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Subsistence hunting of *Cuniculus paca* in the middle of the Solimões River, Amazonas, Brazil

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Abstract

Ungulates, large primates and caviomorfs are cited by Amazonian hunters as preferred species. In this research, paca (*Cuniculus paca*) hunting was investigated in relation to water levels and the lunar cycle. In eight years of monitoring in the Amanã Sustainable Development Reserve, the killing of 625 pacas was registered in five monitored communities. Paca hunting took place mainly at night and the most commonly used method is "spotlighting". A positive correlation between the number of pacas killed and water level (r_s=0.890; p<0.0001) was found. At least 37% of the pacas were hunted when moon illumination level was less than 10%, before moonrise or after moonset. In the Boa Esperança community, capture of paca tended to decrease on nights with high moon illumination (r_s= –0.663; p=0.067). At the same time, an expressive catch-per-unity-effort decrease was also observed in this community (r^2= –0.881; p<0.001), allowing us to predict unsustainable hunting levels for the next decade. The stock of animals in these areas could be continuously replaced if surrounding areas consisted of continuous forests. However, continuous hunting and deforestation force local hunters to travel longer distances to kill prey such as pacas. The confirmation of the relation between paca habits and lunar illumination and water level, a pattern described by local hunters, demonstrates the potential value of participatory research and the possibility of integrating traditional knowledge into scientific knowledge.

Keywords: abundance, catch-per-unity-effort, *Cuniculus paca*, hunting, Amazon.

Caça de subsistência de *Cuniculus paca* no Médio Solimões, Amazonas, Brasil

Resumo

Ungulados, primatas de grande porte e caviomorfos são citados por caçadores amazônicos como espécies preferenciais. Neste trabalho, a caça de paca (*Cuniculus paca*) foi investigada em relação ao nível d'água e ao ciclo lunar. O abate de 625 pacas foi registrado em oito anos de monitoramento em cinco comunidades da Reserva de Desenvolvimento Sustentável Amanã. A caça de paca ocorre principalmente à noite e o método mais utilizado é a "focagem". Encontrou-se uma correlação positiva entre o número de pacas abatidas e o nível d'água (r_s=0.890; p<0.0001). Pelo menos 37% dos indivíduos foram abatidos quando o nível de iluminação lunar era menor do que 10%, antes do nascer da lua ou após seu ocaso. Na comunidade da Boa Esperança, a captura de paca tendeu ao decrescimento em noites com altos níveis de iluminação lunar (r_s=–0.663; p=0.067). Ao mesmo tempo, uma expressiva redução da captura por unidade de esforço foi observada nessa comunidade (r^2=–0.881; p<0.001), permitindo-nos prever níveis de caça insustentáveis para a próxima década. Frente a extensas áreas contínuas de floresta, o estoque de animais nas áreas de caça poderia ser continuamente substituído, mas os efeitos combinados de caça constante e desmatamento forçam caçadores locais a se locomoverem por longas distâncias para abater presas como as pacas. A confirmação dos padrões descritos por moradores locais sobre a relação entre pacas e os níveis de iluminação lunar e de água demonstra o potencial de pesquisa participativa e a possibilidade de integração entre os conhecimentos tradicionais e científicos.

Palavras-chave: abundância, captura por unidade de esforço, *Cuniculus paca*, caça, Amazônia.

1. Introduction

Hunting represents an important source of protein for indigenous and rural populations in the Amazon (Ayres and Ayres, 1979; Redford, 1997). Species weighing more than a kilogramme or even less are generally considered 'good prey' (Robinson and Bodmer, 1999). However, we should be cautious with this generalisation. Hunting in the Amazon is preferably selective. Ungulates, large primates, along with cracids and chelonians, which are particularly important in flooded environments, are cited as main game species for Amazonian hunters (Redford and Robinson,

1987; Bodmer et al., 1997; Peres, 2000; Valsecchi and Amaral, 2009; Constantino et al., 2008). These species have received special attention in publications about hunting activities, either for their biomass (Souza-Mazurek et al., 2000), for the impact on their populations because of the low resilience of some species (Parry et al., 2009; Zapata-Ríos et al., 2009), or even for the relative ease with which information about them can be obtained. Moreover, smaller species with relatively high reproductive capacity, such as paca (*Cuniculus paca*), have received secondary attention, even though they are amongst the most hunted species in the Amazon (e.g. Hill et al., 1997, Souza-Mazurek et al., 2000, Bodmer and Lozano, 2001; Zapata-Ríos et al., 2009; Valsecchi and Amaral, 2009).

