ETHNOBIOLOGY AND CONSERVATION

REVIEW

Ethnobiology and Conservation 2015, 4:2 (26 January 2015)
doi:10.15451/ec2015-1-4.2-1-14
ISSN 2238-4782 ethnobioconservation.com

Evaluation of Mammals Hunting in Indigenous and Rural Localities in Eastern Brazilian Amazon

Geison Pires Mesquita[1]* and Larissa Nascimento Barreto[2]

ABSTRACT

Hunting is responsible for the decline of more than half of all mammal species from Brazil; however, very few studies relating to hunting exist for the Eastern region of the Amazon. Medium and large-sized mammals are valued for their protein and are thus more affected by hunting activity. Four published studies on hunting in the region (in Pará, Mato Grosso, Amapá and Maranhão, respectively) were quantitatively analyzed and used to determine the biomass and extraction rates of species and groups of species, considering the characteristics of each group, as well as the differences and similarities in composition in each type of game in the locality. These four published studies, two were in communities indigenous (Pará and Maranhão) and others two in rural communities (Mato Grosso and Amapá) A total of 32 species from eight orders and 17 families were hunted, totaling 32,726,990 kilograms of game meat with a positive correlation between biomass, the number of animals slaughtered and the number of species. Ungulates were the most hunted group, from which the most biomass was obtained. Concerning food preferences, frugivorous represented the highest number of species hunted and also the highest biomass, and a positive correlation existed between the extraction rate and ungulate biomass. There was no significant difference between the diversity of mammals of different indigenous and rural localities; however, from a multidimensional analysis of the localities, A'Ukre (Pará) and Alto Turiaçu (Maranhão) were more similar to each other, and were more distant from the other groups. Knowledge concerning which species and groups and how many animals are hunted in each locality is necessary to direct conservation management plans and increase their efficiency within localities.

Keywords: *Biomass, Eastern Amazonia, Hunting, Indigenous, Mammals, Rural Communities*

INTRODUCTION

Hunting has been responsible for the decline of more than half of the mammals of Brazil, affecting 53.6 percent of species, and has caused the local extinction of entire populations within a short period of time, such as those of large primates, and a reduction in medium and large-sized prey, precluding the permanence of these species (Robinson and Bodmer 1999; Machado et al. 2008). Although the leading cause of biodiversity loss in tropical forests is currently the destruction of habitats, hunting is the greatest threat to tropical biodiversity in areas of extant forest (Redford 1992; Peres 2000a). Hunting has been practised by man in many different environments around the world for thousands of years. Today, due to the large population growth mainly in the tropics the forest area has reduced significantly, resulting in increased hunting pressure on top of the remaining forest areas. Medium and large-sized mammals

1 Biology Departament, Federal University of Maranhão, 65080-805, São Luís, MA, Brazil.

* Corresponding author – E-mail adress: mesquita.geison@gmail.com

2 Ecology and Limnology Department, Federal University of Maranhão, 65080-805, São Luís, MA, Brazil.
E-mail adress: laraufma@yahoo.com.br

from tropical forests such as the Amazon are very sensitive to human action, because they are large species and low in population density, in addition to being animals from high trophic levels, in some case with specific diets, which further increases their dependence on the presence of other animals that serve as food (Machado et al. 2008). Several studies in tropical forests have shown that the number of mammals in these areas is not a sufficient protein source alone for humans within these localities, and the load capacity of these habitats is only one person per square kilometer when the main source of protein derives from game hunting (Peres 1990; Robinson and Redford 1991a; Redford 1992; Bodmer et al. 1997; Robinson and Bennett 2000; Peres and Nascimento 2006; Baia Júnior et al. 2010; Strong et al. 2010), which can lead to overexploitation and local extinction.

Despite being the second largest cause of local extinctions of mammals in Brazil, commercial hunting is an illegal activity, and a criminal offense provided for in the Environmental Crimes Law (Law 9605/1998) and the Wildlife Protection Act (Law 5197/1967). However, mainly in the Amazon region of Brazil, which contains the largest number of indigenous and traditional localities in the country, hunting for the purpose of household consumption is considered lawful in accordance with Decree 6040/2007 of the National Population and Traditional Communities. Therefore, subsistence hunting is one of the legal forms of hunting performed by various traditional localities.

Within the context of subsistence hunting in South America, Jerozolimski (1998) compiled and analysed 54 studies on subsistence hunting and showed that the population of large mammals is negatively affected by increasing hunting pressure and that this pressure also increases in proportion to the number of hunted species. The territory "Amazônia Legal" is composed of nine Brazilian states (Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins and part of the states of Mato Grosso and Maranhão), which occupy a total area of 5,016,136.3 km^2 that corresponds to 59 percent of the whole Brazilian territory (SUDAM 2012). Within this area, the eastern region since 1960 has experienced mineral exploration from mining, the deployment of railways and ports and consequently, the expansion of roads and cities as a function of regional urbanization and population growth. Currently, the eastern Amazon suffers considerably from human action and has high rates of destruction, such as deforestation and burning of forest areas (INPE 2012). Less forest and more people places a greater pressure on the wildlife that still survives in unaffected areas, and game hunting is the main problem for local biodiversity and is the basis of the "empty forest" phenomenon (Redford 1992; Nasi et al. 2011), in which the density of the animals in these areas is reduced to such a level that does not allow them to exercise the ecological role necessary for the biome.

There is a vast literature related to hunting in the Amazon region (Peres 1997, 2000a, b, 2001; Peres and Nascimento 2006; Martins and Oliveira 2011). Although studies have different aims, they generally demonstrate the impact caused by hunting and the levels of exploitation that relate to hunting pressure (Peres 2000a), sustainability and patterns of hunting (Peres 1997; Ramos et al. 2008; Parry et al. 2009a), the relationship between body size and population density of the hunted species (Peres 1990) and the importance of controlling hunting for the conservation of mammals (Bodmer et al. 1997). Despite the various studies in the Amazon region, few relate to hunting conducted within the eastern area of the Amazon, which is currently considered the Amazonian region that suffers the most from human impact (Martins and Oliveira 2011). Thus, this study contributes to a better understanding of the hunting of mammals in the eastern Amazon region by providing a novel approach and using information from existing data to serve as a basis for management and conservation strategies.

Of all groups of animals in the world, mammals are the most targeted by hunters and therefore suffer most from this activity, partly due to their high protein value and also because they are considered as trophies (Robinson and Bennett 2000). Therefore, this study only considered medium and large-sized mammals, which are the main targets of hunting in the eastern region of the Brazilian Amazon. The aim was to compile available studies and to evaluate the composition of hunted mammals of traditional indigenous and

rural localities, to determine the principal species hunted and the preference of certain mammals by hunters in each locality.

