

JAGUAR AND PUMA IN BRAZILIAN SEMI-ARID REGION – SCAPEGOATS FOR WEAK GOVERNANCE?

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ABSTRACT

Exclusively Brazilian, the Caatinga is a seasonally dry tropical forest where the endangered jaguar (*Panthera onca*) and puma (*Puma concolor*) co-occur with the lowest regional Human Development Indexes. New land uses challenge traditional livelihoods and add threats to species historically poached in retaliation for livestock depredation. Chronicle biodiversity conflicts became acute after a reported increase in depredation allegedly because of those changes and conflicts among stakeholders. Using the framework of human dimensions of wildlife management, pioneer research on the vulnerabilities of rural communities to jaguar-and-puma conflicts was led in 'Boqueirão da Onça', within and surrounding that polygon of protected areas. The aim was to identify, describe, understand, and predict human behaviour, and link the outcomes with the IUCN natural resources governance concept. Negative attitudes arose from 72% and 35.2% participants towards the proximity of jaguar and proximity of puma, respectively. When asked about institutions working for wildlife protection, and institutions working for people facing problems caused by carnivores, 64.9% and 88.8%, respectively, were unaware of them. Regarding beliefs about co-occurrence with jaguars or pumas, 80.9% and 82.9%, respectively, mentioned more problems than benefits, with 74.5% believing in the increase of both species' populations due to the creation of protected areas. This scenario may ease jaguar and puma to become scapegoats for human-wildlife and broader social conflicts, unless values such as justice and transparency are pursued.

Keywords: Biodiversity conflicts; Human dimensions; Protected areas; Governance

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1. INTRODUCTION

Many communities that become neighbours or inhabitants of protected areas consciously or unconsciously live the paradox between the benefit of co-occurrence with wildlife in highly relevant ecological regions, natural resources managed and surveyed to persist in the long term with quality, and the burden of all that may jeopardize their livelihood, traditional habits, behaviours and practices, restrain free-ranging of their livestock and compromise the utility of some elements in the name of existence value and natural heritage from non-dwellers perspective. That paradox often triggers human-wildlife conflicts (HWC) and conflicts among stakeholders related to species, wildlife management and/or new uses of the territory and land. Whether aware or not, these traditional communities deal with governance issues, with more or less preparedness of management agencies, decision makers, leaderships, corporations and facilitators. A “bad” governance undermines people, biodiversity and its interactions. A “good” governance is not a package but an infinite process that must take into account the norms, values, principles and approaches that will be applied in a dialogical decision-making, fairly including diverse right holders and stakeholders together.¹ “Good” or “bad” may change with time, with the background where it takes place and with the individual or social group involved and its interactions and established relations with resources and nature. Because it is rooted in human dimensions linked to ethics and morals, anthropology and culture, beliefs and norms, power and accountability, governance is complex, sensitive and time-demanding beyond a project life cycle. Thus, not all conservation projects, programs or policies approach the subject as a goal to pursue or as a keystone in its foundation.

Neighbouring or residing within a protected area that is also home to large, roaming animals, demanding extensive areas to thrive and carrying the label of charismatic, adds complexity to an already challenging process. Charisma arises not from the eventual damage or its conservation status but from the controversial opinions and feelings they provoke.² Therefore, conservation of species, habitats and human quality of life will not be effective or endure unless human dimensions of biodiversity conflicts are not assessed.

Carnivores like jaguar (*Panthera onca*) and puma (*Puma concolor*) in the neotropics belong to that category of charismatic species. These species are essential to maintain ecological equilibrium as they guarantee the diversity and resilience of ecosystems where they inhabit. As predators, they control

¹ Grazia Borrini and others, ‘Governance of Protected Areas: From Understanding to Action.’ [2013] Best practice protected area guidelines series <<https://www.iucn.org/content/governance-protected-areas-understanding-action-0>> accessed 28 July 2021.

² Silvio Marchini, ‘Who’s in Conflict with Whom? Human Dimensions of the Conflicts Involving Wildlife’, *Applied Ecology and Human Dimensions in Biological Conservation* (Springer Berlin Heidelberg 2014) <http://link.springer.com/10.1007/978-3-642-54751-5_13> accessed 28 July 2021.