Pacas are one of the most hunted animals in the Amazon due to the renowned flavour of their meat (Deutsch and Puglia, 1990). In the Amanã Sustainable Development Reserve (ASDR), paca is one of the species most susceptible to hunting and a favourite for local residents (Valsecchi and Amaral, 2009), behind only the white-lipped peccary, on this last parameter. Bodmer and Lozano (2001) showed that paca is the main hunted species in a rural area in Peru, with an estimated killing rate of 17,000 individuals/year, reinforcing its importance as a protein source for subsistence. However, the species is the fifth in economic importance, preceded by peccaries (*Tayassu pecari* and *T. tajacu*), tapir (*Tapirus terrestris*) and primates. Likewise, Altrichter and Almeida (2002) demonstrated that paca is the main species consumed in 15 communities on the Osa Peninsula, Costa Rica, with a hunting frequency 11 times greater than the peccary, and with consumption equivalent to that of domestic animals.

A species of nocturnal habit (Weckel et al., 2006; Martins et al., 2007), the paca is less active on moonlit nights (Harmsen et al., 2011). Its distribution is related to the location of water bodies (Aquino et al., 2009; Harmsen et al., 2011; Pérez et al. 2010), and there are only a few estimates of paca abundance using the most frequently employed methods, such as sightings and camera traps (e.g. Parry et al., 2009; Endo et al., 2010). Pacas may be locally abundant but the estimation of population parameters is laborious and results are likely to be unsatisfying (Ojasti, 1996). Few studies employed nocturnal surveys (e.g. Glanz, 1990; Malcolm, 1990; Rodríguez, 1992; Beck-King et al., 1999; Vázquez, 2003; Aquino et al., 2009), and these were not always related to water bodies. A great part of knowledge about the paca's natural history comes from studies on feline prey. Weckel et al. (2006) demonstrated that paca prefer shorter trails and that the species was not registered on trails used by men or frequently used by larger mammals such as the jaguar (*Panthera onca*).

In ASDR, hunting monitoring has been carried out since 2002. Local people collect data regarding the specimen killed as well as characteristics of the hunting event. These records provide information on the biology of the hunted species, and also allow for the evaluation of their use and conservation status.

As described for other locations in the Amazon, pacas are one of the main hunted species in ASDR. According to local hunters, killing is easier at night using the spotlighting method. The hunter uses a non-motorised canoe and a flashlight to locate and dazzle prey. Main targets are nocturnal animals, such as pacas (*C. paca*) and armadillos (*Dasypus* spp.), frequently on riversides and lakeshores (Valsecchi, 2005).

A similar strategy was registered in Aripuanã, where hunters go out in canoes using a flashlight to spot pacas only on dark nights during the dry season (Ayres and Ayres, 1979). Ojasti (1996) described hunting from boats and canoes along the edges of waterways, using flashlight spotting as the main strategy to locate paca.

In this study we describe paca hunting in ASDR based on the killing records over eight years of monitoring. We tested the relationship, described by local people, between hunting and water levels and the lunar illumination. We used a catch-per-unity-effort (CPUE) index to evaluate the impacts of hunting on the paca population. We also discuss a method for monitoring paca, based on results of the hunting analysis and surveys undertaken.

2. Material and Methods

2.1. Study area

Amanã Sustainable Development Reserve, comprising 2,313 Km^2, is located between the Negro and Japurá rivers. The Sustainable Development Reserve is a type of protected area classified as category VI by the International Union for Conservation of Nature (IUCN). The Sustainable Development Reserve was established by Brazilian Federal Law (Law 9.985/2000) with the objective of preserving nature and, at the same time, guaranteeing conditions for the reproduction and the improvement of local livelihoods, the exploitation of natural resources by traditional populations, as well as to value, conserve and improve the knowledge and management techniques developed by these populations (Brasil, 2000).

