jacupemba, jacu, Rusty-margined Guan	0.10	0.01	LC	BRL 30 – 70 (~ USD 9.2 – 21.5) per specimen	Sell as food. Customer extract zootherapeutic part
Nyctibiiformes					
Nyctibiidae					
Nyctibius griseus (Gmelin, 1789) – mãe-da-lua, Common Potoo	---	0.01	LC	---	Specimen: BRL 25 (~ USD 7.6)
Anseriformes					
Anhimidae					
Anhima cornuta (Linnaeus, 1766) – inhuma, Horned Screamer	0.01	---	LC	Not sold	Not sold
MAMMALIA					
Artiodactyla					
Cervidae					
Mazama gouazoubira (Fischer, 1824) – veado caatingueiro, Gray Brocket	0.39	0.17	LC	BRL 30 (~ USD 9.2) per kilogram	Sell as food. Customer extract zootherapeutic part
Cetartiodactyla					
Tayassuidae					
Pecari tajacu (Linnaeus, 1758) – caititu, Collared Peccary	0.02	---	LC	Specimen: BRL 50 – 120 / (~ USD 15.3 – 36.9)	---
Carnivora					
Canidae					
Cerdocyon thous (Linnaeus, 1766) – raposinha, raposa comum, Crab-eating Fox	0.01	0.01	LC	Not sold	Not sold
Cingulata					
Dasypodidae					
Dasypus novemcinctus Linnaeus, 1758 – tatu-verdadeiro Nine-banded Armadillo	0.82	0.10	LC	Whole animal: BRL 50 – 100 (~ USD 15.3 - 30.7) Half of the specimen: BRL 25 (~ USD 7.6)	Sell as food. Customer extract zootherapeutic part
Dasypus septemcinctus Linnaeus, 1758 – tatu-china, tatuzinho, Brazilian Lesser Long-nosed Armadillo	0.57	0.10	LC	Whole animal: BRL 15 – 50 / (~ USD 4.6 - 15.3)	Sell as food. Customer extract zootherapeutic part
Euphractus sexcinctus (Linnaeus, 1758) – tatu peba, Yellow Armadillo	0.73	0.30	LC	Whole animal: BRL 25 – 70 / USD ~7.6 – 21.5	Sell as food. Customer extract zootherapeutic part
Rodentia					
Caviidae					
Hydrochoerus hydrochaeris (Linnaeus, 1766) – capivara, Capybara	0.21	0.07	LC	Whole animal: BRL 35 – 80 (~ USD 10.7 – 24.6)	Sell as food. Customer extract zootherapeutic part

(*Contd*.)

Table 2 — Wild animals hunted for food or medicine purposes in Floriano region, Mid North of Brazil (*Contd*.)

CLASS/ Order/ Family/ Species – local name (Portuguese), English name	UV meat	UV medicinal purposes	IUCN Red List 2017-3	Price (as food)	Price (as zootherapeutic)
Cuniculidae					
Cuniculus paca (Linnaeus, 1758) – paca, Spotted Paca	0.02	0.04	LC	Whole animal: BRL 30 – 70 (~ USD 9.2 – 21.5)	Sell as food. Customer extract zootherapeutic part
Dasyproctidae					
Dasyprocta prymnolopha Wagler, 1831 – cutia, Black-rumped Agouti	0.16	0.04	LC	Whole animal: BRL 40 – 65 (USD ~ 12.3 – 20)	Sell as food. Customer extract zootherapeutic part
Pilosa					
Myrmecophagidae					
Tamandua tetradactyla (Linnaeus, 1758) – tamanduá, tamanduá-mirim, Southern Tamandua	0.39	0.06	LC	Whole animal: BRL 45 – 70 / (~ USD 13.8 – 21.5)	Sell as food. Customer extract zootherapeutic part

Legend: IUCN Red List category – LC (Least Concern)

Some socioeconomic factors influenced the exploited species richness by hunters. Younger hunters (< 30 years old, group A) reported significantly fewer species than older hunters (≥ 30 e < 50 y.o., group B; and ≥ 50 anos, group C) (Kruskal-Wallis H test = 10.2, $p<0.001$; post-hoc Dunn tests: A - B, $p<0.05$; A–C, $p<0.05$; B–C, not significant difference; mean ranks: A=24.6; B = 44.13; C = 47.3). In turn, individuals with high schooling (E3) hunt significantly fewer species than individuals with very low schooling (E1) (Kruskal-Wallis H, $p<0.05$; post-hoc Dunn test E1–E3). Although a more comprehensive analysis is needed to ratify our results, we suggest that young hunters with higher schooling - a profile generally associated with higher income - are more directed to a repertoire of target species related to sport hunting. These results are in line with El Bizri et al.[30], who found a typical profile among young Brazilian sport hunters not characterized by the need for subsistence or money from game meat trade, but by the thrill of chasing target species and consuming game meat as a delicacy.