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herbivore populations through a top-down effect on trophic cascades³ and because they usually leave part of their hunted preys, they supply food to maintain the diversity of scavenger and decomposer communities.⁴ Small and mainly large carnivores are hunted and killed worldwide, especially in retaliation to conflicts with rural communities.⁵ Moreover, large animals such as big cats have always been subject to human fascination and fear, generating an enormous and strong record of conflicts.⁶ The dynamics of HWC is challenging and solving conflicts between different social groups can be even more complicated than solving problems between humans and predators.⁷ Studies show that the contact with rural populations has resulted in purposeful elimination of large felids that are killed due to depredation of herds or as a trophy hunt.⁸ This problem is one of the most urgent felids conservation issues and in order to maintain big cats worldwide, the human dimensions and interactions with these animals need to be better understood.⁹

The north-eastern region of Brazil, comprehending the Caatinga domains where this research took place, has the lowest number of studies on HWC with big cats. In a review by Lozano and others¹⁰ about publications concerning human-carnivore relationships between 2000 and 2016, the

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- ³ William J Ripple and Robert L Beschta, 'Linking a Cougar Decline, Trophic Cascade, and Catastrophic Regime Shift in Zion National Park' (2006) 133 *Biological Conservation* 397 <<https://linkinghub.elsevier.com/retrieve/pii/S0006320706002989>> accessed 28 July 2021.
- ⁴ L Mark Elbroch and Heiko U Wittmer, 'Table Scraps: Inter-Trophic Food Provisioning by Pumas' (2012) 8 *Biology letters* 776 <<https://doi.org/10.1098/rsbl.2012.0423>> accessed 28 July 2021.
- ⁵ Philip J Nyhus, 'Human–Wildlife Conflict and Coexistence' (2016) 41 *Annual Review of Environment and Resources* 143 <<https://www.annualreviews.org/doi/10.1146/annurev-environ-110615-085634>> accessed 28 July; K Ullas Karanth and Ravi Chellam, 'Carnivore Conservation at the Crossroads' (2009) 43 *Oryx* 1 <<https://doi.org/10.1017/S003060530843106x>> accessed 28 July.
- ⁶ Thora M Herrmann and others, 'Values, Animal Symbolism, and Human-Animal Relationships Associated to Two Threatened Felids in Mapuche and Chilean Local Narratives' (2013) 9 *Journal of Ethnobiology and Ethnomedicine* 41 <<http://ethnobiomed.biomedcentral.com/articles/10.1186/1746-4269-9-41>> accessed 28 July 2021.
- ⁷ Alexandra Zimmermann and others, 'Contemporary Views of Human-Carnivore Conflicts on Wild Rangelands' in Johan T du Toit, Richard Kock and James C Deutsch (eds), *Wild Rangelands* (John Wiley & Sons, Ltd 2010) <<https://onlinelibrary.wiley.com/doi/abs/10.1002/9781444317091.ch6>> accessed 28 July 2021.
- ⁸ Kathleen Krafte Holland, Lincoln R Larson and Robert B Powell, 'Characterizing Conflict between Humans and Big Cats Panthera Spp: A Systematic Review of Research Trends and Management Opportunities' (2018) 13 *PloS one* e0203877 <<https://doi.org/10.1371/journal.pone.0203877>> accessed 28 July 2021; Marcelo Mazzolli, Mauricio E Graipel and Nigel Dunstone, 'Mountain Lion Depredation in Southern Brazil' (2002) 105 *Biological Conservation* 43 <<https://www.sciencedirect.com/science/article/pii/S0006320701001781>> accessed 28 July 2021; Francisca Belem Lopes Palmeira and Walter Barrella, 'Conflitos Causados Pela Predação de Rebanhos Domésticos Por Grandes Felinos Em Comunidades Quilombolas Na Mata Atlântica' (2007) 7 *Biota Neotropica* 119 <<https://www.biotaneotropica.org.br/v7n1/pt/abstract?article=bn03707012007>> accessed 28 July 2021.
- ⁹ Herrmann and others (n 6); Krafte Holland, Larson and Powell (n 8); Zimmermann and others (n 7).
- ¹⁰ Jorge Lozano and others, 'Human-Carnivore Relations: A Systematic Review' (2019) 237 *Biological Conservation* 480 <<https://linkinghub.elsevier.com/retrieve/pii/S0006320718318330>> accessed 4 August 2021.

