Turning the game around for conservation: using traditional hunting knowledge to improve the capture efficiency of Amazon lowland pacas

Authors: Bizri, Hani Rocha El, Araújo, Luiz Washington da Silva, Araújo, Wigson da Silva, Maranhão, Louise, and Valsecchi, João

Source: Wildlife Biology, 22(1) : 1-6

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/wlb.00127

Wildlife Biology 22: 1–6, 2016
doi: 10.2981/wlb.00127

Subject Editor: Peter Sunde. Editor-in-Chief: Ilse Storch. Accepted 30 June 2015

Turning the game around for conservation: using traditional hunting knowledge to improve the capture efficiency of Amazon lowland pacas

Hani Rocha El Bizri, Luiz Washington da Silva Araújo, Wigson da Silva Araújo, Louise Maranhão and João Valsecchi

H. R. El Bizri (hani@mamiraua.org.br), L. W. da Silva Araújo, W. da Silva Araújo, L. Maranhão and J. Valsecchi, Research Group on Terrestrial Vertebrate Ecology, Mamirauá Sustainable Development Inst., Estrada do Bexiga 2584, Postal Code 69553-225, Tefé, Amazonas – Brasil

The lowland paca *Cuniculus paca* is a large rodent and is one of the most hunted mammal species in the Neotropics. Conservation strategies for the lowland paca that depend on data from live captures have been hampered due to the elusive behavior of the species. Here, we introduce a scientifically standardized version of a traditional method used by hunters in the Amazon to capture pacas and compare its cost-effectiveness with conventional scientific methods. First, we used each of these methods at 11 sites in the Brazilian Amazon. The hunting technique captured 12 pacas, whereas the conventional methods captured none, and the hunting technique proved to be as inexpensive as the least-costly conventional method. Second, we analyzed the cost-effectiveness of the methods by comparing the results obtained in the field with data from previous paca studies. The hunting method was four-fold more efficient than the study with the highest paca capture rates achieved to date. This study shows that the use of a hunting technique to capture paca is an efficient and safe procedure that may be applied at different sites in the Amazon and represents an example of how traditional knowledge can be used in partnership with science to enhance the development of successful conservation efforts.

The capture of wild animals for research is always challenging. Capture is an essential procedure to obtain biological data, such as physiological and reproductive parameters (Alexander et al. 1998), on free-living species and home and movement ranges of wild animals (e.g. telemetry – Bjornlie et al. 2014). In addition, many conservation measures employed by wildlife managers, such as translocation and in situ reintroduction (Tenhumberg et al. 2004), also depend on safe capture procedures.

Live-capture techniques for large mammals are typically inefficient, costly or invasive. Because of this, scientists often rely on vestiges of large animals, such as feces and fur, which may limit the questions their research can answer. Conversely, hunters employ diverse and efficient techniques to capture wildlife (Alves et al. 2009) and these hunting strategies can be adapted for scientific purposes (Fernandez-Gimenez et al. 2006).

The lowland paca *Cuniculus paca* is an example of a large Neotropical game mammal that is hard to capture, mainly because of its nocturnal and cryptic habits, remaining in burrows underground during the day. Lowland pacas are intensely hunted and sensitive to habitat loss (Zapata-Ríos et al. 2009, Morcatty et al. 2013, Valsecchi et al. 2014, El Bizri et al. 2015), which has caused the species to become extinct in several regions of its original distribution (Queirolo et al. 2008) and to be classified as endangered on many local-scale red lists (e.g. several Brazilian States - Chiarello et al. 2008). Despite its importance for human use and its worrisome conservation status, most of the biological information on pacas comes from captive studies (Mayor et al. 2013); thus, the lack of appropriate methods for capturing pacas has hampered the collecting of scientific data needed to develop conservation strategies (Beck-King et al. 1999).

There have only been five studies using paca captures to date, and due to the inefficiency of the methods used, the results have been limited. Most of the attempts at capturing pacas have employed Tomahawk traps. Fournier-Chambrillon et al. (2000) and Collett (1981) working in French Guiana and Colombia, respectively, found that the use of Tomahawk traps to capture paca was ineffectual. Smythe et al. (1982) and Marcus (1984) were the only authors to successfully capture pacas using Tomahawk traps. Both of these studies were carried out in Barro Colorado, a tropical forest isle in Panama with a recognizably high density of pacas (Glanz 1990).