The human population in ASDR is approximately 4,000 people, distributed in communities and settlements along three main forestry formations: terra-firme; várzea and igapó. Local biodiversity patterns and its human use are largely determined by river types, white water or black water rivers.

We conducted this study in five ASDR communities and their common use areas (Figure 1). We chose these sites based on the following criteria: (i) their location; (ii) accessibility to common use areas; (iii) different habitats found in these areas - two communities being on terra-firme with igapó associated environments and three on terra-firme, but using várzea areas (Figure 1); (iv) different community population sizes; (v) and the explicit interest in collaborating with the study. Monitoring was interrupted in São José do Urini in July 2007. To compensate this, studies were then initiated in Belo Monte community in September of that same year.

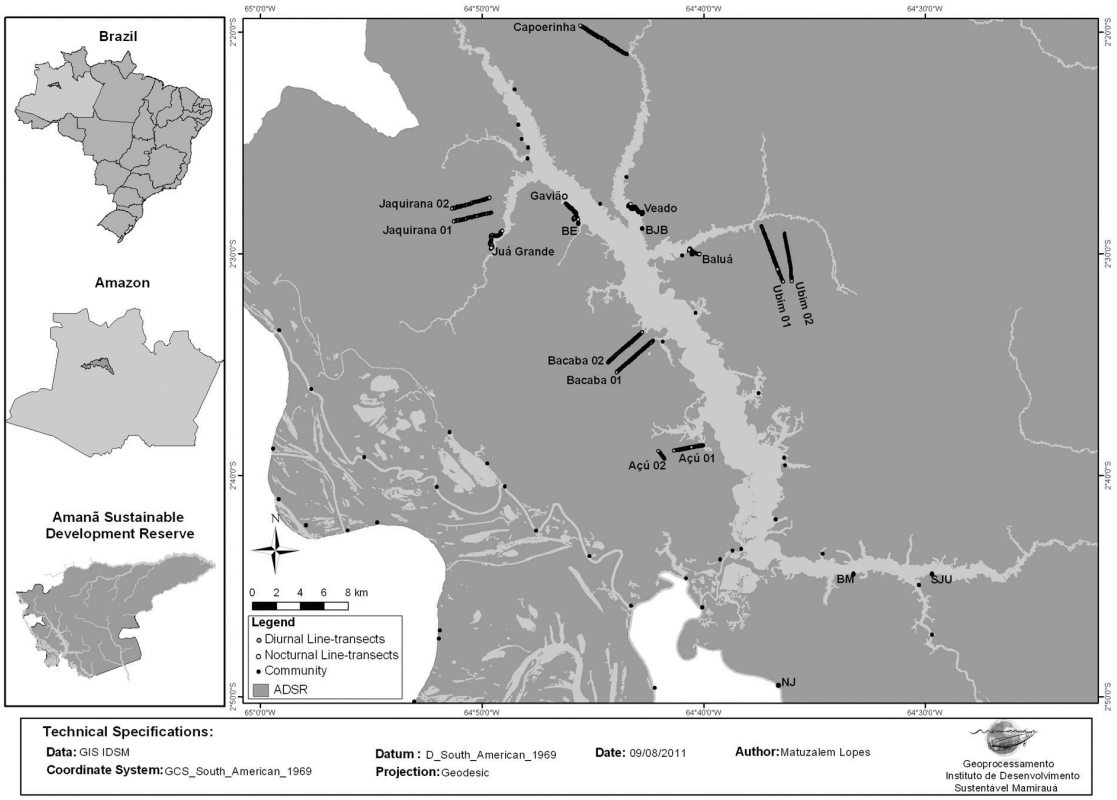

Figure 1. Communities location and diurnal and nocturnal transects in ASDR. Communities on terra-firme with igapó associated environments: BE – Boa Esperança; BJB – Bom Jesus do Baré. Communities on terra-firme, but using várzea areas: NJ – Nova Jerusalém; BM – Belo Monte; SJU – São José do Urini.

2.2. Diurnal line transects

We opened nine line transects on terra-firme in the surrounding areas of the Amanã lake for the monitoring of cynegetic species and primates in ASDR through a distance sampling method (Buckland et al., 1993). All trails were straight-lines perpendicular to the nearest water body. Surveys were conducted from 2007 to 2010. Trails were surveyed by a researcher and a local assistant, always between 07:00 and 11:00 AM.