General aspects of illegal bushmeat hunting and trade aspects

Three major drivers were reported by interviewees as motivation for hunting: (1) Subsistence ("*necessidade*") - obtain meat or to sell this item or other wildlife products to acquire food; (2) sport hunting - as an entertainment or leisure activity among friends and family, and (3) commercial - when hunting is to get money for any purpose, except food. Interviewees reported subsistence (n = 58, 70.73%) or sport (n = 23, 28.05%) as primary reasons for hunting. We found no significant difference (G test, $p>0.05$) between locations relative to the proportion of respondents by category of motivation to hunt. Although a minority number of hunters declared hunting primarily for commercial reasons, virtually all respondents confided their involvement in the sale of wildlife products, especially game meat.

Bushmeat hunting for food and medicines is influenced by the dynamics of local communities and the hunter's personal life[8,9,24]. Our results support this perspective, since hunting in FLO region is usually performed from Fridays to Sundays. Similar pattern has been observed by Souto et al.[15] in market chain of live birds in Brazil, which due to the influence of urbanization and economic demands, non-indigenous people reconcile hunting with regular or irregular jobs on working days. Hunting on the weekends secondarily also promotes lower risk of seizing and arresting because this time coincides with environmental agents' days off[15,26].

Hunting at night is widely preferred and widespread among local hunters (n = 66; 80.5%). We found significant difference between the proportions of interviewees in relation to the preferential time of the day for hunting (G test = 16.37; d.f. = 4, $p<0.05$). This statistical difference, nonetheless, was due to a location (RGD) where all interviewees reported preference for hunting at night. Motivations for night time were basically similar to hunting on weekends, except by mentions to obtain bushmeat to consume it as appetizers or as a special meat for Sundays meals.

Hunting at night in studied areas is performed in two basic ways: (1) "Espera" (ambush) or "batida" (pursuit hunting). We recorded that ecological aspects

of target-species influence local knowledge on the mounting location for ambushes. For example, for hunting of *M. gouazoubira*, the black-rumped agouti, the collared peccary, and spotted paca ambushes are made in nets on high branches of fruit plants, such as cashew apple tree, the *pequi* tree, the *oitizeiro* tree, and mango tree. According to interviewees, hunting for common caiman and capybara, in turn, occurs in ambushes on wooden platforms constructed at a height of 3 or 4 meters from the ground in lagoon areas or on the rivers and streams banks.

Changes in shmeat species, making contemporary hunting a more unsustainable activity[4,31]. This process is already apparently well established in the Floriano region, where hunters from FLO and RGD declared to use motorcycles, cars or buses to go to places or proximity to places where they hunt. Urban and peri-urban hunters from FLO and RGB reach wildlife source areas through the roads BR-230, PI-343 and countless rural roads (roads of *piçarra*) that cut the landscape. The viability for hunting of three species (*P. superciliaris, M. gouazoubira* and *P. tajacu*) was related by interviwees to the use of motor vehicles as a vital resource for transportation to distant hunting areas (> 30 km).

Hunters, in general terms, reported bushmeat as a weekend product for personal or familiar consumption or a main product for dishes of holidays or festivals (*festejos*). Additionally, the meat of wild-caught animals was indicated by interviewees as snack dishes found in chopbars. This is a typical reality of strong transitional areas with urban and market influences on bushmeat consumption, when diverse, marketeable and regular bushmeat alternartives are available. The role of bushmeat as a buffer for times of hardship in tropical areas[32] was not lost in Mid North since a minor, but not negligible, part of our hunter sampled (n = 18; 21.95%) stating the use of game meat, especially armadillos, as an important non-timber forest product for familiar diet in times of scarce resources, as well as for obtaining financial resources to keep household expenses. Besides, several hunters admitted bushmeat as major important source of meat and money in past times before recent Brazilian economic boom (2003 - 2014).

Trade details was obtained of 14 hunters and 4 market vendors only. Bushmeat market locally is an unorganized branched trade chain. We detected a total of five actors in bushmeat trade: hunters, middlemen/re-sellers, chopbar/restaurant owners, market vendors and end-customers. This chain is as found by others[see 7] in tropical zones where wild meat is a product easily and quickly traded, with economic, social and cultural importance in a wide sense; besides the participation of different actors who expand the geographic reach of wild meat when bushmeat trade is profitable.

In present study we detected that the primary route of bushmeat is from hunters to end-customers. Almost all market chain operations are catalyzed by communications technological resources. The end-customers, mostly urban residents in FLO and RGB, usually order wild meat from interviewees through phone calls or messenger apps. Hunters also reported themselves to contact customers, by phone or social media, to offer game meat after hunting journeys. Some small chopbars and restaurants in non-central parts of FLO and RGD order by phone bushmeat species - mainly armadillos, *M. gouazoubira* and the black-rumped agouti – from urban hunters to sell special dishes and appetizers for fidelity and trusted clients. The communications improvements has contributed to support a black market of game meat and other wildlife products in South America[5,15]. However, the role of mobile phones and internet resources for communications has led to more radical changes of bushmeat trade chain in South Piauí with a reduced importance of middlemen.