MATERIAL AND METHODS

Data Set — The data considered in this study were collected from a detailed review of the literature on hunting within the Eastern region of the Amazon in the last 10 years. The eastern Amazon includes the states of Amapá, Pará, Tocantins and the region west of the meridian of 44° west longitude in the states of Maranhão and Mato Grosso (SUDAM 2012). The requirements of the papers considered in this study were that they should: (1) Study some of the states that form the eastern Brazilian Amazon; (2) provide data on the number of mammal individuals at the species level; (3) provide information on the locality and area where data were collected; and (4) have a minimum duration of six months. Despite the vast literature on hunting in the Amazon, few studies of this type have been performed in the eastern Amazon. In this meta-analysis, were considered four studies conducted in four differents states (Peres and Nascimento 2006; Trinca and Ferrari 2007; Parry et al. 2009b; Martins and Oliveira 2011; in Pará, Mato Grosso, Amapá and Maranhão, respectively) within the "Amazônia Legal", two were conducted in indigenous localities in Pará and Maranhão, and two in traditional rural localities in Mato Grosso and Amapá. All the data of the four studies were colleted in consecutives months and do not consider seasonal variation, with exception of the Peres and Nascimento (2006) that consider monthly variation in daily game biomass and relates with the river water level. For each of the four studies, the compiled data consisted of the number of slaughtered species, the diet of each species, the body mass, population biomass and the duration of the study in days. When data were not available, the studies of Queiroz (1992), Peres (2001), Peres and Nascimento (2006), Kings et al. (2011) were used. Medium to large-sized mammals were considered in this study, following the taxonomic classification of Wilson and Reeder (2005), in which medium-sized mammals are those whose adults weigh between 1 and 14.9 kg, and large mammals weigh more than 15 kg. Therefore, *Sylvilagus brasiliensis* (Linnaeus 1758), *Pithecia pithecia* (Linnaeus 1766) and *Myoprocta acouchy* (Erxleben 1777) were considered in this study, because they have a mean body mass >1 kg, although they are small mammals. Food categories and species taxonomies followed Robinson and Redford (1986) and Reis et al. (2011), who considered six categories: carnivorous (C), herbivorous–granivorous (HG), herbivorous–folivorous (HF), frugivorous-herbivorous (FH), frugivorous/granivorous (FG), frugivorous/omnivorous (FO), insectivorous/omnivorous (IO) and myrmecophagous (M). To recognize the degree of threat to species, national and international lists of endangered species (Machado et al. 2008; IUCN 2014) were used.

Biomass and Extraction Rate — The biomass (kg/km^2) of each species was used to determine the relative contribution of each group to the total biomass killed by hunting and the number of slaughtered species was used to determine the annual rate of extraction (number slaughtered/year). Annual rates of extraction for sites were estimated as the number of animals slaughtered in the site during the study period in days, and the annual extraction of species was estimated by the number of animals slaughtered in all locations where the species appeared for a period of one year. Correlation analyses were performed, using regressions that were based on the best-fit curve and coefficient of determination, considering the species, orders and local studies.

Composition of Hunting by Localities — Species diversity was calculated for each of the four studies using the rates of Margalef D(mg) for random samples, Pielou's Equitability (J') and Simpson's heterogeneity. The Margalef index was used to offset the effect of different sizes of samples, this index quantifies the alpha diversity through a functional relationship between the number of species and the total number of individuals (Magurran 2004).These three indices were used to reduce the underestimation and bias resulting from the use of only one of the indices (Zar 2010; Magurran 2004). The Kruskal–Wallis test

(Siegel 1956) was used to compare the indices, since the data did not meet the assumptions of normality and homoscedasticity, and three or more independent samples were compared.

The hierarchical clustering method of weighted average (UPGMA) (Sneath and Sokal 1973) was used to sort and group the species of hunted mammals using the Bray–Curtis distance, from data compiled from the four studies. Firstly, the study sites were grouped according the presence/absence data of species slaughtered, and subsequently, the species were grouped according to their record within the study. A multi-dimensional NMDS ordination analysis using the Jaccard index was also performed for two dimensions, with 500 interactions and Varimax rotation, both for the species and study sites. Multidimensional scaling was used as a complementary technique to visualize the behaviour of the species and study sites in reduced dimensions. For all analyses, significance levels of 5% were used, and were calculated using Statistica and PC-ORD 6.0 software.

RESULTS

General Features of Studies — The mean duration of the studies was 416.25 days (SD; 161.59), the annual rate of extraction was different among the four studies and ranged from 113 to 845 animals slaughtered/year (: 372.85). The mean biomass of the studies was 97.34 kg/km^2, with a minimum of 0.37 kg/km^2 in the study of Martins and Oliveira (2011) and a maximum of 276.51 kg/km^2 in Parry et al. (2009a).

A total of 32 species of mammals were identified: seven primates (three families), five Artiodactylas (two families), one Perissodactyla (one family), six rodents (four families), one Lagomorpha (one family), seven Carnivores (three families), two Cingulatas (one family) and three Pilosa (two families), taking into account that the species of armadillos were grouped as one species, with only *Priodontes maximus* separate from the others (Table 1). Considering all studies, the biomass of hunted species was positively correlated with the number of animals slaughtered, ($r = 0.70$; d.f. = 30; $P = 0.000$) (Fig. 1), as well as biomass in each study ($N = 32$; $r = 0.92$; d.f. = 2; $P = 0.037$), and for the number of species and total number of animals slaughtered in each study ($N = 4$; $r = 0.82$; d.f. = 2; $P = 0.093$). Animals were grouped at the level of super-order and order, and the extraction rates and biomass of species were analyzed, to verify that groups (primates, ungulates, rodents, carnivores and Xenarthra) showed a positive correlation (Fig. 1).

Table 1. Features, extraction rates, biomass and recording sites (PA-A'Ukre: MT-Japuranã; Jari-AP, MA-Caru and Alto Turiaçu) of the slaughtered species; Diet FH (Frugivorous-Herbivorous), FO (Frugivorous-Omnivorous), FG (Frugivorous-Granivorous), HF (Herbivorous-Folivorous), HG (Herbivorous-Granivorous), C (Carnivorous), M (Myrmecophagous)