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Caatinga as a domain or as a semi-arid region was not even mentioned. Despite the high ecological relevance of Caatinga, the newest frontier to science in Brazil, and the regional conservation status of jaguar (critically endangered) and puma (endangered),¹¹ in the last decade the Caatinga has seen changes being implemented very fast in pristine areas. These landscapes with emerging socioeconomic interests are also regions where apex predators have their distribution range, and concomitantly used by traditional pastoralist groups growing small number of livestock (mainly goats and sheep) grazing in the wild, especially in the dry season, and displaying a very close to ‘hunt-and-gather’ behaviour combined with a small-scale farming, in the short rainy season. The population is formed by families in a situation of high socioeconomic vulnerability, that depend on natural resources for their livelihoods.

After sharp decrease in jaguar populations until 1970’s for fur markets, nowadays its populations are threatened for persecution and poaching of its individuals as retaliation for depredation of livestock, with or without proved guilt, and even though depredation events are more frequent having puma as perpetrator.¹² Domestic animals such as dogs and pigs are also commonly seen attacking lambs and small livestock (Campos, 2019, pers. comm.).

New land uses through the establishment of wind and solar farms, mining (legal and illegal) and commercial crops have encroached and fragmented jaguar and puma habitats, which demand extensive areas to obtain resources necessary for their survival.¹³ In addition, infrastructure associated with these developments, such as road networks where none existed before, have paved the way for outsiders to increase hunting pressure on the wild prey of these big cats.¹⁴

In this paper we addressed the issue that big cats become, in fact, scapegoats for problems that go beyond HWC, such as lack of “good” governance, as per the judgment of as many as possible stakeholders within the Brazilian Dry Forest. We did it by analysing how the relationships

¹¹ Fernanda Cavalcanti de Azevedo and others, ‘Avaliação Do Risco de Extinção Da Onça-Parda Puma Concolor (Linnaeus, 1771) No Brasil’ [2013] Biodiversidade Brasileira 107 <https://www.icmbio.gov.br/portal/images/stories/biodiversidade/fauna-brasileira/avaliacao-do-risco/carnivoros/onca-parda_Puma_concolor.pdf> accessed 4 August 2021; A Desbiez, RC Paula and S Cavalcanti, ‘Plano de Ação Nacional Para a Conservação Da Onça-Pintada’ [2013] Instituto Chico Mendes de Conservação da Biodiversidade, ICMBio 1 <<https://www.icmbio.gov.br/portal/images/stories/docs-pan/pan-onca-pintada/1-ciclo/pan-onca-pintada-livro.pdf>> accessed 4 August 2021; Carlos Roberto Fonseca and others, *Caatinga* (José Maria Cardoso da Silva, Inara R Leal and Marcelo Tabarelli eds, Springer International Publishing 2017) <[https://books.google.com.br/books?hl=pt-BR&lr=&id=029GDwAAQBAJ&oi=fnd&pg=PR5&dq=Silva,+J.M.C.,+Leal,+I.R.+and+Tabarelli,+M.+\(ed.\),+Caatinga.+The+largest+tropical+dry+forest+region+in+South+America,+Cham:+Springer+International+Publishing,+pp.+429-443.&ots](https://books.google.com.br/books?hl=pt-BR&lr=&id=029GDwAAQBAJ&oi=fnd&pg=PR5&dq=Silva,+J.M.C.,+Leal,+I.R.+and+Tabarelli,+M.+(ed.),+Caatinga.+The+largest+tropical+dry+forest+region+in+South+America,+Cham:+Springer+International+Publishing,+pp.+429-443.&ots)> accessed 4 August 2021.

¹² Desbiez, Paula and Cavalcanti (n 11).

¹³ L David Mech, ‘A New Era for Carnivore Conservation’ (1996) 24 *Wildlife Society Bulletin* (1973-2006) 397 <<http://www.jstor.org/stable/3783319>> accessed 4 August 2021.

¹⁴ Douglas de Matos Dias and others, ‘Human Activities Influence the Occupancy Probability of Mammalian Carnivores in the Brazilian Caatinga’ (2019) 51 *Biotropica* 253 <<https://onlinelibrary.wiley.com/doi/10.1111/btp.12628>> accessed 4 August 2021.

