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ORIGINAL ARTICLE

Bushmeat consumption and its implications for wildlife conservation in the semi-arid region of Brazil

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Abstract Hunting plays an important socioeconomic role in the semi-arid region of Brazil, by supplying meat and other products. Nevertheless, there is a lack of information on which species are most used by the local populations and what are the implications for conservation of exploited animals. This paper explores the bushmeat consumption in the Brazilian Caatinga region, where wild animals comprise an important protein source. A questionnaire was used to gather information from hunters, and the consumption of bushmeat by their families was monitored. Interviews revealed that 58 vertebrate species could potentially be consumed as bushmeat, but the samples provided by the monitored families comprised only 28 species. Birds were the animals most consumed, followed by mammals, although the biomass of both groups was similar. The consumption of bushmeat was not correlated with hunters' socioeconomic data (income, age or schooling). Hunters recognized that the populations of some game species appeared to be declining, showing that bushmeat consumption, together with the cultural, economic and social aspects of the human populations involved in hunting, should be considered when discussing the conservation of animal resources in the Caatinga region.

Keywords Caatinga · Ethnozoology · Hunting · Game species · Vertebrates

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Introduction

Bushmeat represents an important source of animal protein consumed by millions of people worldwide (Alvard et al. 1997; Alves 2012; Bennett and Robinson 2000; Hanazaki et al. 2009; Nasi et al. 2008; Ojasti 1997). Even in societies with an agriculture and livestock-based economy, hunting is important for many families, providing up to 80 % of the meat consumed in certain rural communities (Bakarr et al. 2001). While invertebrates can be locally important dietary items, it is the larger vertebrates that constitute the majority of the terrestrial wild animal biomass consumed by humans (Nasi et al. 2008). In Latin America, for example, over 200 species of mammals, ca.750 bird species (including over 530 species for the pet trade), more than 60 species of reptiles and a minimum of 5 species of amphibians have been registered as harvested for household consumption and for markets (Ojasti 2000).

The variability of the magnitude of bushmeat exploitation and consumption is primarily determined by its availability; it is also influenced by governmental controls on hunting, and by socioeconomic status and cultural prohibitions (Fa et al. 2003; Melo et al. 2014; Ntiamoa-Baidu 1997; Souza and Alves 2014). For instance, the rural population of the Brazilian Amazon alone consumes between 9.6 and 23.5 million reptiles, birds and mammals

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each year, which represent an estimated yield of 36–89 tons of wild meat (Peres 2000); considering the moist forests of the Congo Basin in Africa, one to three million metric tons of dressed (slaughtered) wild meat is eaten each year (Fa et al. 2003). More recently, Nasi et al. (2011) estimated that the harvest of wild animals in the Congo and Amazon Basins provides benefits to local people worth millions of US$ annually and represents around 6 million tons of animals extracted yearly.

Hunting comprises one of the most common activities of wild vertebrate exploitation in Brazil, despite being forbidden by the Brazilian Environmental Crimes Law ("Lei de Crimes Ambientais" no 9.605, 1998), excepting for subsistence (i.e. in case of hunger). In spite of this, hunting of wild animals still takes place into a greater or lesser extent in all Brazilian biomes. The persistence of hunting activities in Brazil in spite of the well-known illegality of this practice is closely associated with cultural aspects as well as the fact that in some Brazilian regions those animals can have great nutritional importance to low-income families that cannot obtain sufficient protein sources from domestic animals (Alves et al. 2009).

Generally, studies on hunting and bushmeat utilization are still scarce in Brazil (Alves and Souto 2011) and concentrated in the Amazonian region (Alves and Souto 2011; Mesquita and Barreto 2015; Peres and Nascimento 2006; Torres 2013; van Vliet et al. 2014, 2015); very few studies are available for the Brazilian semi-arid region (particularly the Caatinga biome, a tropical dry forest) (Alves et al. 2009; Alves and Souto 2011; Fernandes-Ferreira et al. 2012; Miranda and Alencar 2007). In Caatinga, hunting plays an important socioeconomic role and the meat of wild animals constitutes an important protein source for several rural and urban communities, especially during the seasonal drought periods, when crops become scarce and domestic animals are decimated by starvation and thirst (Albuquerque et al. 2012; Alves et al. 2009).