2.3. Nocturnal transects

A nocturnal survey was undertaken between January and July 2010. We opened four transects on the banks of Baluá, Juá Grande, Gavião and Veado streams by cutting branches and vines in the igapó flooded forest, keeping a two to three metre distance from the margin. All transects were non-linear and 2,500 metres long. Since the survey was performed from the beginning to the peak of flooded season, transects were subjected to inundation and therefore had to be reestablished when necessary. We used a sampling method similar to the technique applied by local hunters to catch pacas (the spotlighting). We glided through the flooded forest boarding a canoe conducted by a local assistant, between 8:00 and 11:30 PM, at an average speed of 0.7 km/h. We chose nights to allow for surveys on bright nights (BN), with over 50% of the moon illuminated, and during dark nights (DN), with 25% or less of the moon illuminated, before moonrise or after moonset (see below). In order to better simulate the hunting conditions of local residents, we used the same kind of flashlights they use. Using these flashlights we were able to spot and identify animals from up to a 20 metres distance from the margin. We used Kruskall-Wallis tests to compare paca records among transects; we used T-test with separate variances to compare records between bright nights and dark nights.

2.4. Hunting surveys

The selected communities are part of a long-term hunting monitoring system called SMUF and carried out by researchers of the Mamirauá Institute. In ASDR the system is composed of four communities monitored daily by local collectors along 11 months per year. Each collector hired is a local resident and all participate in a capacity building training process. Specific questionnaires are used for each species or group monitored. The following data are registered: location and time spent on the hunting activity, number of hunters involved, materials used and weight, sex and reproductive status of the killed specimens. The sample period analysed in this article corresponds to eight years of monitoring activities, from 2003 to 2010.

2.5. Lunar phase and water level

Lunar phase, moonrise and moonset times, and the percentage of the moon disk lighted by the sun were determined using the software Moonphase 3.3 - the Southern Hemisphere version (www.tingan.com/) at one central coordinate point of reference for the whole study area. To standardise the moonlight variation of hunting events, we ranked the moonlight into 10% rates varying from 0% to 100% illumination, categorising each day surveyed and each hunting event by these rates. In the case of hunting events when the hunter returned to the community before moonrise or started his activity after moonset, we ascribed a 0% moonlight rate. Spearman coefficient was used to test a possible relation between the number of specimens killed and lunar illumination.

The water level was also determined for each hunting event. Flood elevation data was obtained from the Mamirauá's Institute website (http://www.mamiraua.org/fluviometrico). The water level was grouped into one-metre quotas and we determined the frequency of each quota during the period studied (2,922 days). The number of kills was calculated proportionally to each frequency obtained. Spearman coefficient was used to test a possible relation between the number of specimens killed and water level.

2.6. Productivity analyses

To evaluate the sustainability of paca hunting in ASDR, we performed an analysis of productivity based on the information of the effort applied and the biomass obtained by the Amanã hunters. We considered as catch-per-unity-effort (CPUE) the weight obtained by each hunter per hour spent during hunting (Kg/hunter*hour). The hunting period was defined as the time spent by the hunter when involved with this activity, from the moment he left the community to his return to this same location. For animals we could not determine body weight, we used average weight values obtained from the total number of individuals hunted. We did not analyse events about which we had no information on period of hunting and/or production obtained.

The comparison of CPUE values must be done taking in consideration unsuccessful hunting events. However, this information is frequently omitted by hunters. In this paper, we discarded these events since they were rare and appeared only in the recent years of monitoring, after great efforts in training the collectors and convincing the hunters. We assumed that without this information the model produced is less sensitive, but shall still reflect overhunting patterns if the population has been impacted. For the CPUE analysis we considered only the intentional events, i.e., those in which hunting was the main goal. Opportunistic hunting events, normally related to agricultural activities, fishing or the displacement of animals by rising waters, tend to produce a highly variable CPUE, since the effort applied to those activities differ largely from those applied during spotlighting hunting. Linear regression was used to test the prediction that the excessive hunting, combined with the loss of forested area, could cause a decrease of the CPUE values through time. The CPUE for nocturnal and diurnal intentional events was analysed in an annual time scale.