Order/Family	Species	Common names	Diet	Body Mass (kg)	Extration rate			Recording sites	Biomass (kg/km2)
					N	X	SD		
Primatas									
Atelidae	*Alouatta belzebul*	Red-handed Howler Monkey	FH	6,5	17,00	4,25	6,65	PA, MA	0,18
	Alouatta macconnelli	Guianan Red Howler Monke	FH	6,5	23,00	5,75		AP	1,19
	Ateles paniscus	Black Spider Monkey	FH	9,02	8,00	2,00		AP	0,58
Cebidae	*Cebus apella*	Black-capped Capuchin	FO	3,24	227,00	56,75	98,00	PA, AP, MA	6,78
	Cebus kaapori	Ka'apor Capuchin	FO	3,05	1,00	0,25		MA	0,00
Pitheciidae	*Chiropotes satanas*	Black Bearded Saki	FG	2,4	100,00	25,00	49,34	PA, MA	2,03
	Pithecia pithecia	Golden-faced Saki	FO	2	1,00	0,25		AP	0,02
Artiodactyla									
Tayassuidae	*Tayassu pecari*	White-lipped Peccary	FH	32	319,00	79,75	64,84	PA, MT, AP, MA	117,55
	Tayassu tajacu	Collared Peccary	FH	21,7	171,00	42,75	26,59	PA, MT, AP, MA	44,65
Cervidae	*Odocoileus virginianus*	White-tailed Deer	HF	30	1,00	0,25		PA	0,26
	Mazama gouazoubira	Gray Brocket	FH	18	29,00	7,25	10,87	PA, AP	5,01
	Mazama americana	Red Brocket	FH	36	89,00	22,25	29,89	PA, MT, AP, MA	51,09
Perissodactyla									
Tapiridae	*Tapirus terrestris*	Brazilian Tapir	FH	150	47,00	11,75	14,45	PA, MT, AP, MA	60,86
Rodentia									
Caviidae	*Hydrochoerus hydrochaeris*	Capybara	HF	50	6,00	1,50	2,38	PA, MT	1,10
Cuniculidae	*Cuniculus paca*	Spotted Paca	FG	8,5	241,00	60,25	62,84	PA, MT, AP, MA	22,74
Dasyproctidae	*Myoprocta acouchy*	Red Acouchi	FG	1	1,00	0,25			0,01
	Dasyprocta agouti	Common Acouchi	FG	4,2	189,00	47,25	89,22	PA, MT, AP	46,12
	Dasyprocta prymnolopha	Black-rumped Agouti	FG	4,5	52,00	13,00		MA	0,03
Erethizontidae	*Coendou prehensilis*	Brazilian Porcupine	FG	4,5	5,00	1,25	1,89	AP, MA	0,14
Lagomorpha									
Leporidae	*Sylvilagus brasiliensis*	Tapeti	HG	1,2	1,00	0,25		PA	0,01
Carnivora									
Felidae	*Panthera onca*	Jaguar	C	35	8,00	2,00	1,41	PA, MT, AP, MA	2,37
	Leopardus pardalis	Ocelot	C	10,3	9,00	2,25	2,22	MT, AP, MA	1,69
	Puma yagouaroundi	Jaguarundi	C	6,5	2,00	0,50		MT, AP	0,39
	Puma concolor	Puma	C	30	3,00	0,75	0,96	MT, MA	0,16
Mustelidae	*Eira barbara*	Tayra	FO	4,8	1,00	0,25		MT	0,01
Procyonidae	*Potos flavus*	Kinkajou	FO	2,6	4,00	1,00		PA	0,09
	Nasua nasua	South American Coati	FO	3,1	48,00	12,00	18,02	PA, MT, AP, MA	1,15
Cingulata									
Dasypodidae	*various species*	Armadillos	IO	7,2	274,00	68,50	61,66	PA, MT, AP, MA	18,09
	Priodontes maximus	Giant Armadillo	M	43	7,00	1,75	2,36	PA, AP	2,53
Pilosa									
Megalonychidae	*Choloepus didactylus*	Southern Two-toed Sloth	HF	6	1,00	0,25		MA	0,00
Myermecophagidae	*Tamandua tetradactyla*	Southern Tamandua	M	3,1	1,00	0,25		PA	0,03

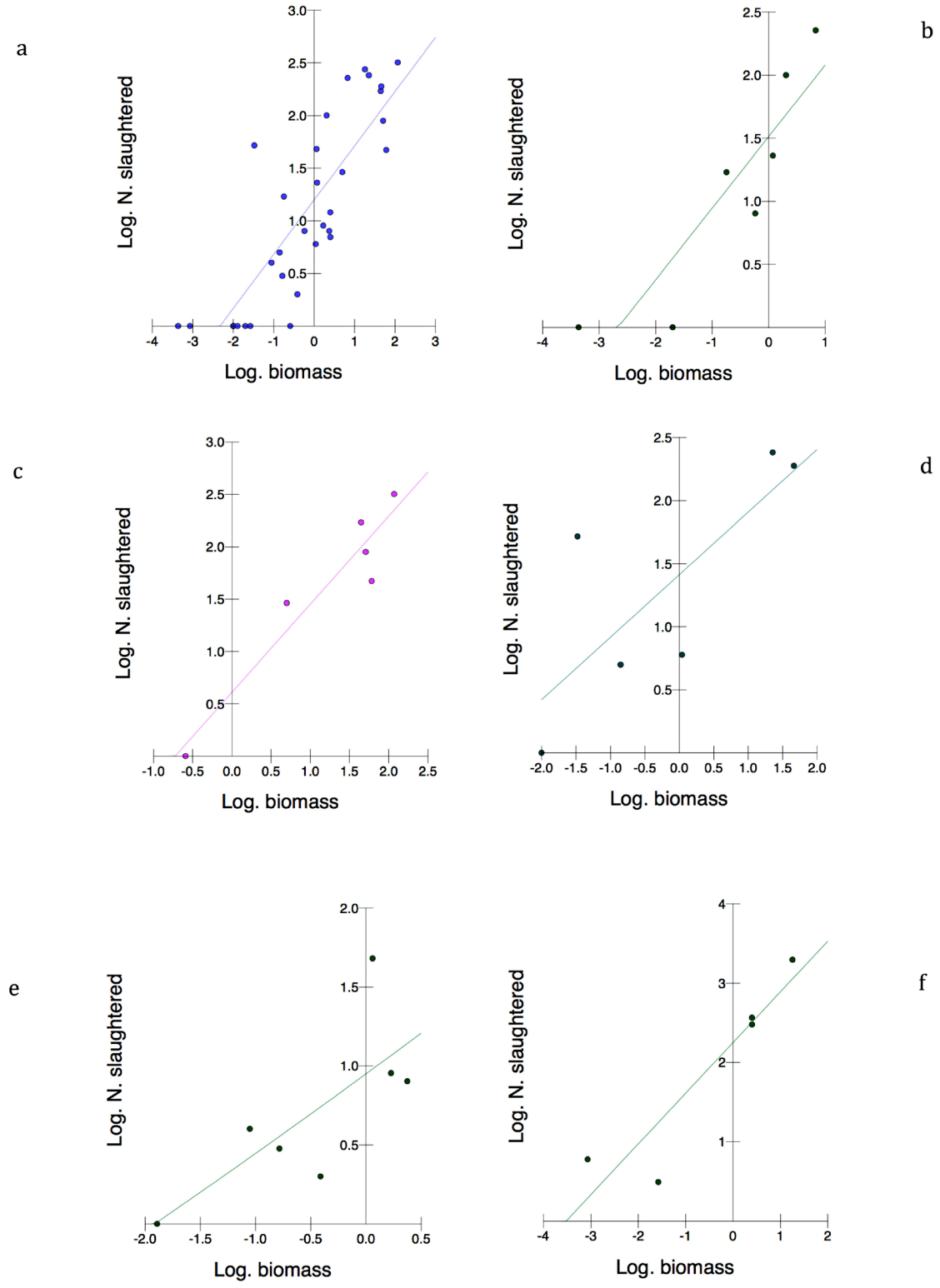

Figure 1. Regressions between biomass and the number of animals slaughtered by species and taxonomic groups of all studies. a - all species (r2=0.70; d.f.=30; P=0.000), b - Primates (r2=0.80; d.f.=5; P=0.006), c - Ungulates (r2=0.90; d.f.=4; P=0.003), d - Rodents (r2=0.59; d.f.=4; P=0.070) e - Carnivores (r2=0.60; d.f.=5; P=0.040) f - Xenarthra (r2=0.85; d.f.= 3; P=0.024)