The use of wild animals for food is a common practice and one of the major motivations for hunting in Caatinga. Nonetheless, it is worth mentioning that hunting and use of wildlife in Caatinga have become regarded as threats to some vertebrate species (Alves et al. 2009; Fernandes-Ferreira et al. 2012; Ministério do Meio Ambiente 2014), thus highlighting the importance of understanding such activities in this region.

Indeed, unsustainable bushmeat consumption within the tropics threatens both wildlife populations and the livelihoods of people who depend on these resources (Robinson and Bennett 2004). Awareness of the bushmeat harvest has increased enormously in recent years, and, besides of its conservation concerns, it has also been of interest to development agencies (Brown and Williams 2003). The species chosen, the socioeconomic context of wildlife exploitation and the motivations for hunting are essential aspects of understanding the form of use and degree of threat that hunting causes to wildlife. In this sense, ethnozoological studies are essential to the development of effective management strategies for regulating hunting and use of faunistic resources sustainably (Alves 2012; Alves and Souto 2015).

This is the first study to assess bushmeat consumption in the Brazilian semi-arid region and was based on the following questions: (1) Which are the main taxonomic groups consumed as bushmeat in Caatinga? (2) Does the consumption of bushmeat follow the trends observed in the Amazon? (3) What is the influence of socioeconomic aspects on this activity? (4) Is there any relationship between seasonality and bushmeat consumption? By investigating the patterns of bushmeat consumption in Caatinga, we expect to stimulate further discussions about the cultural and socioeconomic ties that allow hunting practices to persevere in that region despite legal implications, since wildlife hunting is forbidden in Brazil. Moreover, we hope that this assessment may support management actions towards the sustainability of this practice in Caatinga, as well as allowing comparative analyses with other biomes.

Methods

Study area

The present study was carried out in the municipality of Pocinhos, located in the semi-arid region of Paraíba State, north-eastern Brazil. Pocinhos is 630 km^2 in area, with approximately 17,032 inhabitants. The average annual temperature is 23 °C, varying little throughout the year. The region has a very low rainfall rate, fluctuating annually between 400 and 600 mm. The climate is hot, semi-arid, with rainfall in the autumn and winter months, and the vegetation is dominated by sub-deciduous and deciduous forests typical of semi-arid regions (Alves et al. 2009). Agriculture and commerce are the main economic activities of the municipality.

Procedures

Information on the species hunted was obtained through semi-structured questionnaires complemented by semi-structured interviews (Albuquerque et al. 2014; Huntington 2000), which were applied to 124 hunters. Questionnaires encompassed the following aspects: local name of the animals hunted; reasons for hunting these animals; hunting place areas; hunting techniques; frequency of bushmeat consumption; preference of meat of wild species; and why

the interviewee consumed bushmeat. Socioeconomic data (per capita income, age and schooling) were also gathered through interviews (Table 1).

Bushmeat consumption was monitored from October 2010 to September 2011; despite our attempts at monitoring as much hunters' residences as possible, we got permission of only 36 interviewees. This is a common situation faced by ethnozoological researchers in Brazil: as wildlife hunting is forbidden in the country, potential interviewees mostly look at researchers with suspicion (Alves and Souto 2011). On the other hand, our sampling was favoured by the fact that the first two authors hail from the study area, and many hunters were of their previous knowledge. This rendered hunters more confident to provide the information, allowing the monitoring of bushmeat consumption in their residences.

Hunters were supplied with 5-L plastic buckets, filled with alcohol 96°, in which they were asked to store the heads of every wild animal consumed during the sampling period. Hunters (and their families) were instructed to separate the heads by species in plastic bags, which were then identified with the animals' vernacular names using tracing paper tags. The heads were collected fortnightly from every hunter's home, identified and counted. After analysis, heads were deposited at the zoological collections of the Universidade Federal da Paraíba. Samples were collected with the permission of the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) and the Sistema de Autorização e Informação em Biodiversidade (SISBIO), license number 25926-2.