3. Results

3.1. Abundance of paca

No paca was registered in the 2016.94 Km of diurnal surveys on the terra-firme transects. Conversely, during the nocturnal transects, 44 pacas were registered with a significantly lower effort: 152.5 Km. We did not find significant differences in average number of pacas sighted amongst the streams sampled, not even when considering the illumination conditions (BN: $H=4.75$; $p>0.5$; DN: $H=3.33$; $p>0.5$), or for integrated data ($H=3.62$; $p>0.5$), making it possible to conduct a joint analysis of both sets. Thus, the average number of individuals registered was significantly less on bright nights (t-value= –4.01; df=55.1; $p<0.001$, Table 1).

3.2. Paca hunting in Amanã SDR

Between 2003 and 2010 there were 452 records of hunting events, with 625 pacas among the animals killed, representing 4,862.74 Kg. Hunting of paca occurred mainly in terra-firme with igapó associated communities, with an average of 0.19 specimens per person/year in Boa Esperança, and 0.22 specimens per person/year in Bom Jesus do Baré. In the communities associated with várzea areas, Nova Jerusalém, Belo Monte and São José do Urini, the averages were 0.06, 0.04 and 0.01 specimens per person/year, respectively.

Pacas were hunted especially at night (394 individuals or 63.04% of the killings). The spotlighting method was intentionally used in most cases (n=326), the others being opportunistic during fishing activities or by killing animals

Table 1. Sighting effort and paca abundance by the spotlighting survey.

TRAIL	BN[a] (KM)	DN[b] (KM)	BN[a] (nº indiv.)	DN[b] (nº indiv.)	BN[a] (Indiv./Km)	DN[b] (Indiv./Km)
Baluá	17.50	20.00	04	07	0.229	0.350
Juá Grande	20.00	22.50	02	11	0.100	0.489
Veado	17.50	20.00	-	07	0.000	0.350
Gavião	15.00	20.00	01	12	0.067	0.600
Total	70.00	82.50	07	37	-	-
Average	-	-	-	-	0.099	0.447

[a]Bright nights (BN); [b]Dark nights (DN).

that 'invaded' community areas. The spotlighting hunting strategy is specifically used to locate paca in ASDR. However, armadillos (*Dasypus ssp*.), brocket-deer (*Mazama americana*), one capybara (*Hydrochaeris hydrochaeris*), and one capuchin monkey (*Sapajus macrocephalus*) were also hunted using this strategy. Only armadillos and capybara were killed at the same paca hunting event.

During the diurnal kills another 28 species were registered at the same time as paca, the crested agouti being the most frequent. The rifle was the main instrument used in ASDR. Sniffer dogs were only used during the day, being associated with nearly half of the pacas killed in this period. Nevertheless, this number is likely to be higher, since the pacas declared as having been killed with a machete must also have been found and flinched by dogs (Table 2). Dogs are mainly utilised to locate land birds like the tinamous (*Tinamus* and *Crypturellus*) and crested agoutis and pacas in their burrows and hollows. In these cases, the method utilised is that of a sweep, in which hunters make an active search rather than keeping only on previously opened trails. The canoe hunting method used during the day can also be considered a sweep, since hunters search the mosaic of islands formed during the flooding period.

Although hunters spotlight alone, the trip from the community to the hunting area may involve up to six hunters. When a hunting trip involves two hunters they spotlight alone and meet again at the end of the hunt, returning to the community together. Events involving more than two hunters were frequently related to fishing and hunting was opportunistic. Such strategies optimise the hunting effort and are mainly used for areas distant from the community.

During most of the paca hunting events only one (77.6%) or two (17.0%) specimens were killed (mean=1.35 individuals, SD=0.87). Events with higher quantity of hunted prey were related to these afore mentioned strategies and to fishing events, when, in a sole event, 11 individuals were killed at one time. The gender proportion registered was 80 males to 100 females (n=534). Amongst all females killed (n=296), 11.4% were pregnant. The months that displayed the higher proportion of pregnant females were April (18.2%), May (16.7%) and June (16.2%). Nevertheless, pregnant females were killed year round and the proportion would be higher if we consider that hunters and local collectors only detect pregnancy after an advanced stage in pregnancy.