Beck-King et al. (1999) employed the method of burrow excavation to capture pacas in Costa Rica and obtained few individuals. In addition, Fournier-Chambrillon et al. (2000) and Lange and Schmidt (2007) suggested placing nets on the escape holes of paca burrows as a live-capture method, but no results using this technique have yet been reported in the literature.

Dogs have been used in previous scientific studies to improve research results (Zwickel 1980), especially for the live capture of cryptic animals such as felids (Elbroch and Wittmer 2012) and mustelids (Thompson et al. 2012), and Collett (1981) suggested that dogs could be used to capture pacas as well. The paca is one of the preferred game species in rural communities in the Amazon (Bodmer 1995, Read et al. 2010, Valsecchi and Amaral 2009), and active searching with dogs is one of the principal and most efficient hunting techniques used (Koster 2009).

Techniques to sample biodiversity should be tested and compared to identify those methods with the highest efficiency and lowest implementation costs to optimize conservation resources (Schemnitz et al. 2009, Gardner et al. 2008). However, the feasibility of using dogs to capture live pacas has not yet been appropriately tested and compared with the other methods commonly employed. This is the first attempt to standardize and test the use of hunting dogs to capture pacas. In this study, we (a) compare the cost-effectiveness of an adaptation of the traditional hunting technique with dogs to the two conventional techniques most commonly mentioned in the literature to capture lowland pacas and (b) discuss the advantages and disadvantages of each of the methods employed.

Material and methods

Study area

The 2313 km^2 Amanã Sustainable Development Reserve (ASDR) is located in the Brazilian Amazon between the Negro and Japurá rivers (3°83′43.2″S and 64°51′98.4″W). The main objective of a sustainable development reserve is to conserve nature while providing conditions for the sustainable use of natural resources by people and improving the knowledge and management techniques developed by the local communities (BRASIL 2000), which corresponds to the IUCN protected areas category VI. The human population of the ASDR is approximately 4000 people. The mean annual rainfall in the ASDR is 2857 mm, and the mean annual temperature is 26.6 ± 1.1°C. The ASDR contains three main ecosystem types: 'terra-firme' (upland forest), characterized as a dense and non-flooded forest reliant on red and yellow latosols; 'várzea' (whitewater flooded forest), which is a forest seasonally flooded by white water rivers, with a constantly renewed soil rich in nutrients; and 'igapó' (blackwater flooded forest), a forest flooded by black water rivers with lower amount of nutrients than 'várzea' and with low plant biomass but a rich plant diversity. We sampled pacas in a stream of the ASDR called Ubim, which is composed of 'terra firme' and 'igapó'.

Data collection

We performed capture campaigns during the rivers' flood, ebb and drought periods between August 2013 and October 2014. We attempted to capture pacas at 11 sites on the margin of the Ubim stream. At each site, we delimited a 10-ha area, 2.5 km long and 40 m wide, thus forming a plot in which we applied three capture methods: traditional hunting technique with dogs (August 2013 to October 2013 and March 2014), placement of nets on the burrows' escape holes (November 2013 and February 2014), and Tomahawk traps with baits (September and October 2014) (Fig. 1). To guarantee independence among the methods, the time interval between the application of the methods at each site was at least one month. Due to the natural flooding intensity in the study area, which causes a mean variation of 2 m in water level height in one month (Ramalho et al. 2009), each plot varied in position during the year and thus was independent for each method used. The methods were approved by the Committee on the Ethical Use of Animals and Plants for Research of the Mamirauá Sustainable Development Institute (CEP Protocol no. 006/2013) and were licensed by the environmental institution responsible (SISBIO 38099-3 and SISBIO 41020-1).

Traditional hunting technique: active searching with dogs

We adapted a traditional hunting technique by actively searching with dogs to capture pacas. Two dogs that had been previously trained by local residents to hunt pacas were led by two local assistants along the extension of the plot during four hours in the morning. The first assistant walked at a distance of 10 m from the stream margin, whereas the second assistant walked at 30 m from the margin. Thus, the total area of each plot was visually searched for paca burrows. The hunting dogs were responsible for detecting pacas on the terrain and expelling them by barking or entering the burrows. A third assistant remained in a canoe close to the margin searched by the land assistants, and due to this species' characteristic escape strategy, the expelled pacas jumped into the stream and were captured by the third assistant with a net. The dogs were leashed immediately afterwards to avoiding injuring the pacas.