Table 1 Socioeconomic conditions of the households interviewed ($n = 36$)

Age categories	
25 or younger	8 (22 %)
26–35	8 (22 %)
36–45	7 (19 %)
46–55	7 (19 %)
56 or older	6 (18 %)
Per capita income (Brazilian Real)	
Undeclared	1 (3 %)
Lesser than 100	7 (19 %)
101–200	16 (44 %)
201–300	4 (11 %)
301–400	5 (14 %)
More than 400 (maximum 633.00)	3 (8 %)
Educational attainment	
Illiterate	9 (25 %)
Attended school for 8 years	20 (55.5 %)
Attended school for less than 8 years	2 (5.5 %)
Finished high school	5 (14 %)

Ethical approval for the study was obtained from the Ethics Committee of Hospital Lauro Wanderley (protocol number: CEP/HULW no 103/10).

Data analyses

In order to verify whether socioeconomic aspects (hunter income, age and number of schooling years) predicted bushmeat consumption (biomass) of the three taxonomic categories analysed in this study (mammals, reptiles and birds), a multiple regression analysis was performed. Pearson's correlation coefficients were used to verify further relationship between household size and biomass of animals consumed. A two-way ANOVA (Tukey's post hoc applied for multiple comparisons) was performed to verify: (1) possible differences in biomass and the number of specimens consumed by taxonomic group (mammals, reptiles and birds); and (2) seasonal variation of consumption (rainy season and dry season). All data were normally distributed and homoscedastic.

Biomass values were determined by multiplying the number of specimens consumed by the average body mass recorded for each species in the literature (mammals: Bonvicino et al. 2008; Hayssen 2011; McBee and Baker 1982; Reis et al. 2011; birds: Dunning 2007; reptiles: Meiri 2010). Extrapolations of animals specimens and biomass consumed to the total number of interviewees were solely performed considering mammals and birds, as reptiles was consumed by less than 50 % of the monitored households.

Results

According to all respondents ($n = 124$), 58 vertebrate species could potentially be consumed as bushmeat in the region surveyed. Nevertheless, the samples provided by monitored hunters ($n = 36$) comprised only 28 species (Table 2), of which birds were the most consumed category recorded ($n = 19$ species), followed by mammals ($n = 7$) and reptiles ($n = 2$). Of the most frequent species recorded (in terms of number of specimens sampled), we highlight the mammals *Galea spixii* (Spix's yellow-toothed cavy) ($n = 20$ specimens), *Conepatus semistriatus* (Striped hog-nosed skunk) ($n = 19$ specimens) and *Euphractus sexcinctus* (Six-banded armadillo) ($n = 16$ specimens), and the birds of the families Columbidae and Tinamidade (see Table 2). Regarding reptiles, only two lizard species were recorded: *Tupinambis merianae* (tegu) ($n = 10$ specimens) and *Iguana iguana* (Green Iguana) ($n = 2$ specimens).

During the monitoring period, 32 households consumed 1821 birds (total biomass = 208.9 kg; 5.8 ± 1.1; mean ± 95 % confidence interval), while 19 consumed 65 specimens of mammals (166.8 kg; 4.6 ± 1.1); reptiles

Table 2 Bushmeat species consumed by hunters' families ($n = 36$) in the municipality of Pocinhos, in the Brazilian semi-arid