Composition of Hunted Mammals — In total, 1,898 animals were slaughtered in all study sites, totaling 32,726.99 kg of meat. The group of ungulates was the most hunted, with 34.58 percent of the total, followed by rodents with 26.04 percent, both were the most representative groups relative the amount of game meat with respectively 75.55 percent and 10.38 percent of the total weight. Of the six animals with records in all four studies, three belonged to the super-order of ungulates (*Tayassu peccary*, *Tayassu tacaju* and *Mazama americana*). The White-lipped Peccary (*Tayassu peccary*) was the most-hunted animal and provided the most game meat of all 32 recorded species, accounting for 16.80 percent of total slaughtered animal meat and 31.19 percent of the game meat in the four studies. The weight of the game meat of the three species of ungulates alone contributed 52.32 percent of all meat in all studies. The number of slaughtered animals of medium-sized species (1.0 to 14.9 kg) was greater than that of large species (>15 kg), being respectively 63.54 percent and 36.46 percent of the total animals hunted; however, large species represented 79.63 percent of the total weight. Moreover, 73.98 percent of the biomass was provided by large mammals, i.e. ungulates, which also had the highest biomass among groups with 71.76 percent of the total, followed by rodents with 18.01 percent. Taking the feeding category into consideration, frugivorous–herbivorous represented highest number of species (25%), the greatest number of slaughtered animals (37.03%) and game meat (76.47%) and the greater biomass (72.19%). In general, frugivorous represented the majority of species (62.5%), the higher amount of slaughtered animals (82.87%), the amount of hunting meat (89.44%) and biomass (92.51%). The large amount of frugivorous is directly related to the large number of ungulates and rodents, since the most of the ungulados are frugivorous. For all frugivorous, ungulates and rodents, there was a significant positive correlation between the extraction rate and biomass ($r = 0.81$; d.f. = 8; $P = 0.003$), as well as between body mass and extraction rate ($r = 0.90$; d.f. = 8; $P = 0.000$). Based on the mean extraction by species (Table 1). Except for the species of armadillos of the Dasypodidae family, the most representative frugivorous species, such as *Cebus apella*, *Chiropotes satanas*, *Tayassu pecari*, *Tayassu tajacu*, *Cuniculus paca* and *Dasyprocta agouti*, also represented the highest extraction rate. Of all large animals hunted 45.45 percent were frugivorous, and this class contained all ungulates; i.e. all hunted large frugivorous belonged to the super-order of ungulates.

Hunting Locality Profile — Considering the diversity index Margalef, Pielou and Simpson), there was no significant difference between the diversities of mammals hunted in the four study sites ($H = 3$; d.f. = 3; $P = 0.3916$). However, the biomass of slaughtered animals in each study was significantly different ($H = 36.33$, df = 3, $P = 0.000$) and was higher in the localities A'Ukre (PA) and Jari (AP). The richness and abundance were also analyzed, to correlate them with diversity in each study. Thus, having defined the abundance class of each species harvested in each study site (12 classes, each with an interval of 16), a maximum of 16 individuals were killed for over 70 percent of the species. Therefore, there was no significant difference between the abundance classes of the four studies ($H = 3.434$, df = 3, $P = 0.329$).

Based on the analysis of aggregation of records of mammals hunted in all studies, a split into three groups was observed: PA-MA, MT and AP (Fig. 2a). The group of mammals hunted in the indigenous locality of A'Ukre (PA) showed a greater similarity to the mammalian group of the indigenous locality Caru and Alto Turiaçu (MA), whereas although the traditional rural localities Japuranã (MT) and Jari (AP) were more related to each other, they showed a value of similarity below the mean cut-off value that separated the two localities into two distinct groups based on the species hunted in the regions. Aggregating the species from hunting records, we identified five groups, the largest being formed by the species *Cebus apella*, *Tayassu peccary*, *Tayassu tacaju*, *Mazama americana*, *Tapirus terrestris*, *Cuniculus paca*, *Panthera onca*, *Nasua Nasua*, *Leopardus pardalis*, *Puma concolor* and *Coendou prehensilis* and the smaller formed by *Dasyprocta agouti*, *Puma yagouaroundi* and *Eira barbara* (Fig. 2b).

In parallel, the analysis of multi-dimensional NMDS ordination in two dimensions allowed

the visualization of similarities and differences between the four localities from the records of the species. The indigenous localities A'Ukre and Caru and Alto Turiaçu (MA) showed a greater proximity to each other, and a greater distance from the others. However, the traditional rural localities Japuranã (MT) and Jari (AP) were distant from each other, demonstrating differences in the mammals hunted in the regions (Fig. 3a). Similarly, distances and similarities between localities can be observed in the analyses of aggregation and ranking, demonstrating that there is a greater similarity between the composition of hunted animals and the indigenous localities A'Ukre Caru and Alto Turiaçu, and a greater difference between the composition of hunting in the traditional rural localities Jari and Japuranã and between these and other localities.

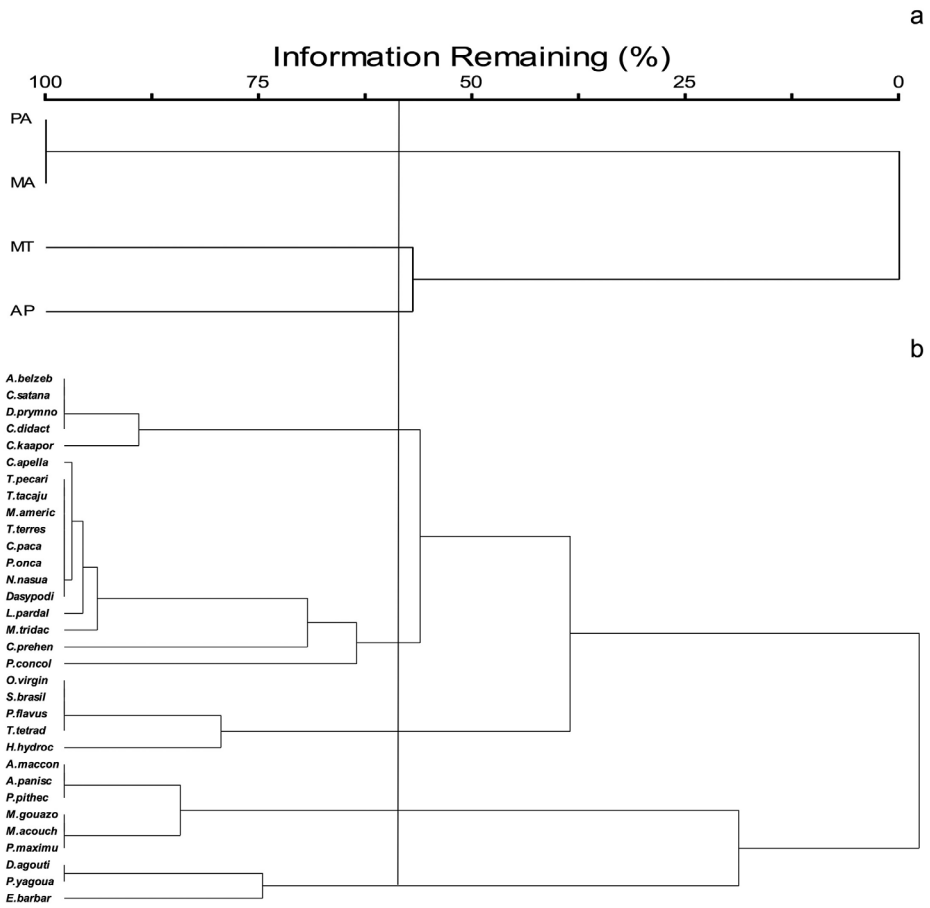

Figure 2. Dendrogram of similarity: (a) Among the study sites, (b) between species from the data records for each study site.