3.3. Flooding level and moon phase

Paca hunting was concentrated in July, immediately after the peak of the flooded season. Eighty three percent of killing events took place during high water levels (higher than 32 metres above sea level). The analysis showed a positive correlation between the number of hunted specimens and water levels (r_s=0.890; p<0.0001, Figure 2).

Moonlight rate was also a determinant for paca killing in ASDR. At least 37% of hunting events happened on nights with moonlight rates lower than 10%, before moonrise or after moonset. However, this figure is likely to be even higher, because for many slaughtering records, the time was not noted, making it impossible to determine whether they occurred before the rising or after the setting of the moon. Besides, we registered a series of events in which the hunter aborted his hunting activity soon after moonrise, irrespectively of the lunar phase.

In Boa Esperança community, where we registered the higher quantity of hunting events with spotlighting, it was possible to verify a trend of an increase in average CPUE at nights with lower illumination levels (r_s = –0.663, p=0.067, n=9, Figure 3).

Table 2. Hunting instruments used to kill paca by hunting strategy and period of the day.

Period of The day	Hunting strategy	Instrument						
		Club	Dog + Gun	Shotgun	Machete	Javelin	No info.	Total overall
DAY	On the trail	01	20	40	12			73
	Canoe		13	18	07			38
	On an island		11	07	07			25
	Fishing		09	07	01			17
	On the crops		17	08	05		01	31
	No info.		02	09	04		04	19
Total		01	72	89	36		05	203
NIGHT	Spotlighting			324	01	01		326
	At the community			02				02
	Fishing			40		01		41
	No info.		01	01			23	25
Total			01	367	01	02	23	394
No info.				18			10	28
Total overall		01	73	474	37	02	38	625

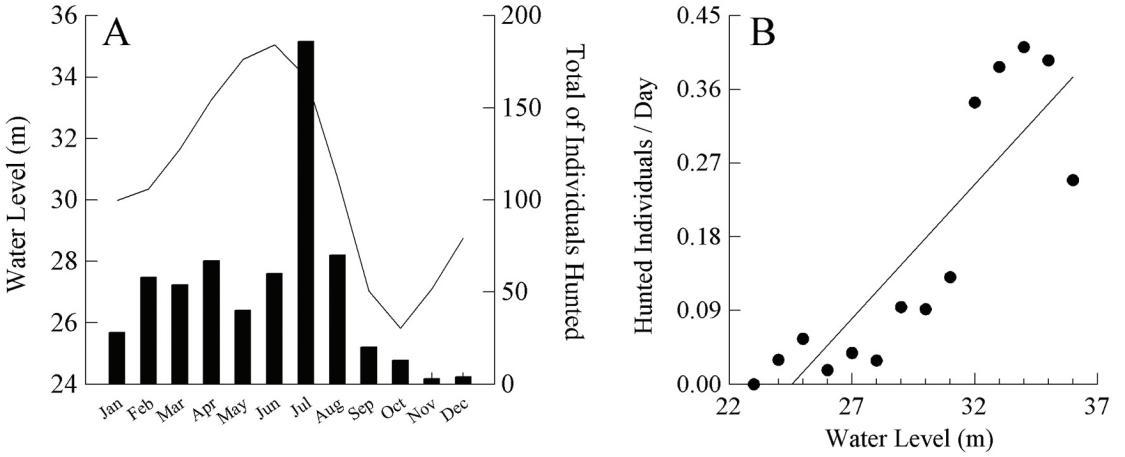

Figure 2. A) Number of pacas killed per month and average water level (http://www.mamiraua.org/fluviometrico). B) Number of pacas killed per day by water altimetric quota in ASDR.