To minimize the risks of zoonosis transmission between the dogs and the wild animals, we treated the dogs with specific medications, administering vermifuges based on fenbendazol, pyrantel pamoate and praziquantel (VetMax Plus, Vetnil - one pill/10 kg) and ivermectin (Ivomec - 0.2 mg kg^{-1}). The assistants and dogs were the same throughout the entire study. Each of the 11 plots was sampled once by active searching with dogs.

Placement of nets on escape holes

This method consisted of active searches for burrows without dogs and the placing of nets on burrow escape holes. The position of the assistants with regard to the stream margin was the same as in the previous method. However, in this method, the assistants were the only ones responsible for detecting burrows possibly occupied by pacas. After these burrows were identified, nets were adjusted over the escape holes as suggested by Fournier-Chambrillon et al. (2000), and the pacas were expelled from the burrows by inserting branches into the burrows' interior. As in the active searches with dogs, a third assistant remained on the canoe waiting for the paca to move

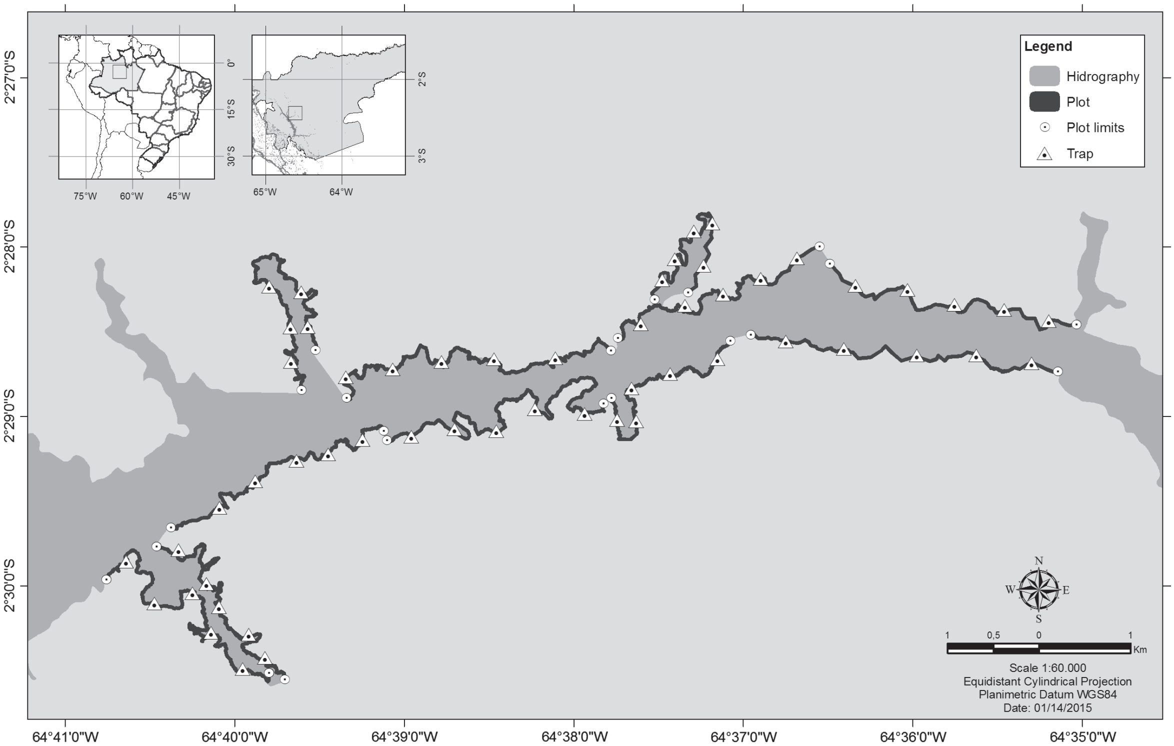

Figure 1. Map of the Amanã Sustainable Development Reserve, Central Amazon, showing the study area and the 11 plots used for lowland paca capture at the margins of the Ubim stream.

into the water. Each of the 11 plots was sampled once by active searching with nets.