The ordering of species from hunting records in each locality also enabled the visualization of five major groups of species, which was consistent with the results of the analysis of aggregation. This ordering is an association of species hunted, with the localities in which they were hunted, showing a direct relationship between the species and localities. Group number four (Fig. 3 b), for example, was associated with the indigenous localities, since all species of this group were hunted in both localities Jari and Caru and Alto Turiaçu, or only in Caru and High Turiaçu. Group number three, the largest group, was mostly formed of species that were present in all localities. Group number

five contained species that were present only in A'Ukre, group number one comprised species hunted only in the traditional rural locality of Jari and group number two was formed of hunted species in localities A'Ukre and Jari or only Jari.

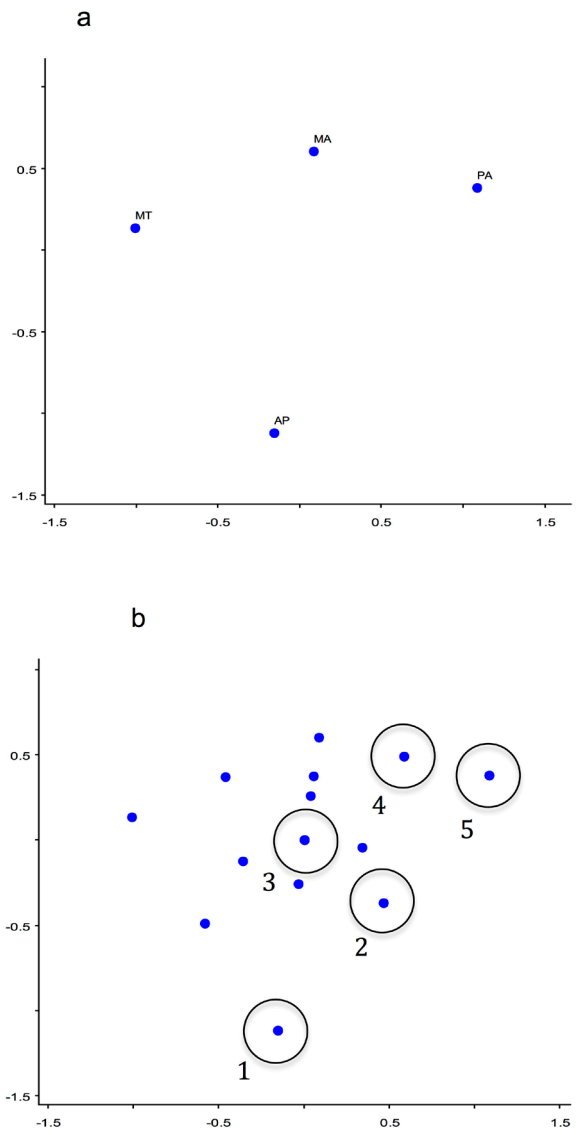

Figure 3. Non-metric Multidimensional Scaling (NMDS) of the locality studies (a) and of the species (b) from the records of slaughtered animals. Each point within the circle is a group of species formed from the multidimensional analysis: 1 (*A. paniscus, A. macconnelli, P. pithecia*), 2 (M gouazoubira, M. acouchy, *P. maximus*), 3 (*T . peccary, T. tajacu, M. americana, Tapirus terrestris, C. paca, P. onca, N. nasua, Dasypodidae*), 4 (A. belzebul, *C. satanas, D. prymnolopha, C. didactylus*), 5 (*O. virginianus, S. brasiliensis, P. flavus, T. tetradactyla*)

The similarities and differences of the localities from the diversity of slaughtered mammals might reflect the food preferences of existing rural and indigenous localities. Indigenous communities value primate meat (Peres and Nascimento 2006), whereas rural communities prefer large terrestrial mammals. For example, in the considered studies, indigenous localities contributed 85.67 percent of all slaughtered primates, 72.63 percent of their biomass, 85.71 percent of the total number of anteaters and sloths and 93.70 percent of their biomass. Some animals were hunted in only one locality, such as the White-tailed deer (*Odocoileus virginianus*), Tapeti (*Sylvilagus brasiliensis*), Kinkajou (*Potus flavus*), Southern Tamandua (*Tamandua tetradactyla*), which is only found in A'Ukre, or the Guianan Red Howler Monkey (*Alouatta macconelli*), Guianan Spider Monkey (*Ateles paniscus*), White-faced Saki (*Pithecia pithecia*), and Red Acouch (*Myoprocta acouchy*), only found only in Jari. The Tayra mustelid (*Eira barbara*) was hunted only in Juparanã, and the endangered primate Ka'apor Capuchin (*Cebus kaapori*), one species of Agouti (*Dasyprocta prymnolopha*) and the Southern Two-Toed Sloth (*Choloepus didactylus*) were hunted only in Caru and Alto Turiaçu. The largest group formed from the analyses of aggregation and ranking was mainly composed of species that were hunted in all localities (*Tayassu peccary, Tayassu tacaju, Mazama americana, Tapirus terrestris, cuniculus paca, Panthera onca, Nasua Nasua* and armadillos of the family Dasypodidae).

Among the studies considered here, that of Parry et al. (2009a) had a duration of 365 days conducted within a population of 5,600 inhabitants, and recorded 19 species, 845 slaughtered animals, with a total biomass of 276.51 kg/km^2. The study by Trinca and Ferrari (2007) lasted 210 days among a population of 40 inhabitants, and recorded 15 species, 113 slaughtered animals and a total biomass of 9.59 kg/m^2.

DISCUSSION

Despite the limitation of the number of studies considered, the data in this study are consistent

with several studies of hunting in the Amazon region (Robinson and Redford 1986; Bodmer et al. 1994; Peres, 1997, 2000a; Endo et al. 2009). The data concerning the number of species, the total number of slaughtered animals and biomass were directly related to the duration of the study, the population of the locality, and the characteristics and size of the hunting area considered. In general, a longer period of study increases the chances of recording greater numbers of hunting activities and consequently, a greater number of species and slaughtered animals; biomass in turn, is also influenced by the size of the study area. Similarly, traditional rural localities and indigenous localities with larger populations tend to have more hunters and consequently, more hunting activity.