Family/species/vernacular name	Number of specimens	Mean biomass per specimen (g)[a]	Total biomass (g)
Reptiles			
Teiidae			
Tupinambis merianae (Duméril and Bibron 1839)—lizard, "tegu", "tejuaçú"	10	1118	11,180
Iguanidae			
Iguana iguana (Linnaeus 1758)—common iguana, "camaleão"	2	1530	3060
Birds			
Tinamidae			
Crypturellus parvirostris (Wagler 1827)—yellow-legged tinamou, "lambu pé vermelho"	48	200	9600
Crypturellus tataupa (Temminck 1815)—tataupa Tinamou, "lambu pé roxo"	281	219.5	61,679.5
Nothura boraquira (Spix 1825)—white-bellied nothura, "cordoniz"	124	283	35,092
Nothura maculosa (Temminck 1815)—spotted nothura, "Lambu espanta boiada"	93	247	22,971
Rallidae			
Gallinula chloropus (Linnaeus 1758)—common moorhen, "galinha-d'água"	2	305	610
Cariamidae			
Cariama cristata (Linnaeus 1766)—red-legged "seriema"	3	1400	4200
Charadriidae			
Vanellus chilensis (Molina 1782)—southern lapwing, "Tetéu"	2	327	654
Columbidae			
Columbina minuta (Linnaeus 1766)—plain-breasted ground dove, "Rolinha cambuta"	330	32.3	10,659
Columbina talpacoti (Temminck 1810)—Ruddy ground dove, "Rolinha vermelha"	12	45.6	547.2
Columbina picui (Temminck 1813)—Picui ground dove, "Rolinha branca"	558	47	26,226
Claravis pretiosa (Ferrari-Perez 1886)—blue ground dove, "Rolinha Azul"	14	68.2	954.8
Patagioenas picazuro (Temminck 1813)—picazuro pigeon, "Asa branca"	3	279	837
Zenaida auriculata (Des Murs 1847)—eared dove, "Ribaçã" "Avoante"	226	89.3	20,181.8
Leptotila verreauxi (Bonaparte 1855)—white-tipped dove, "Juruti"	98	134	13,132
Psittacidae			
Aratinga cactorum (Kuhl 1820)—Caatinga parakeet, "Gangarra, maroca"	3	1	3
Cuculidae			
Coccyzus melacoryphus Vieillot 1817—dark-billed cuckoo, "Largateiro"	13	49.9	648.7
Guira guira (Gmelin, 1788)—guira cuckoo, "Anum branco"	2	141	282
Turdidae			
Turdus rufiventris Vieillot 1818—rufous-bellied thrush, "Sabiá vermelho"	8	69.5	556
Bucconidae			
Nystalus maculatus (Gmelin 1788)—spot-backed puffbird, "Fura barreira"	1	42	42
Mammals			
Dasypodidae			
Euphractus sexcinctus (Linnaeus 1758)—six-banded armadillo, "tatu peba"	16	4680	74,880
Dasypus novemcinctus (Linnaeus 1758)—nine-banded armadillo, "tatu galinha"	4	4000	16,000
Echimydae			
Thrichomys apereoides (Lund 1839)—common Punaré, "punaré"	1	266.6	266.6
Caviidae			
Galea spixii (Wagler 1831)—Spix's yellow-toothed cavy, "preá"	20	275	5500
Kerodon rupestris (Wied 1820)—rock cavy—"mocó"	3	855	2565
Mephitidae			
Conepatus semistriatus (Boddaert 1785)—striped hog-nosed skunk, "ticaca"	19	3050	57,950
Myrmecophagidae			

Table 2 continued

Family/species/vernacular name	Number of specimens	Mean biomass per specimen (g)[a]	Total biomass (g)
Tamandua tetradactyla (Linnaeus 1758)—collared anteater, Southern Tamandua, "Tamanduá-de-colete", "Tamanduá-mirim"	2	4830	9660
Total	1898		389,937.6

[a] Mean biomass values were determined according the literature (mammals: McBee and Baker 1982; Bonvicino et al. 2008; Hayssen 2011; Reis et al. 2011; birds: Dunning 2007; reptiles: Meiri 2010)

comprised only 12 specimens, consumed by four households (14.2 kg; 0.4 ± 0.2). An extrapolation to the total number of hunters interviewed ($n = 124$) indicated an annual consumption estimate of 6638 bird specimens (719,461.7 kg) and 223.8 mammals (534.4 kg). It is worth noting that 32 hunters (25.8 % of the total interviewees) stated that parts of the hunted animals are either consumed at the hunting camps or sold to third parties, therefore suggesting that the number of animals hunted and consumed must be higher.