Use of traps

We distributed five Tomahawk traps (75 × 45 × 45 cm) within the area of each of the 11 plots, using a total of 55 traps. Based on the estimation of a paca home range size of 2.5 ha and on the species' resident behavior (Beck-King et al. 1999), we placed the traps 500 m from one another and 10 to 20 m from the stream margin. Because each trap was placed in at least one paca home range, the number of traps was sufficient to cover the entire area of the plots and heightened the capture probability (Fig. 1). We positioned each trap near paca burrows and trails identified by the assistants and camouflaged the traps by covering them with leaves and earth. We consulted local farmers to select baits to attract pacas to the traps, and they suggested three locally cultivated species that would serve this purpose. We employed the same procedures of bait use and capture as Marcus (1984). For this, we placed baits composed of a mixture of banana, cassava and yams around and within the traps for seven days. We attempted capture on the seventh day of baiting. We activated the traps during the waning and new moon, as moonlight may decrease paca activity (Harmsen et al. 2011, Valsecchi et al. 2014). We checked all traps at 5-h intervals during the night.

Data analysis

We used descriptive statistics to compare the number of pacas captured with each method used in the field. We estimated the 95% confidence intervals (CI) for the total number of pacas captured per method using the confidence limits of Poisson-distributed events, considering that captures were randomly distributed and each capture was an independent event. In addition, we made cost estimations in order to perform a cost-effectiveness analysis. First we estimated the costs of implementing and applying the three methods used. We considered as 'implementation costs' the structural investments and as 'application costs' the costs during field sampling (Table 1). Fuel expenses refer to movement from the field support base to the sampling plots by river motorboats with a 30-hp outboard motor. Assistant costs were calculated based on the compensation for local day wages in the ASDR. The time effort expended in each method was the same and thus did not influence the costs. We did not consider the presence of a researcher during sampling, as the local assistants are able to perform the proposed sampling by themselves.

We then calculated the cost-effectiveness of the methods by dividing the number of captured pacas per application cost of each technique (paca US$$^{-1}$). We also calculated the cost-effectiveness obtained by Marcus (1984) in Barro Colorado Island because his sampling effort with traps was similar to ours. Although Barro Colorado is not located in the Amazon, this study had the greatest paca capture rates reported in the literature and was a valuable comparison with our results to understand whether the use of dogs in our context would be as cost-effective as the study with the maximum capture rate to date. For this calculation, we used the same cost values as for the present study conducted in the field in the ASDR (Table 1). We compared cost-effectiveness values using 95% CI, calculated by means of the same confidence

Table 1. Prices established for the items necessary for sampling and the total amount spent for each method.

Item	Purchase unit	Price (US$)	US$ (no. of items)			
			Searching with dogs	Searching with nets	Tomahawk traps	Marcus (1984)
Implementation						
Canoe	unit	132.70	132.70 (1)	132.70 (1)	0 (0)	0 (0)
Net	unit	29.50	88.50 (3)	88.50 (3)	0 (0)	0 (0)
Trap	unit	88.50	0 (0)	0 (0)	4867.50 (55)	4867.50 (55)
Leash	unit	4.40	8.80 (2)	0 (0)	0 (0)	0 (0)
Medication	boxes	28.85	28.85 (1)	0 (0)	0 (0)	0 (0)
Total			259 (7)	221 (4)	4868 (55)	4868 (55)
Application						
Manpower[a]	assistant	17.70	584.10 (33)	584.10 (33)	708.00 (40)	15292.80 (864)
Bait[a]	mixed vegetables	17.70	0 (0)	0 (0)	123.90 (7)	4460.40 (252)
Food (personnel)[a]	food	11.00	363.00 (33)	363.00 (33)	440.00 (40)	9504.00 (864)
Food (dogs)[a]	feed	1.40	30.80 (22)	0 (0)	0 (0)	0 (0)
Gasoline	liter	1.80	212.40 (118)	212.40 (118)	2124.00 (1180)	5702.40 (3168)
Total			1190 (206)	1160 (184)	3396 (1267)	34960 (5148)

[a]purchase unit costs estimated per application day. The currency used for the calculations was the US Dollar (US$) (exchange rate 08/05/2014 – 1 US Dollar = 2.26 Brazilian Real).

limits of Poisson distribution used for the total number of pacas captured per method. We considered that cost-effectiveness values were distinct between methods when their CI did not overlap.