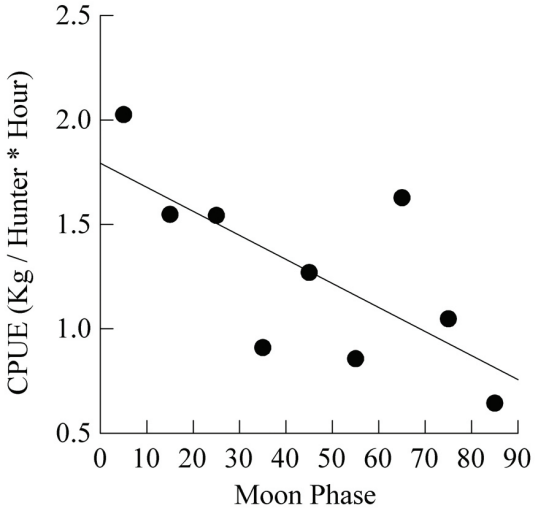

Figure 3. Relationship between catch-per-unity-effort (Kg/hunter*hour) and lunar illumination level, measured as a percentage of the lunar disc.

3.4. Annual variation of CPUE

There were no changes of CPUE values for spotlighting in Nova Jerusalém and Bom Jesus do Baré throughout the years surveyed ($p>0.20$), contrary to what was observed for Boa Esperança, where unsustainable levels of exploitation can be predicted for the next decade ($Y=341{,}74 – 0.17\ X$, $r^2= –0.881$, $p<0.001$, Figure 4). For diurnal intentional events not related to pacas, we did not register significant temporal variations in CPUE in any of the communities studied.

4. Discussion

The difference found between the number of animals killed in communities associated to várzea and to igapó is probably due to two reasons: (i) the várzea environment is characterised by high fish productivity thus communities located in this environment, as Nova Jerusalém, use fish as their main source of protein; (ii) two out of three communities located near the várzea, Nova Jerusalém and São José do Urini, have residents whose religious beliefs restrict the consumption of some foods, including rodents. These reasons explain, at least partially, why paca is not among the most susceptible hunted species in Nova Jerusalém, and why only a small portion of its inhabitants mention paca as their most valued food (Valsecchi and Amaral, 2009). Irrespective of the differences found, paca remains amongst the main hunted species in ASDR.

In four ASDR communities, *C. paca* was the third most killed mammal and the fourth in biomass, although this represents only 6.5% of the total weight for mammals in a six-month period (Valsecchi and Amaral, 2009). However, when manatees and tapirs (the heaviest, but rarely killed) and tayassus (relatively light, but opportunistically killed in herds of tens of individuals, while crossing the Amanã lake) are excluded from the analysis, paca takes the second place in number of individuals, representing 34.95% of hunted biomass. This emphasizes its importance as a basic source of protein in ASDR.

Pacas were not registered on the diurnal transects surveys even though they occur in the area, according to rare records of footprints on transects. The lack of visual records may be influenced by the time of monitoring, since paca is a species of nocturnal habits (Weckel et al., 2006; Martins et al., 2007; Harmsen et al., 2011). The abundance registered on the nocturnal transects is not comparable to those presented in other works (e.g. Glanz, 1990; Malcolm, 1990; Rodríguez, 1992; Vázquez, 2003) due to the different method applied in this study. Besides, the abundance registered in this study refers to the portion of the paca population located next to the margin of monitored streams, whereas other studies did not specifically sample transects near water bodies.

Although flooding levels higher than 36 metres are rare in ASDR (Ramalho et al., 2009) they influence the

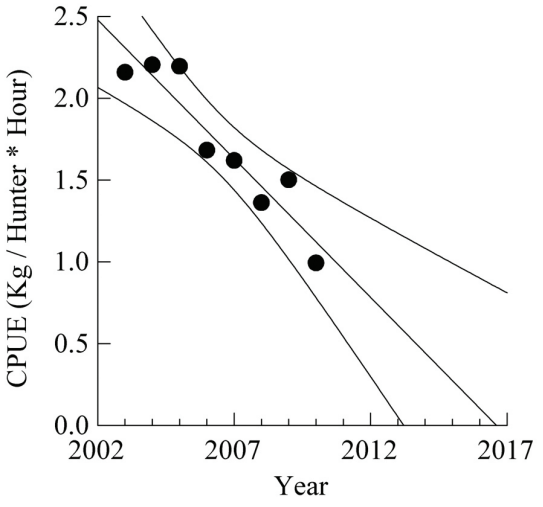

Figure 4. Nocturnal catch-per-unity-effort (Kg/hunter*hour) values decrease in Boa Esperança from 2003 to 2010.

reduction of paca killings, possibly as a consequence of the movements of pacas to dry environments. Similarly, Janson and Emmons (1990) suggested that high water levels in Manu (Peru) limit the capacity of the environment to sustain numerous dry burrows, which would explain the reduction in the abundance of pacas and also of armadillos. High water levels also affect the activities of local residents. Crops, like manioc root, should be harvested to avoid production loss. With their houses exposed to flooding, some families remain less time in the community, in some cases moving temporarily to cities nearby. Others spend time making their houses adequate to endure flooding conditions. As a consequence, hunting efforts are reduced in these occasions, resulting in a lower number of hunted animals.