The number of specimens consumed differed significantly between taxonomic categories ($F_{2,30} = 25.78$; $P < 0.001$). Specifically, bird specimens were consumed more in comparison with mammals and reptiles (Tukey's post hoc, $P < 0.05$); no difference was found between the latter two groups. Moreover, birds and mammals did not differ in terms of biomass, but accomplished higher consumed biomass values than reptiles ($F_{2,30} = 10.22$; $P < 0.001$; Tukey's post hoc, $P < 0.05$).

Our analysis showed that seasonality (dry and rainy periods) did not predict the number of specimens consumed ($F_{1,30} = 0.007$; $P = 0.93$), and there were no significant interactions between seasons and the taxonomic categories consumed by hunters ($F_{2,30} = 0.003$; $P = 0.99$). The same was observed for biomass values: there were no differences between seasons ($F_{1,30} = 0.32$; $P = 0.57$), nor were there interactions among seasons and taxonomic categories ($F_{2,30} = 0.17$; $P = 0.84$). Seasonality in consumption was only recorded for the species *Zenaida auriculata*, which was more intensely consumed between March and June 2011 ($n = 211$ specimens; biomass = 18.842 kg). During the year sampled (2011), monthly precipitation levels were higher than 70 mm from March to August, which corresponded to the rainy season.

Hunters also stressed that bushmeat has a better flavour than the meat of domestic animals. Nevertheless, due to the difficulty in obtaining the bushmeat, its consumption occurs occasionally, especially during parties or special occasions, when hunters receive important visitors (such as local authorities) or relatives who live apart from the family. It is also a common practice in the region to present friends and relatives with bushmeat as a gift. Bushmeat biomass and hunters' socioeconomic data (income, age or schooling) were not correlated in terms of the consumption of bushmeat ($r^2_{\text{adjusted}} = 0.0020$; $F_{2.32} = 1.02$; $P = 0.39$). Likewise, there was no relationship between socioeconomic data and the biomass of birds ($r^2_{\text{adjusted}} = 0.0074$; $F_{1,34} = 0.74$; $P = 0.39$), mammals ($r^2_{\text{adjusted}} = 0.017$; $F_{1,34} = 1.62$; $P = 0.21$) and reptiles ($r^2_{\text{adjusted}} = 0.045$; $F_{2,33} = 1.83$; $P = 0.17$). Moreover, household size did not correlate with either the total biomass of animals consumed ($r = 0.0058$; $P = 0.73$) or with the animal groups separately (reptiles: $r = -0.0429$, $P = 0.80$; birds: $r = -0.2791$, $P = 0.1$; mammals: $r = 0.0148$, $P = 0.93$). It should be highlighted that, in general, the interviewees had low income (mean R$188 per capita) and schooling and that bushmeat represents a source of protein, as well as a source of income for the acquisition of other commodities, especially for those hunters with lower incomes. For instance, of the eight monitored hunters who reported an income up to R$80 per capita, six traded part of the animals they captured.

The majority of respondents ($n = 99$; 79.8 %) in the surveyed area stated that the populations of some species, such as *Dasypus novemcinctus* and *Puma yagouaroundi*, appeared to be declining.

Discussion

Unsurprisingly, bushmeat consumption is a persistent activity in the surveyed area, despite prohibition by Brazilian legislation, corroborating a situation that has been reported in other localities in the semi-arid region in the country (Albuquerque et al. 2012; Alves et al. 2009; Barbosa et al. 2011; Fernandes-Ferreira et al. 2012). Irrespective of the lower vertebrate richness acknowledged to exist in Caatinga in comparison with the Amazon biome, the number of wild vertebrate species potentially used as food in this study was similar to that reported in some localities in the Amazonian tropical forests (Redford and Robinson 1991). Although hunters generally consume more mammals than birds in the Neotropics (Melo et al.