Results

We detected 16 lowland pacas by active searching with dogs and captured 75% of them (n = 12). In comparison, only one paca was detected but not captured by active searching without dogs. Similarly, no pacas were captured with Tomahawk traps, which captured only two opossums *Didelphis marsupialis*. The pacas that were not captured during both types of active searching either escaped by land or were not found after entering the water.

Tomahawk traps had the greatest implementation cost, which was approximately 20-fold greater than those of either type of active searching (Table 1). As we did not capture any pacas by active searching with nets or by using traps, the cost-effectiveness of these methods was close to zero. Compared to Marcus (1984), the cost-effectiveness of active searching with dogs was approximately four-fold greater than the highest capture rates with traps obtained to date (Table 2).

Discussion

The hunting technique was efficient in both cost and effort when capturing lowland pacas in the Amazon, even when compared with the use of traps in places where that technique had great success. Studies involving paca capture with traps usually have extremely low capture success rates, comparable to that obtained in our sampling (Fournier-Chambrillon et al. 2000). The capture rates with Tomahawk traps may vary with environmental seasonality because animals are likely to be more inclined to enter the traps when food is scarce. Furthermore, capture rates may also vary according to the reproductive cycle of the target species. The high capture rates of pacas obtained by Marcus (1984) and Smythe et al. (1982) with Tomahawk traps may be related to the high density of this species in Barro Colorado (Glanz 1990) and/or to the marked seasonal differences in fruit availability at this site (Marcus 1984), resulting in a greater predisposition of the pacas to enter the traps to feed. However, even though the capture rates with traps were relatively high in those studies, this technique is still less cost-effective than the method of active searching with dogs. Furthermore, although food availability in our study area is less variable during the year than in Barro Colorado, the period during which we placed the traps was the dry season, which is

Table 2. Number of paca detections and captures and the cost-effectiveness calculated for each capture method.

Parameter	Searching with dogs	Searching with nets	Tomahawk traps[a]	Marcus (1984)[a]
Sampling days	11	11	8	288
Sampled area (ha day^{-1})	10	10	10	25
Pacas detected[b]	16 (9.15–26.0)	1 (0.06–5.58)	0 (0.00–3.70)	83 (66.1–103)
Pacas captured[b]	12 (6.20–21.0)	0 (0.00–3.70)	0 (0.00–3.70)	83 (66.1–103)
Pacas detected per day[b]	1.45 (0.83–2.36)	0.09 (0.002–0.51)	0 (0.00–0.46)	0.29 (0.23–0.36)
Pacas captured per day[b]	1.09 (0.56–1.91)	0 (0.00–0.34)	0 (0.00–0.46)	0.29 (0.23–0.36)
Cost per sampling day (US$)	108.21	105.41	424.49	121.39
Cost-effectiveness (pacas US$$^{-1}$)[b]	0.0101 (0.0052–0.0176)	0 (0.0000–0.0032)	0 (0.0000–0.0011)	0.0024 (0.0019–0.0029)
Cost per captured paca (US$)[b]	99 (57–192)	n.a. (n.a.–313)	n.a. (n.a.–918)	421 (340–529)

[a]pre-baiting days were considered as sampling days.
[b]values in parenthesis are the 95% confidence intervals calculated using Poisson distribution.

precisely the season when fruits are less abundant both in 'terra firme' and 'igapó' forests (Haugaasen and Peres 2005); thus, we would expect higher capture rates during this period if food limitation significantly affected the attractiveness of baits. The reproductive cycle of paca must have had little effect on our sampling with traps, as pacas reproduce fairly consistently throughout the year in ASDR (Valsecchi et al. 2014). This finding agrees with that of Dubost et al. (2005), who found that the percentage of pregnant females and young in a paca population in French Guiana was the same throughout the year.

In addition to being costly and inefficient, traps are not selective, as they capture a number of mammals not targeted by the study that are then subjected to unnecessary confinement stress (Marcus 1984). A high number of injuries suffered by pacas during capture with traps is also frequently reported (Smythe and Guanti 1995). No confinement-related wounds were recorded with the use of dogs, as the data was collected immediately after capture. Reports of injuries during the capture of wild animals with dogs are usually related to the chemical or physical confinement of the animal being captured (McBride Jr. and McBride 2007) or to the excessive use of dogs when searching in areas where the animal has few possibilities of escaping from pursuit, increasing the probability of physical conflicts (Elbroch et al. 2013). In this study, we observed that dogs may be used in lower numbers with great efficiency and that as long as leashes are used to contain the dogs after the paca has been expelled, this technique may be considered safe.