The hunting of 32 different species of large and medium sized mammals shows a great breadth and diversity of hunting activity in the eastern Amazon region. Carnivores and primates were the groups that contained the greatest diversity of species hunted, similar to the findings of Bodmer et al. (1994) in other regions of the Amazon. There was a positive linear relationship between the number of animals slaughtered and biomass, as found in the studies of Far and Purvis (1997). As the number of slaughtered animals increases, the biomass increases linearly; this relationship, which has addressed by Jerozolimski (1998), shows that there is a correlation between the increase in the number of species hunted, with an increased hunting pressure. Considering the total weight of bushmeat recorded in four studies, it can be concluded hypothetically that more than 85 kg of game meat was extracted per day within four comparable localities, which is equivalent to the hunting of one Capybara (*Hydrochoerus Hydrochaeris*) and one Red Brocket (*Mazama americana*) adults per day.

Despite a large record of primate and carnivore species, the highest number of slaughtered animals and consequently a higher biomass, were ungulates. Half of the total number of animals that were hunted in all localities were ungulates, amongst which the White-lipped peccary (*Tayassu pecari*) was the most-hunted animal, considering all localities. Ungulates are generally large animals, and as they have a high body mass, they consequently have a higher protein value and are more prized by hunters. As demonstrated by the studies of Peres (1990) and Bodmer (1995), Neotropical hunters prefer large species, when these are available, for their protein value. The number of hunted White-lipped peccary for example, can be explained by the high abundance of these animals in the region, since they have a wide distribution area and can live in different habitats and have a high population density, but are not a species with a declining population in the Amazon region (Keuroghlian et al. 2012). Despite the preference of hunters for large animals, it was found that most animals slaughtered were mid-sized (1.0 to 14.9 kg). The large number of slaughtered species of medium size can be explained by the unavailability of large species, since the density decreases with an increase in body mass, as demonstrated by Far and Purvis (1997) and Far and Garcia (2001). According to Martins and Oliveira (2011), the probability of capture is influenced by the population density of the species; large species are more difficult to hunt because there are fewer animals within a given region, compared to other smaller species. According to Far and Purvis (1997), body mass, which is associated with the trophic level of the species, is also a factor that influences population density. Among the species of large mammals recorded in the four localities, the Jaguar (*Panthera onca*) and Puma (*Puma concolor*) represented the fewest animals slaughtered, which agrees with the findings of Far and Purvis, that large animals at the top of the food chain have a smaller population than herbivorous such as the White-lipped peccary and Collared Peccary, which are considered to be their prey. It should also be highlighted that the hunting of big cats, such as the Jaguar, does not occur as a function of their protein value, but to obtain the skin as a trophy, or due to their threats to domestic livestock (Morato et al. 2013). The Giant Anteater is another example of a large mammal with a low population density and consequently low biomass, as well as a specialized diet that was recorded in the study. The high number of ungulates can also be explained by the characteristics of the eastern part of the Amazonian biome, which include a rainy season, a heterogeneous landscape, a

discontinuous canopy structure and many fruit resources during much of the year, which facilitate the locomotion and feeding of large, mainly frugivorous mammals in the region (Peres and Nascimento 2006).

Within the four localities, 31 percent of the hunted species are officially endangered. Among the ungulates, the group with the highest number of animals slaughtered, the White-lipped peccary and Brazilian Tapir, which is the largest mammal in South America, were both classified as vulnerable according to the IUCN classification (2014). Both species were hunted in all rural and indigenous localities of the compiled studies, and these two species alone were responsible for over 50 percent of the total weight of slaughtered game meat. Although the Brazilian Tapirs is one of Brazil's most endangered mammals, very few studies have been performed with this animal in the Brazilian Amazon. The total biomass of the Brazilian Tapir recorded in the four localities was 60.86 kg/km^2, which is compatible with the population estimate for this species by Peres (2000a) in the Amazon, which ranged between 0.11 and 0.52 individuals/ km2, taking into account that the mean weight of an adult animal of this species is 150 kg. The total biomass of the White-lipped peccary at 117.55 kg/ km2 was higher than that of the Brazilian Tapir, but does not represent a threat to the population, because as already mentioned, it is one of the few large mammals in the Amazon that live in large groups and has a wide distribution without showing population decline in the Amazon. However, because they live in large groups of 50–130 individuals, as demonstrated by Fragoso (1998), dozens of animals can be slaughtered in a single hunt, including cubs and females, since in most cases, hunting is not selective, the White-lipped peccary is considered to be extremely susceptible to overhunting (Peres and Nascimento 2006).

Over half of the primates that were hunted in the four localities are also threatened with extinction. With the exception of the Guianan Spider Monkey (*Ateles paniscus*), all other endangered primates have been hunted only in indigenous localities. These results can be explained mainly by two factors: firstly, traditional rural communities do not value primate meat, which also possesses less protein than the meat of other land mammals of a medium size; secondly, arboreal animals such as Neotropical primates, require forest environments with little anthropogenic impact, i.e., primary forests with large trees. Primary forests near rural localities are increasingly rare, and most are found in indigenous reserves or protected areas. Furthermore, indigenous hunters show a preference for primates, as observed by Peres and Nascimento (2006). In general, neotropical primates, have a low birth rate, long growth period and development, short fertile periods during the year, a low population density and a large dependence on the quality of the forest (Robinson and Redford 1996). These features make them prone to overhunting, particularly when they are at risk of extinction. The Ka'apor Capuchin (*Cebus kaapori*) is a critically endangered primate species that is hunted in the indigenous locality of Caru and Alto Turiaçu (Martins and Oliveira 2011). It is therefore a rare species and has one of the smallest geographic ranges for species of the genus Cebus (Machado et al. 2008), making it extremely vulnerable to hunting, even if only a single individual is hunted within an area of 7,032 km^2 (Martins and Oliveira 2011). Similar to the Ka'apor Capuchin, the Black Bearded Saki (*Chiropotes satanas*) has the smallest geographical distribution among species of the genus Chiropotes, which unfortunately coincides with the most densely-populated area of the Amazon, the northern part of Eastern Amazonia (Machado et al. 2008). In Aúkre in Pará, 99 Black Beraded Saki were slaughtered in an area of 117 km2. Considering that the Black Bearded Saki is officially endangered and is a highly frugivorous species, which requires large areas to sustain viable populations and that it has the smallest distribution area among the *Chiropotes*, restricted to a part of the Amazon that suffers the most from human action, the hunting of 99 individuals within the region is extremely detrimental to the viability of the population of this species.