Peres (2001) predicted a rapid decline of various species of mammals and birds in fragments of the Amazon forest, a result of the synergy between deforestation and overhunting. Excessive hunting is also related to the low abundance of pacas in some regions in Costa Rica (Carrillo et al., 2000). Boa Esperança community hunting grounds may also be moving toward the same scenario. Although paca is considered a resilient species due to its high density, reproductive rates and tolerance to secondary forest-growth mosaics (Peres, 2001), our results indicated that by mid 2017, paca hunting efforts would be unfruitful in Boa Esperança.

It is important to consider that the CPUE decline registered for Boa Esperança may be underestimated, due to the absence of records of unsuccessful hunting events. Also, hunting in Boa Esperança is not concentrated in forest fragments or on islands formed during the flooding period, but within a 5 km radius around it, in areas often used for cultivating manioc and other cultures (Valsecchi and Amaral, 2009). The stock of animals in these areas could be continuously replaced if surrounding areas consisted of continuous forests. However, continuous hunting and deforestation force local hunters to travel longer distances to kill prey such as pacas. The Shuar population in the Miasal's region, Equator, faced a similar situation (Zapata-Ríos et al., 2009). In a period of 30 years, Shuar population, with an estimated density of 1.7 people/Km^2, reduced the stocks of various mammal species weighing over 5 Kg, forcing the capture of smaller animals and the expansion of hunting areas (Zapata-Ríos et al., 2009). Curiously, as happens with the Shuar, hunters in Boa Esperança also acknowledge the increasing hunting effort associated to the decrease in prey abundance, but most believe that forest stocks are inexhaustible (pers. obs.). The CPUE reduction in Boa Esperança contrasts the maintenance of stable CPUE indexes of neighbouring communities, with different protein sources, and where the substitution of the native forest with agricultural areas is less pronounced.

Much of the information on the biology and ecology of *C. paca* are based on observations of captive animals and the use of indirect techniques, like analysis of predated seeds, burrows and footprints (e.g. Sabatini and Costa, 2006; Guimarães et al., 2008). The confirmation of the relation between paca habits and lunar illumination and water level, a pattern described by local hunters, demonstrates the potential value of participatory research and the possibility of its integration to scientific knowledge. The application of spotlighting – a local hunting technique – can be a more efficient and less costly alternative to the conventional survey and monitoring methods applied to *C. paca* studies. Estimation of pirarucu (*Arapaima gigas*) population sizes in Mamirauá SDR is a good example of the successful practical application of traditional knowledge. The counting of fish by local fishermen replaces the slow and expensive mark-recapture method, and also allows the fishermen to participate in decision making related to management (Castello, 2004; Castello et al., 2009).

The spotlighting method used by ASDR hunters is also very similar to nocturnal counting, or spotlight surveys, extensively utilized to determine abundances and evaluate the conservation status of crocodilians populations (e.g. Thorbjarnarson and Hernández, 1992; Da Silveira, 2002). Both methods have in common the variation in the number of individuals observed according to water level and lunar illumination. The method is considered relatively accurate for crocodilians, especially when these variables are accounted for (Da Silveira et al., 2008). However, the spotlighting method needs to be standardised for monitoring paca populations near water bodies and, in this case, hunters´ knowledge must underpin standardisation efforts. This would allow for monitoring the main portion of the paca population under pressure from hunting, especially in Amazonian environments (Aquino et al., 2009; Harmsen et al., 2011; Pérez et al., 2010). On the other hand, nocturnal surveys on trails, photographic traps and indirect techniques will still be needed for monitoring extensive areas of forest.

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