In turn, the placement of nets on the escape holes, which has been suggested in some studies (Fournier-Chambrillon et al. 2000), was shown to be unproductive, as the assessment of whether a lowland paca is present within the burrow and the location of all burrow entries is not always apparent. This study presents the first results using this technique, suggesting that it is not indicated for the study of pacas.

Regarding the number of pacas that were detected but not captured, the use of dogs along with nets placed on the escape holes could be an alternative to prevent individuals from escaping. However, we do not consider this a safe technique as it may increase the chance of animals being injured by dog attacks.

Few studies worldwide have employed hunting dogs to capture rodents. Silvius and Fragoso (2003) captured agoutis *Dasyprocta leporina* on Maracá Island in the Brazilian Amazon with the aid of hunting dogs trained by local residents, and they noted that this method was the only one to be efficient enough to locate a large number of animals. Bergman et al. (1995) noted that armadillos *Dasypus novemcinctus*, which are nocturnal burrowing animals similar to pacas, may be more efficiently captured using dogs than with traps and nets.

The efficiency of capturing paca using dogs is relevant because it provides the opportunity to collect biological material. In the Amazon, pacas are part of the biological cycle of both human and animal parasites such as echinococcosis *Echinococcus vogeli* (Gardner et al. 1988) and leishmaniasis *Leishmania* (*Viannia*) *lainson* (Silveira et al. 1991), and collecting biological material may help develop strategies for reducing the incidence of these diseases in rural communities. Additionally, live capture with dogs may also aid in telemetry studies, which are rare for pacas.

As the use of dogs is a traditional hunting practice, this method may be easily implemented as a community-based monitoring for pacas, thereby allowing the development of strategies for paca management using abundance calculated by capture-recapture models (as long as the specimens are individually marked) or abundance indexes such as encounter rates (pacas or active burrows per km), and our experience shows that this procedure is viable (El Bizri et al. unpubl.). Increased knowledge and control of paca numbers in the Amazon would enable the locals to make adequate decisions to prevent over-hunting, which has been shown by a number of studies in the biome (Sánchez and Vásquez 2007).

Although camera trap surveys can be an efficient method for detecting pacas, we believe that in most cases active searching with dogs will be cheaper and more appropriate to a community-based monitoring approach. Furthermore, although pacas have distinct coat markings, no study has yet evaluated the reliability of identifying individual pacas from photographs. Also, Foster and Harmsen (2012) indicated several challenges and failures of density estimation with capture–recapture models using data from camera traps, especially for elusive species such as the paca. In this context, the use of dogs to capture pacas would allow for a more robust analysis using camera trap data such as the capture–resight models, as individuals would be marked during live capture (e.g. with tags or ink) and individually identified in photographs.

At some sites where the bodies of water do not permit free canoe movement or where locating the paca in the water is hampered by other factors, the use of dogs to capture pacas may be limited. These cases would require new tests in which dogs would remain in use for detecting the species at the site, but the capture method may have to be changed.

This study shows that the use of dogs to capture pacas is an efficient and safe method that may be used throughout the Amazon. The results described here show the importance of integrating scientific and local knowledge and the potential of this integration to generate effective methods for the study of game fauna worldwide (Rönnegård et al. 2008).

Acknowledgements – We thank the National Council for Scientific and Technological Development (Conselho Nacional de Pesquisa e Inovação - CNPq) and the Ministry of Science, Technology and Innovation (Ministério da Ciência, Tecnologia e Inovação - MCTI) for their financial support. We thank the Mamirauá Sustainable Development Institute (Instituto de Desenvolvimento Sustentável Mamirauá – IDSM) for logistical support. We thank all members of the Research Group on Terrestrial Vertebrate Ecology, especially T. Q. Morcatty, I. J. Lima and L. P. Lemos for aid in the field and research advice. We thank E. O. Neves for producing the map. We thank J. B. Macedo for helping with the revision of the text. We also thank the residents of the Amanã SDR who contributed their traditional knowledge, offering valuable suggestions for the study design as well as essential support in the field.