Among the group of carnivores, two endangered species were hunted: the Jaguar (*Panthera onca*), the largest feline in the Americas, and the Ocelot (*Leopardus pardalis*). In the studies compiled from all localities, at least one individual

of *Panthera onca* was slaughtered. The presence of this species in four localities can be linked directly to the presence of ungulates (*Tayassu pecari, T. Tajacu, Mazama americana* and *Tapirus terrestris*), which are considered as its main prey. Other animals that are hunted by both traditional rural and indigenous localities, Jaguars and Ocelots, are not hunted for their protein value, but to prevent them from causing economic damage by attacking domestic livestock, or also to obtain their skins, which are used as decoration in homes or are marketed (Valsecchi 2012). Although these two species occur in almost all Brazilian biomes, the loss and fragmentation of habitats, together with hunting for retaliation, comprise the major threats and reasons why they are classified as vulnerable in Brazil. The hunting of *Panthera onca* in the four localities demonstrates that the lack of knowledge and environmental awareness about the importance of this species to the environment still contributes to its decline.

It is relevant that 53.6 percent of mammals in Brazil are affected by hunting (Machado et al. 2008), although this is an illegal activity and is not necessary for subsistence. In this study, 15.4 percent of primates, 22.2 percent of carnivores, and 28.6 percent of Xenarthrans were reported as endangered; at least two species of endangered mammals of each order were hunted in the four localities. These records show that species that are considered endangered are affected by hunting in the area and are at risk of local extinction.

As show the result of the Margalef index, there was no significant difference between the diversities of mammals hunted in the PA, MA, MT, AP and similarities were observed between the diversity and abundance of the mammals hunted in the four localities. The physiognomic feature of eastern Amazonia might explain the similarity of mammal species found in the four localities, besides abundance, which was fewer than 16 individuals per slaughtered species — a result that is consistent with the abundance of mammals in the Neotropical forest environment. The variation between 15 and 20 hunted species respectively in Japuranã (MT) and A'Ukre (PA), shows little difference between the localities, even one that is traditionally rural, (Japuranã), and one that is indigenous (A'Ukre). In contrast, the difference between the biomass of slaughtered animals in these two localities was considerable and was higher in A'Ukre. Comparing only the biomass of these two localities might assume that the biomass of mammals hunted in indigenous localities is higher than in traditional rural localities. However, when comparing the other two localities Jari (AP) and Caru and Alto Turiaçu (MA) together, the highest biomass was observed in the traditional rural locality Jari (AP). The population of Jari (AP) locality was 5,600 inhabitants, therefore, the presence of hunters was very large. In the study of Martins and Oliveira (2011), the population of the indigenous locality of Caru and Alto Turiacu was not stated, but was significantly lower than the indigenous populations in the study by Peres and Nascimento (2006). Thus the number of hunters, which is proportional to the total population of the community, can be considered as a contributing factor to the higher biomass in the Jari traditional rural locality. Concomitant with this factor, the level of protection of the area that is used for hunting is also critical in determining the amount of biomass in the locality. In Caru and Alto Turiaçu (MA), the hunting area is part of an indigenous reservation protected by the government and is adjacent to the Gurupi Biological Reserve (Rebio). Although the Reserve Gurupi is considered to have the "worst condition of Brazil" by the IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) (Machado et al. 2008), it manages to limit hunting activity, which reduces the amount of mammal biomass that is extracted from the region.

The multidimensional and parallel ordering of localities from species of mammals hunted using clustering analysis, showed that the two indigenous localities A'Ukre (PA) and Caru and Alto Turiaçu (MA) are more similar to each other than to the other two localities. The hunting of the Red-handed Howler Monkey (*Alouatta belzebul*) and Black Bearded Saki (*Chiropotes satanas*), which are endangered primates, was recorded only in these two localities. As shown by Robinson and Redford (1987) in several indigenous communities in South America, the similarity between the fauna in indigenous communities reflects the

preference for hunting certain species by these communities. The presence of these two primates, which was confirmed by the hunting records in the localities, also serves as an indicator of the degree of conservation of the hunting area, since these animals require conservation areas with large fruit trees and little human interference. In the other two traditional rural localities, it was not been possible to make a consistent aggregation based on the species of hunted mammals. Although both localities are within the Eastern Amazon, the distance between them and the difference between their vegetation, might be factors that distinguish them. The hunting area considered in Japuranã (MT) was 374 km2 and was a boundary region between the Amazon and the Cerrado, whereas that considered in Jari (AP) was 2,500 km2 and had a fully Amazonian vegetation.

CONCLUSION

Our data suggest that the ungulates superorder was the mammals group more hunted in all locations, and this group showed the highest number of hunted animals and higher biomass. Although there was no significant difference in mammalian diversity hunted between indigenous and rural communities in the Eastern Amazon, there was greater similarity between the indigenous localities and lower similarity between rural communities, which may reflect the different cultures and eating habits between these communities.

The species cited here derive from data compiled from studies conducted with different durations and in different localities, having only the limits of the Eastern Amazon in common. The hunting activity in these localities is extremely similar, together with the large number of species that are impacted by hunting. Knowledge concerning which species are hunted, how and in which localities, is critical for further studies on the vulnerability and hunting sustainability in the area, as well as providing the basis for studies of management and conservation of species that should be protected or that will require protection and conservation. Thus, this study provides an initial assessment of medium and large-sized mammalian species that are most impacted in different localities within the Eastern Amazon, and suggests, through multidimensional analysis, that subsequent management studies for certain species should consider whether a locality is indigenous or traditional, since the hunting preferences in each locality are different.

ACKNOWLEDGEMENTS

We are grateful for Juarez Pezzuti for his great advices for the development this paper. We thanks comments from anonymous reviewers improved an earlier version of this paper.

REFERENCES

1. Baia Júnior PC, Guimarães DAA, Le Pendu Y (2010) **Non-legalized commerce in game meat** in the Brazilian amazon: a case study. Revista de Biología Tropical 58:1079-1088.
2. Bodmer RE, Fang TG, Moya L (1994) **Managing wildlife to conserve Amazonian forests: population biology and economic considerations of game hunting.** Biological Conservation 67:29-35.
3. Bodmer RE (1995) **Managing Amazonian wildlife: biological correlates of game choice by detribalized hunters**. Ecological Applications 5:872–877.
4. Bodmer RE, Eisenberg JF, Redford KH (1997) **Hunting and the likelihood of extinction of Amazonian mammals**. Conservation Biology 11:460-466.
5. Endo W, Peres CA, Salas E, Mori S, Sanches-Vegas JL, Shepard GH, Pacheco V, Yu DW (2009) **Game Vertebrate Densities in Hunted and Nonhunted Forest Sites in Manu National Park, Peru**. Biotropica 42:251-261.
6. Fa JE, Garcia Yuste JE (2001) **Commercial bushmeat hunting in the Monte Mitra forests, Equatorial Guinea: extent and impact**. Animal Biodiversity and Conservation 24:31–52.
7. Fa JE, Purvis A (1997) **Body size, diet and population density in Afrotropical forest mammals: a comparison with neotropical species**. Journal of Animal Ecology 66:98-112.
8. Fa JE, Peres C (2001) **Game vertebrate extraction in African and Neotropical forests: an intercontinental comparison**. In: Reynolds JD, Mace GM, Robinson JG, Redford KH (eds) Conservation of Exploited Species. Cambridge University Press, Cambridge, pp. 203-241.
9. Fragoso JMV (1998) **Home range and movement patterns of white lipped peccary (Tayassu pecari) herds in the Northern Brazilian Amazon**. Biotropica, 30:458-469.
10. INPE (2012) **Projeto PRODES**. [http://www.obt.inpe.br/prodes/index.php] Accessed 10 october 2014
11. IUCN (2014) **IUCN Red List of Threatened Species. Version 2014.3**. [http://www.iucnredlist.org] Acessed 20 december 2014

12. Jerozolimski A (1998) **Effects of subsistence huting on the structure of mammal assemblages in neotropical forest**. Norwich, Dissertation (Ph.D) – Universty of East Anglia.