2014; Mesquita and Barreto 2015; Redford and Robinson 1987), and despite mammals comprised the food resource preferred by hunters in the surveyed area (due to their larger body size and therefore larger quantities of meat per animal), the avifauna formed the major vertebrates consumed as bushmeat in the region, although the biomass of both groups consumed by respondents was similar. These results appeared to reflect the trends of richness in the Caatinga biome, where 511 species of birds and 156 species of mammals have been recorded (Albuquerque et al. 2012). Moreover, in comparison with other Brazilian biomes (such as Amazonia, Cerrado and Atlantic Forest; Paglia et al. 2012), Caatinga presents a lower richness for large-sized mammals, therefore reflecting the capture of small-sized animals with cinegetic potential, such as birds (Albuquerque et al. 2012; Fernandes-Ferreira et al. 2012; Stearman and Redford 1995). Some authors also relate the high capture rate of birds in Caatinga to the ease with which these animals can be captured, by both active hunting and the use of several non-selective traps (Alves et al. 2012a; Bezerra et al. 2012; Fernandes-Ferreira et al. 2012), particularly during drought periods, when birds typically aggregate in the vicinity of water bodies (Alves et al. 2009, 2013; Bezerra et al. 2012).

One might expect that the consumption of bushmeat in the surveyed area would fluctuate throughout the year, since Caatinga's seasonality, with clearly separated dry and rainy periods, influences the ecology of several species (Alves et al. 2009). However, our results highlighted that, although population sizes may fluctuate, all game species can be captured throughout the year in Pocinhos. This was not surprising, since the local fauna is typically characterized by drought-resistant species, which are well-adapted to the seasonality of the area (Mares et al. 1985). The only exception to this trend was the bird species *Z. auriculata*, which has a migratory behaviour, moving from Middle-Southeast to Northeast Brazil at the end of this region's winter period (March–June), and forming breeding aggregations in areas of the Caatinga (Bucher 1982). It should be stressed that the composition of the game fauna in Caatinga has been altered in recent years, since populations of several important species appear to have declined in many areas (Albuquerque et al. 2012; Alves et al. 2012a; Barboza 2013). Among such species, we highlight: some medium- and large-sized mammals, such as *Mazama guazoupira*, *M. americana*, *Tayassu tajacu*, *Cuniculus paca* and *Dasyprocta prymnolopha*, and game birds such as *Penelope jacucaca* and *Crypturellus noctivagus zabele* (Alves et al. 2009; Fernandes-Ferreira et al. 2012). None of the interviewees reported the consumption of those species in our study, which certainly reflects their rarity/scarcity in the sampled area. A lack of consumption of species traditionally amply consumed in the past (e.g. deer, peccaries, some birds) raises concerns about the likelihood of local extinctions (Barboza 2013; Feijó and Langguth 2013). Furthermore, the lack of large-sized animals in Caatinga may result in a higher capture rate of smaller species, therefore leading to a higher likelihood that these populations will decline. Despite this, no species consumed by hunters in the surveyed area, including those reportedly in decline, are recorded in any available list of threatened species.

The hunting of wild animals in Pocinhos is influenced by a series of complex biological, socioeconomic, political and institutional factors, demonstrating the need to understand the multidimensional context within which effective conservation measures can be conceived. The lack of correlation found between socioeconomic factors and bushmeat consumption reflects the low variation in respondents' income. This is not surprising, considering that a large portion of the human population inhabiting this region is very poor, highlighting the fact that the capture of wild animals is indissolubly tied to socioeconomic factors (Alves et al. 2009). Furthermore, hunting is frequently influenced by cultural preferences (Alvard et al. 1997; Bennett and Robinson 2000; Coad et al. 2013; Hanazaki et al. 2009).