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between people, and relationships between people and institutions, impact on the conservation of jaguars and pumas in the Caatinga. We identified, described and tried to understand human dimensions of the individual but also attempted to investigate association between aspects that belong to an individual and are affected by aspects of the individual's interpersonal and institutional environment, not necessarily under his/her control. In this context, some research questions arose: is it the perception of economic and social vulnerability alone that leads a person to hunt for food or to chase and kill a jaguar (or puma) because they are convinced that it is a risk to personal safety or their way of life? Or the trigger is their perceived vulnerability to conflict due to experiences with or exposure to the species, or their lack of future prospects, or their lack of trust in institutions, as a consequence of their perception of historical negligence and poor transparency from public administration and other institutions? Or again, when they perceive those institutions that should safeguard people's interests acting against them, by excluding them from governance since its very beginning, is accountability projected towards big cats? And because they cannot control any of these external factors that leave them vulnerable, how does an experience of livestock loss (or simply delay in goat or sheep returning home) translate into threat to jaguar and puma? Our aim is that this pioneer approach may provide valuable insights to support the young protected areas managed by the central government.

2. METHODOLOGY

2.1 Study area

The study took place in a region called 'Boqueirão da Onça', a polygon of protected areas established by the Decrees 9336 ("Boqueirão da Onça" National Park, with 347,557 hectares) and 9337 ('Boqueirão da Onça' Environmental Protected Area, with 505,692 hectares, including 11,651 hectares of "Toca da Boa Vista" Wildlife Zone), both published on 5th April 2018.

"Boqueirão da Onça" is within the range of the Caatinga biome, a Seasonally Dry Tropical Forest and Woodlands (SDTFW),¹⁵ the second most vulnerable Brazilian biome to climate change,¹⁶ where populations of the largest wildcats of Americas, jaguar and puma, co-occur with the lowest human development indexes (HDI) of North-eastern Brazil. The climate is semi-arid, characterized by high mean temperatures (30°C) and low mean annual precipitation (693 mm), and presents two well-defined seasons, rainy

¹⁵ Luciano Paganucci de Queiroz and others, *Caatinga* (José Maria Cardoso da Silva, Inara R Leal and Marcelo Tabarelli eds, Springer International Publishing 2017) <<http://link.springer.com/10.1007/978-3-319-68339-3>> accessed 4 August 2021.

¹⁶ Alistair WR Seddon and others, 'Sensitivity of Global Terrestrial Ecosystems to Climate Variability' (2016) 531 *Nature* 229 <<https://doi.org/10.1038/nature16986>> accessed 4 August 2021.

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and dry, usually with long periods of drought.¹⁷ Caatinga comes from the indigenous word “ka’a-tinga” which means “white bush”, the typical feature of vegetation cover during the dry season.

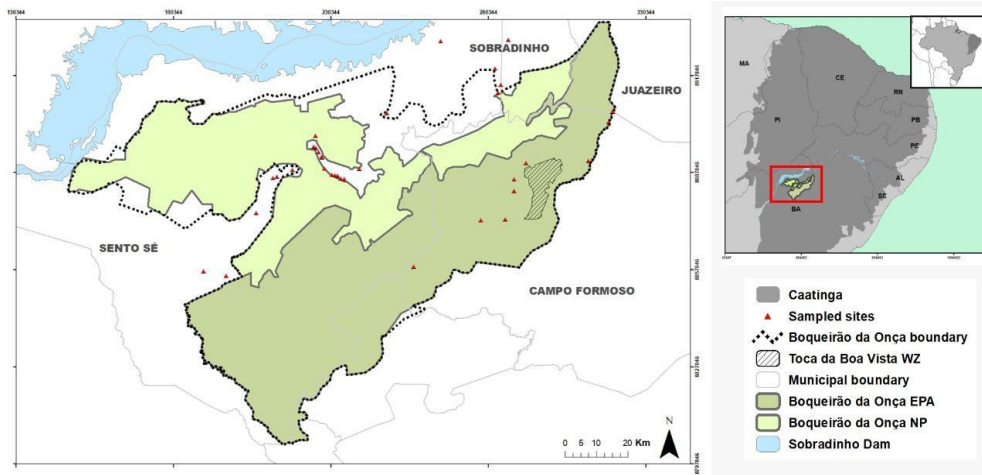


Figure 1: Location of the study area formed by protected areas: Boqueirão da Onça National Park (NP), Boqueirão da Onça Environmental Protection Area (EPA) and Toca da Boa Vista Wildlife Zone (WZ), north-eastern Brazil

The region has a heterogeneous landscape, with the presence of saws, plateaus, *lajedos* (rocky slab), *veredas*, as well as dry or wet *boqueirões* (deep forested valleys). It is also rich in grottoes and small temporary rivers, which accumulate water even during the driest periods of the year. These are key locations for all the biota and human populations in the region, since they ensure the water supply, with their springs, and forest cover that prevents the loss of water from the soil through evaporation.¹⁸