13. Keuroghlian A, Desbiez ALJ, Beisiegel BM, Medici EP, Gatti A, Pontes ARM, Campos CB, Tófoli CF, Moraes Junior EA, Azevedo FC, Pinho GM, Cordeiro JLP, Santos Júnior TS, Morais AA, Mangini PR, Flesher K, Rodrigues LF, Almeida LB (2012) **Avaliação do Risco de Extinção do Queixada Pecari tajacu Link, 1795, no Brasil**. Biodiversidade Brasileira 3:74-83

14. Machado ABM, Drummond GM, Paglia AP (2008) **Livro vermelho da fauna brasileira ameaçada de extinção**. 1 ed. Ministério do Meio Ambiente, Brasília.

15. Magurran AE (2004) **Measuring Biological Diversity**. Blackwell Science Ltd, Oxford.

16. Martins M B, Oliveira TG (2011) **Amazônia Maranhense: diversidade e conservação. Belém**. MPEG.

17. Morato RG, Beisiegel BM, Ramalho EE, Campos CB, Boulhosa RLP (2013) **Avaliação do Risco de Extinção da Onça-Pintada Panthera onca Link, 1758, no Brasil**. Biodiversidade Brasileira 3:122-132.

18. Nasi R, Tambler A. Van Vliet N (2011) **Ending empty forests: management and sustainable use of wildlife in tropical production forests**. ITTO Tropical Forest Update 20:19–21.

19. Parry L, Barlow J, Peres CA (2009a) **Hunting for Sustainability in Tropical Secondary Forests**. Conservation Biology 23:1270-1280.

20. Parry L, Barlow J, Peres CA (2009b) **Allocation of hunting effort by Amazonian smallholders: implications for conserving wildlife in mixed-use landscapes**. Biological Conservation 142:1777-1786.

21. Peres CA (1990) **Effects of hunting on western Amazonian primates communities**. Biological Conservation 54:47-59.

22. Peres CA (1996) **Population status of white-lipped Tayassu pecari and collared peccaries T. tajacu in hunted and unhunted Amazonian forest**. Biological Conservation 77:115-123.

23. Peres CA (1997) **Evaluating the sustainability of subsistence hunting in tropical forests**. Centre for Social and Economic Research on the Global Environment, London.

24. Peres CA (2000a) **Effects of Subsistence Hunting on Vertebrate Community Strutucture in Amazonian Forests**. Conservation Biology 14:240-253.

25. Peres CA (2000b) **Evaluating the impact and sustainability of subsistence hunting at multiple Amazonian forest sites**. In: Robinson JG, Bennett EL (eds) Hunting for Sustainability in Tropical Forests. Columbia University, New York, pp. 83-115.

26. Peres CA (2001) **Synergistic effects of subsistence hunting and habitat fragmentation on Amazonian forest vertebrates**. Conservation Biology 15:1490-1505.

27. Peres CA, Nascimento HS (2006) **Impact of game hunting by the Kayapó of south-eastern Amazonia: implications for wildlife conservation in tropical forest indigenous reserves**. Biodiversity and Conservation 15:2627-2653.

28. Queiroz HL (1992) **A new species of capuchin monkey, genus Cebus Erxleben 1977 (Cebidae, Primates), from eastern Brazilian Amazonia**. Goeldiana Zoologia 15:1-3.

29. Ramos RM, Carmo NS, Pezzuti JCB (2008) **Caça e uso da fauna**. In: Monteiro MA (ed). Atlas socioambiental: municípios de Tomé-Açu, Aurora do Pará, Ipixuna do Pará, Paragominas e Ulianópolis. NAEA, Belém, pp.224-232.

30. Redford KH, Robinson JG (1987) **The game of choice: patterns of Indian and colononist hunting in the Neotropics**. American Anthropologist 89:650-667.

31. Redford K (1992) **The empty forest**. Bioscience 42:412-422.

32. Reis NR, Peracchi AL, Pedro WA, Lima IP (2011) **Mamíferos do Brasil: Guia de Identificação**. 2 ed. Nelio R. dos Reis, Londrina.

33. Robinson JG, Redford KH (1986) **Body size, diet, and population density of neotropical forest mammals**. American Naturalist 128:665-680.

34. Robinson JG, Redford KH (1991a) **Subsistence and commercial uses of wildlife in Latin America**. In: Robinson JG, Redford KH (eds) Neotropical Wildlife Use and Conservation. 1 ed. The University of Chicago Press, Chicago, pp. 6-24.

35. Robinson JG, Redford KH (1991b) **Sustainable harvest of neotropical forest mammals**. In: Robinson JG, Redford KH (eds) Neotropical Wildlife use and Conservation. 1 ed. The University of Chicago Press, Chicago, pp. 415-429.

36. Robinson JG, Bodmer RE (1999) **Towards wildlife management in tropical forests**. Journal of Wildlife Management 63:1-13.

37. Robinson JG, Bennett EL (2000) **Hunting for Sustainability in Tropical Forests**. 1 ed. Columbia University Press, New York.

38. Siegel S (1956) **Nonparametric statistics for the behavioral sciences**. 1 ed. McGraw Hill, New York.

39. Sneath PHA, Sokal RR (1973) **Numerical classification: the principles and practice of numerical classification**. 1 ed. Freeman, San Francisco.

40. Strong JN, Fragoso JMV, Oliveira LFB (2010) **Padrões de uso e escolha de caça pelos índios Macuxi em Roraima**. In: Barbosa RI, Melo VF (eds) Roraima: Homem, Ambiente e Ecologia. 1 ed. INPA, Manaus, pp. 631-644.

41. SUDAM (2012) **Superintendência de Desenvolvimento da Amazônia**. [http://www.ada.gov.br] Accessed 15 september 2014.

42. Trinca CT, Ferrari SF (2007) **Game populations and hunting pressure on a rural frontier in southern brazilian Amazonia**. Biologia Geral e Experimental. Universidade Federal de Sergipe 7:5-16.

43. Valsecchi JA (2012) **Caça de Animais Silvestres nas Reservas de Desenvolvimento Sustentável Mamirauá e Amanã**. PhD Thesis, Universidade Federal de Minas Gerais - UFMG, Belo Horizonte, BR.

44. Wilson DE, Reeder DA (2005) **Mammal species of the World: a taxonomic and geographic reference**. 3 ed. The Johns Hopkins University Press.

45. Zar JH (2010) **Biostatistical Analysis**. 5 ed. Englewood Cliffs.

Received: 21 August 2014
Accepted: 10 January 2015
Published: 26 January 2015