References

Alexander, B. et al. 1998. Detection of *Leishmania* (*Viannia*) *braziliensis* complex in wild mammals from Colombian coffee plantations by PCR and DNA hybridization. – Acta Trop. 69: 41–50.

Alves, R. R. N. et al. 2009. Hunting strategies used in the semi-arid region of northeastern Brazil. – J. Ethnobiol. Ethnomed. doi:10.1186/1746-4269-5-12.

Beck–King, H. et al. 1999. Home range, population density, and food resources of *Agouti paca* (Rodentia: Agoutidae) in Costa Rica: a study using alternative methods. – Biotropica 31: 675–685.

Bergman, D. L. et al. 1995. An alternative method for capturing armadillos. – Southwest. Nat. 40: 414–416.

Bjornlie, D. D. et al. 2014. Whitebark pine, population density, and home-range size of grizzly bears in the Greater Yellowstone Ecosystem. – PLoS ONE 9: e88160.

Bodmer, R. E. 1995. Managing Amazonian wildlife: biological correlates of game choice by detribalized hunters. – Ecol. Appl. 5: 872–877.

BRASIL 2000. Sistema Nacional de Unidades de Conservação da Natureza. – Federal Law No. 9.985, de 18 de julho de 2000, Brazil.

Chiarello, A. G. et al. 2008. Mamíferos ameaçados de extinção no Brasil. – In: Machado, A. B. M. et al. (eds), Livro Vermelho da Fauna Brasileira Ameaçada de Extinção. Ministério do Meio Ambiente, Brasília, pp. 681–702.

Collett, S. F. 1981. Population characteristics of the *Agouti paca* (Rodentia) in Colombia. – Mich. State Univ. Biol. Ser.

Dubost, G. et al. 2005. Seasonality of reproduction in the three largest terrestrial rodents of French Guiana forest. – Mamm. Biol. 70: 93–109.

Elbroch, L. M. and Wittmer H. U. 2012. Puma spatial ecology in open habitats with aggregate prey. – Mamm. Biol. 77: 377–384.

Elbroch, L. M. et al. 2013. Trailing hounds vs foot snares: comparing injuries to pumas *Puma concolor* captured in Chilean Patagonia. – Wildl. Biol. 19: 210–216.

El Bizri, H. R. et al. 2015. The thrill of the chase: uncovering illegal sport hunting in Brazil through YouTube™ posts. – Ecol. Soc. 20: 30.

Fernandez-Gimenez, M. E. et al. 2006. Integration or co-optation? Traditional knowledge and science in the Alaska Beluga Whale Committee. – Environ. Conserv. 33: 306–315.

Foster, R. J. and Harmsen, B. J. 2012. A critique of density estimation from camera-trap data. – J. Wildl. Manage. 76: 224–236.

Fournier-Chambrillon, C. et al. 2000. Mammal trap efficiency during the fragmentation by flooding of a Neotropical rain forest in French Guiana. – J. Trop. Ecol. 16: 841–851.

Gardner, S. L. et al. 1988. *Echinococcus vogeli* Rausch and Bernstein, 1972, from the paca, *Cuniculus paca* L. (Rodentia: Dasyproctidae), in the Departamento de Santa Cruz, Bolivia. – J. Parasitol. 74: 399–402.

Gardner, T. A. et al. 2008. The cost-effectiveness of biodiversity surveys in tropical forest. – Ecol. Lett. 11: 139–150.

Glanz, W. E. 1990. Neotropical mammalian densities: how unusual is the community on Barro Colorado Island, Panama? – In: Gentry, A. (ed.), Four neotropical rainforests. Yale Univ. Press, pp. 287–338.

Harmsen B. J. et al. 2011. Jaguar and puma activity patterns in relation to their main prey. – Mammal. Biol. 76: 320–324.

Haugaasen, T. and Peres, C. A. 2005. Tree phenology in adjacent Amazonian flooded and unflooded forests. – Biotropica 37: 620–630.

Koster, J. 2009. Hunting dogs in the Lowland Neotropics. – J. Anthropol. Res. 65: 575–609.