The presence of government authorities as wildlife management agencies is new, irregular and mainly for control of hunting and fire. Channels and means available for communication between rural inhabitants and authorities either are absent or suffer from noise, consequence of a history of oppression and negligence, that caused a rupture among residents of rural and natural areas and urban residents, the first perceiving an absence of fundamental rights and a vulnerability to conflict with wildlife, to be managed by themselves. The arrival of corporations to exploit natural resources met human populations' expectations that have never been achieved through public administration. Internet connection recently arrived, triggered by the operational demands of wind and solar plants, even with the absence of water supply, sanitation, electricity supply, health care

¹⁷ Guilherme de Oliveira and others, 'Conserving the Brazilian Semiarid (Caatinga) Biome under Climate Change' (2012) 21 *Biodiversity and Conservation* 2913
<<http://link.springer.com/10.1007/s10531-012-0346-7>> accessed 4 August 2021.

¹⁸ Cláudia Bueno de Campos and others, 'Medium and Large Sized Mammals of the Boqueirão Da Onça, North of Bahia State, Brazil' (2019) 59 *Papéis Avulsos de Zoologia* e20195912
<<https://www.revistas.usp.br/paz/article/view/150168>> accessed 4 August 2021.

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provision, public transportation or schools for all levels, in the majority of rural communities.

2.2 Stakeholders

Within a framework of conflicts related to environmental issues, the stakeholder is the one (individual or group) with legitimacy, political influence, enough power to interfere and hinder a decision to be implemented, and moral claims.¹⁹ In this research, stakeholders correspond to the adults residing within and surrounding protected areas in “Boqueirão da Onça”, livestock owners or not, farmers or not, men and women, being the single criteria the co-occurrence with jaguar and puma, and the volunteer cooperation with the research.

2.3 Data collection

In this explanatory, deductive and observational research,²⁰ a semi-structured questionnaire was submitted to the Ethics Committee in Research involving Human Beings (CEP), and once approved²¹, applied face-to-face to 168 people from 27 sites (farms and communities) between October 2018 and April 2019. The protocol had 108 questions, arranged in four sections: 1. exposure to the conflict (comprising variables such as exposure to the species, experience with the species, attitudes, beliefs, perceptions and habits), 2. sensitivity to the conflict (comprising variables such as perceived control behaviour, attitudes, relation with wildlife management agencies, socioeconomic vulnerability, knowledge, perceptions and social norms), 3. conflict adaptation capacity (comprising variables such as knowledge, attitudes, beliefs, husbandry practices, and socioeconomic vulnerability), and, 4. personal questions (comprising variables such as land tenure, and income source).

2.4 Sampling strategy

This is a cross-sectional, probabilistic study with sampling having used clusters. Three data collection campaigns were established; thus, the polygon was divided into three sections. Each section corresponds to one cluster.²² The total number of sites (including farms, communities) identified within the polygon were 93, and for convenience, one third of sites were to be visited to apply the questionnaire. The proportion of sites to data collection

¹⁹ Lawrence Susskind and Jeffrey Cruikshank, *Breaking the Impasse: Consensual Approaches to Resolving Public Disputes*. (Basic Books 1987) <<https://scienceimpact.mit.edu/breaking-impasse-consensual-approaches-resolving-public-disputes>> accessed 4 August 2021.

²⁰ Helen Newing, *Conducting Research in Conservation: Social Science Methods and Practice* (Routledge, Taylor and Francis Group 2011).

²¹ CAAE n. 68314417.1.0000.5395, 28th June 2017 (CEP); SISBIO n. 67264-1 (Art. 28, IN 03/2014).

²² Floyd J Fowler Jr., *Survey Research Methods, 2nd Ed.* (Sage Publications, Inc 1993) <[https://books.google.com.br/books?hl=pt-BR&lr=&id=Wm11AwAAQBAJ&oi=fnd&pg=PP1&dq=Fowler,+F.J.+\(1993\).+Survey+research+methods.+Newbury+Park,+CA:+SAGE+Publications+Inc.&ots=6PtHChcQbU&sig=zcMJQ_tH970UBM8yIBiJiUvrcqI#v=onepage&q&f=false](https://books.google.com.br/books?hl=pt-BR&lr=&id=Wm11AwAAQBAJ&oi=fnd&pg=PP1&dq=Fowler,+F.J.+(1993).+Survey+research+methods.+Newbury+Park,+CA:+SAGE+Publications+Inc.&ots=6PtHChcQbU&sig=zcMJQ_tH970UBM8yIBiJiUvrcqI#v=onepage&q&f=false)> accessed 4 August 2021.