Besides their use as food, some game species are also used as pets or for medicinal and religious purposes (Alves et al. 2010b, 2012c; Bezerra et al. 2013; Confessor et al. 2009; Léo Neto et al. 2009; Martinez 2013; Roldán-Clarà et al. 2014). Such multiple uses should be considered when implementing recovery plans, especially for highly exploited species (Alves et al. 2009, 2010a, 2012c; Souza and Alves 2014). Other concerns relate to the fact that some species are persecuted and killed due to conflict with people, which may include attacks on livestock, risk to human lives, destruction of crops and risk of disease transmission (Alves et al. 2012b; Fernandes-Ferreira et al. 2012, 2013; Mendonça et al. 2011). The main taxa involved in such conflicts are reptiles, mammals (particularly carnivores) and, to a lesser extent, birds (granivores or falconiformes) (Alves et al. 2012b; Mendonça et al. 2011, 2014). Conflicting interactions between wildlife and human communities are extremely important from a conservation perspective and represent a significant challenge for conservation managers, who must try to benefit all parties involved.

The persistence of the consumption of wild vertebrates in the study area reinforces the socioeconomic and cultural importance of such practice, and highlights the ineffectiveness of current measures adopted by the Brazilian environmental agencies to inhibit it (Alves et al. 2009). Indeed, despite their notorious legal implications, hunting and bushmeat consumption are recurrent activities recorded in all Brazilian regions (Barbosa et al. 2011; Bodmer et al.

1997; Fernandes-Ferreira et al. 2012; Hanazaki et al. 2009; van Vliet et al. 2014). In this context, prohibition leads to enhanced conflicts and makes the exploitation and use of wildlife by-products a clandestine activity, which certainly contribute to the dearth of detailed information on that matter, thus hampering appropriate management measures.

Conservation concerns about hunting and consumption of game species have been emphasized in several studies (Alves et al. 2009; Bailey 2000; Bodmer et al. 1997; Silvius et al. 2004). In Caatinga, in particular, hunting has been referred by interviewees as one of the causes of decline of several game species which were historically hunted, but have not been caught recently in that biome. As a result, hunting focus shifted to non-targeted species (e.g. low-sized animals), as reported in this study.

This scenario becomes aggravated as several factors other than hunting are affecting animal populations in the Caatinga biome (Alves et al. 2009). For instance, non-sustainable slash-and-burn agriculture, and the continuous use of native pastures for goat and cattle husbandry, are causing environmental impoverishment on a huge scale in the Caatinga biome (Albuquerque et al. 2012; Leal et al. 2005). This trend has been recorded in other dryland regions worldwide, where, in response to the increasing demand for food, water and other natural resources, people are frequently forced to intensify their use of those limited natural resources, which leads to further degradation of impacted ecosystems (Ffolliott 2012).

Overhunting of wildlife in the Brazilian semi-arid must therefore be considered alongside other anthropogenic pressures, particularly habitat loss. Actually, those factors have been stressed as the major threats to game vertebrates in that region. For instance, some well-known as game animals in Caatinga, although not recorded in this study, such as the birds *P. jacucaca* and *Crypturellus noctivagus zabele*, are currently threatened by extinction due to such pressures (MMA 2012).

Finally, conservationist strategies must therefore aim to reconcile and integrate both the wildlife conservation and human need perspectives. Indeed, the success of potential conservation and management strategies requires the establishment of networks among academic and governmental institutions, as well as human communities involved in hunting, as several ethnozoological studies have shown that hunting and the use of animals resources are well-disseminated practices in the semi-arid. Hence, reduction in hunting pressure, especially of the most targeted species, has commonly been pointed out as an essential conservation, and wildlife management strategy may not be feasible in many rural settings for a variety of reasons (Alves et al. 2009). For instance, in the case of the Brazilian semi-arid region, where hunting involves several aspects (i.e. biological, political and institutional), measures should guarantee the sustainability of hunting for subsistence (the only condition in which hunting is allowed in the country). In order to minimize the impacts of wild fauna harvesting, regulations should focus on developing wildlife management educational programmes, with robust environmental legislation components and effective enforcement of wildlife laws against illegal hunting and trade of game species. Furthermore, it is recommended the adoption of measures which promote ecosystems protection and recovery. In Paraíba State, this could be improved with the creation of priority conservation areas in the Caatinga biome, thus ensuring protection to targeted cinegetic species, particularly those with population declines due to hunting and habitat degradation.

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