The hunter's effort to commercialize bushmeat in a fresh way as quickly as possible can be understood as a strategy to avoid possible denunciations and subsequent seizures by environmental agents. Fresh bushmeat is associated with immediate consumption or freezing capacity by customers, something acceptable in a region where most of the population already has freezers or refrigerators. Our results are clearly different from central parts of Amazon region and of West/Central Africa[28,33], regions where bushmeat is mainly traded as smoked product. Bushmeat is sold frozen at the MMF. Additionally, we recorded that traders at the MMF freeze the wild meat and store it in styrofoam boxes with ice cubes, not exposing wild specimens directly for sale. Traders also keep bushmeat in freezers at homes of relatives or friends close to the market. Most of the time, traders only expose the meat to customers who traditionally buy this product or to people perceived as trustworthy who order and go to the market to pick up the item. In general terms, the recorded prices suggest bushmeat trade supplies an urban demand by a luxury item. Whereas livestock meat is found by

prices as BRL 8 (pork), BRL 10 (chicken), BRL 15 (lamb/ mutton meat), BRL 20 (cattle) per kilogram, the game meat is not locally fractioned per kilogram by hunters or market vendors.

Despite of the use and trade of wild animals parts for medicinal purposes be widespread in NE Brazil[1,11]; except by *Nyctibius griseus*, hunters and traders typically sold animals ordered to traditional medicine as unities for sale of bushmeat. We conclude that this strategy represents a value-adding mechanism, since parts of medicinal animals can be relatively inexpensive and the removal of a part of the carcass could make it impossible to trade it as a bushmeat for other kinds of customers. Hunters, in general terms, reported fats, bones and leathers as the most important zootherapeutic resources. This pattern is seen to be widespread in Brazil[11], and it reinforces the cultural importance of medicinal animals on the continent. According to hunters, respiratory problems (e.g., asthma, bronquitis, and colds are popular diseases reported by customers for treatment with zootherapeutics. Diseases of the respiratory system are those with most number of zootherapeutic species prescribed in traditional pharmacopoeia of South America[11,34]. Consequently, hunters can be considered important sources of traditional knowledge for studies on the use of medicinal animals.

Implications and challenges for wildlife conservation of hunting species in Mid North

All species exploited by hunters in South of Mid North are categorized as Least Concern on the IUCN Red List version 2017-3 (Table 2). This does not imply that species suffer low hunting pressure locally. Aspects of biogeography, biology and ecology of the species contribute to keeping them, in general, still included in the LC category. For instance, hunting is considered one of the major threats to armadillos, but due to the high reproductive rate and wide geographic distribution *Dasypus novemcinctus* and *Euphractus sexcinctus* are not threatened with extinction[20]. However, in Floriano region, *D. novemcintus* was reported by interviewees less abundant than in ten years ago due to high demand by urban customers.

Such as nine-banded armadillo, collared peccary *P. tajacu* is a LC species in Brazil[35]. *P. tajacu* tolerates moderately altered habitats throughout its distribution in the Neotropics[36]. However, hunting pressure synergistically with high levels of habitat loss and fragmentation have led to depletions of this ungulate in several parts of Brazil, especially in the Atlantic Forest[35]. Local hunters reported the species as rare and no longer present in the surroundings of the study area, with the only two interviewees still hunting this species by moving at least 100 km with motorcycles to access source areas in Piauí and Maranhão States.

Bushmeat hunting is a very dynamic and unlikely activity to be solved or managed only by law enforcement in tropics[25,37]. As in Brazil usually there is no a dialogue between environmental agencies and the general population on the motivations for hunting and the factors that lead to the use of wild animals, established top-down conservation strategies tend to be inefficient. As highlighted by Policarpo et al.[1], the exclusion of local populations from the discussion/ decision processes may lead to the establishment of public policies devoid of historical and traditional material, without much community resonance.

Several actions directed to hunters need to be considered by decision makers. They must transcend the merely criminal field. Proposals of income generation for hunters and relatives, thus greater access to education and leisure are essential to ensure a more sustainable scenario of wildlife use and conservation. Environmental education participatory strategies can, in turn, act at various levels of the problem about illegal hunting, with actions aimed at sensitizing the public about the risks and excessive consumption of bushmeat. Participatory strategies on hunter-level can guarantee or encourage them not to engage in an indiscriminate and unnecessary activity. While dialogue for conservation is not established among stakeholders and Brazilian authorities do not understand the drivers of bushmeat hunting on regional perspective, illegal hunting and trade will persist as a drain of wildlife resources and a major threat to a number of target species, compromising not only biodiversity but also the livelihoods for some human groups.

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