Lange, R. R. and Schmidt, E. M. S. 2007. Rodentia: roedores silvestres (capivara, cutia, paca, ouriço). – In: Cubas, Z. S. et al. (eds), Tratado de Animais Selvagens: Medicina Veterinária. Roca, São Paulo. pp. 475–491.

Marcus, M. J. 1984. Behavioral ecology of paca (*Agouti paca*) on Barro Colorado Island, Panama. – Ms thesis, Univ. of Maine.

Mayor, P. et al. 2013. Functional morphology of the genital organs in the wild paca (*Cuniculus paca*) female. – Anim. Reprod. Sci. 123: 249–257.

McBride Jr., R. T. and McBride, R. T. 2007. Safe and selective capture technique for jaguars in the Paraguayan Chaco. – South. Nat. 52: 570–577.

Morcatty, T. Q. et al. 2013. Habitat loss and mammalian extinction patterns: are the reserves in the Quadrilátero Ferrífero, southeastern Brazil, effective in conserving mammals? – Ecol. Res. 28: 935–947.

Queirolo, D. et al. 2008. *Cuniculus paca*. The IUCN Red List of threatened species. Ver. 2014.2. – <www.iucnredlist.org> accessed 3 October 2014.

Ramalho, E. E. et al. 2009. Ciclo hidrológico nos ambientes de várzea da Reserva de Desenvolvimento Sustentável Mamirauá – Médio Rio Solimões, período de 1990 a 2008. – Uakari 5: 61–87.

Read, J. M. et al. 2010. Space, place, and hunting patterns among indigenous peoples of the Guyanese Rupununi region. – J. Lat. Am. Geogr. 9: 213–243.

Rönnegård, L. et al. 2008. Evaluation of four methods used to estimate population density of moose *Alces alces*. – Wildl. Biol. 14: 358–371.

Sánchez, A. and Vásquez, P. 2007. Presión de caza de la comunidad nativa Mushuckllacta de Chipaota, zona de amortiguamiento del Parque Nacional Cordillera Azul, Perú. – Ecol. Aplicada 6: 131–138.

Schemnitz, S. D. et al. 2009. Capturing and handling wild animals. – In: Silvy, N. J. (ed.), The wildlife techniques manual. Johns Hopkins Univ. Press, pp. 64–117.

Silveira, F. T. et al. 1991. Leishmaniose cutânea na Amazônia: isolamento de *Leishmania* (*Viannia*) *lainsoni* do roedor *Agouti paca* (Rodentia: Dasyproctidae), no estado do Pará, Brasil. – Rev. Inst. Med. Trop. São Paulo 33: 18–22.

Silvius, K. M. and Fragoso, J. M. V. 2003. Red-rumped agouti (*Dasyprocta leporina*) home range use in an Amazonian forest: implications for the aggregated distribution of forest trees. – Biotropica 35: 74–83.

Smythe, N. and Guanti, O. B. 1995. Domestication and husbandry of the paca (*Agouti paca*). – FAO Conservation Guide.

Smythe, N. et al. 1982. Population regulation in some terrestrial frugivores. – In: Leigh Jr., E.G. et al. (eds), The ecology of a tropical forest: seasonal rhythms and long-term changes. Smithsonian Inst. Press, pp. 227–238.

Tenhumberg, B. et al. 2004. Linking wild and captive populations to maximize species persistence: optimal translocation strategies. – Conserv. Biol. 18: 1304–1314.

Thompson, C. M. et al. 2012. A framework for inference about carnivore density from unstructured spatial sampling of scat using detector dogs. – J. Wildl. Manage. 76: 863–871.

Valsecchi, J. and Amaral, P. V. 2009. Perfil da caça e dos caçadores na Reserva de Desenvolvimento Sustentável Amanã, Amazonas – Brasil. – Uakari 5: 33–48.

Valsecchi, J. et al. 2014. Subsistence hunting of *Cuniculus paca* in the middle of the Solimões River, Amazonas, Brazil. – Braz. J. Biol. 74: 560–568.

Zapata-Ríos, G. R. et al. 2009. Mammal hunting by the Shuar of the Ecuadorian Amazon: is it sustainable? – Oryx 43: 375–385.

Zwickel, F. C. 1980. Use of dogs in wildlife biology. – In: Schemnitz, S. D. (ed.), Wildlife management techniques manual. The Wildlife Society, Washington, pp. 531–536.