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followed the proportion of territory of each municipality belonging to “Boqueirão da Onça” (five municipalities in total). Random sites were chosen within each municipality (16 in Sento Sé, seven in Campo Formoso, four in Umburanas, three in Sobradinho and one in Juazeiro). In farms and small communities one adult per house was interviewed; in medium to large communities, one adult in alternate houses in every street was interviewed.

Eventually, due to threats to field researchers, following a series of unexpected events such as the intensification of activities in one illegal mining site and enforcement related to illegal hunting mainly in one cluster, not 31 but 27 sites were surveyed. Expected sample size ($n=381$) follows Dillman²³ and Salant and Dillman²⁴ guidelines and relates to the whole population residing in the study area.

2.5 Data analysis

Data was analysed with a statistical trust level of 95%. Some descriptive statistical analysis was done to explore the data and to create graphics (average, standard deviation, percentage, and frequency). Other statistical tests were used to assess categorical variables: Qui-Square (χ^2), Fisher exact test, Wilcoxon, Linear Regression and Logistic Regression.

3. RESULTS

Of the 168 people interviewed, 134 agreed to respond to the complete protocol. To assess people’s perception of vulnerability to conflict due to experience with or exposure to the species, questions on attitudes were applied. On the question about attitude towards proximity of jaguar or puma, 72% declared to be against the proximity of jaguar and 35.2% against the proximity of puma, within a context where the frequency of contact (sightseeing or report from other people) with puma is significantly higher than the frequency of contact (sightseeing or report from other people) with jaguar (Wilcoxon test, $p\text{-value}=0.0077$).

People articulated a low perception of risk to their personal safety (20% and 15.3% of respondents, for jaguar and puma, respectively), and a higher perception of risk to their livelihoods (58.2 and 61.5% of respondents, for jaguar and puma, respectively). Table 1 shows that there was no relation between individual aspects that could enhance people’s socioeconomic vulnerability and influence attitudes towards the species, protected areas or wildlife management, such as schooling level, knowledge on ecology and behaviour of jaguar and puma or habits related to traditional husbandry practices.

²³ D Dillman, *Mail and Internet Surveys: The Tailored Design Method (2nd Ed.): 2007 Update with New Internet, Visual, and Mixed-Mode Guide*, vol 1 (2nd edn, John Wiley and Sons 2007).

²⁴ Priscilla Salant and Don, A Dillman, *How to Conduct Your Own Survey* (1994)
<<https://www.wiley.com/en-cg/How+to+Conduct+Your+Own+Survey-p-9780471012733>>
accessed 4 August 2021.

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Table 1: Factors related to attitudes towards jaguars and pumas, protected areas, and wildlife management

<i>Aspects influencing human dimensions</i>	<i>Attitudes</i>	<i>p-value</i>	<i>Jaguar</i>	<i>Puma</i>
Schooling level	Towards the increase on hunting control	0.313		
	Towards the increase on tourism due to jaguar and puma appeal	0.098		
	Towards the opportunity of more locals improve their knowledge about their carnivores' neighbours	0.283		
	Towards the installation of ponds for wildlife drink water especially in the dry season	0.207		
	Towards new enterprises supported by the management agency as alternative to traditional livelihoods	0.194		
Knowledge on ecology and behaviour of jaguar and puma	Towards exclusion of people from protected areas known as carnivores' territories	0.814		
Habits related to traditional husbandry practices	Towards proximity of carnivores			
Natural areas for livestock grazing during day			0.003	0.005
Structures available (or not) as night-shelters for livestock			0.036	0.151
Areas excluded (or not) from livestock access to prevent predation			0.016	0.041
Gathering livestock (or not) every end of the day	Towards exclusion of people from protected areas known as carnivores' territories	1.000		
Potential transition for husbandry including improved corrals as pen-proof attack of carnivores		0.628		

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Table 2: Factors that determine attitudes towards jaguars and pumas in Caatinga

<i>Factor</i>	<i>Effect</i>	<i>Reference</i>	<i>OR</i>	<i>p-value</i>
Number of events of loss			1.39	0.084
Social norm to poach jaguar (or puma)	More than 1		6.7	<0.001
Landowner	Yes	No	0.28	0.043
Income	Livestock or farming	Pension or social benefit	0.5	0.183
	Occasional employment		0.13	0.019
	Fixed employment		0.07	0.04

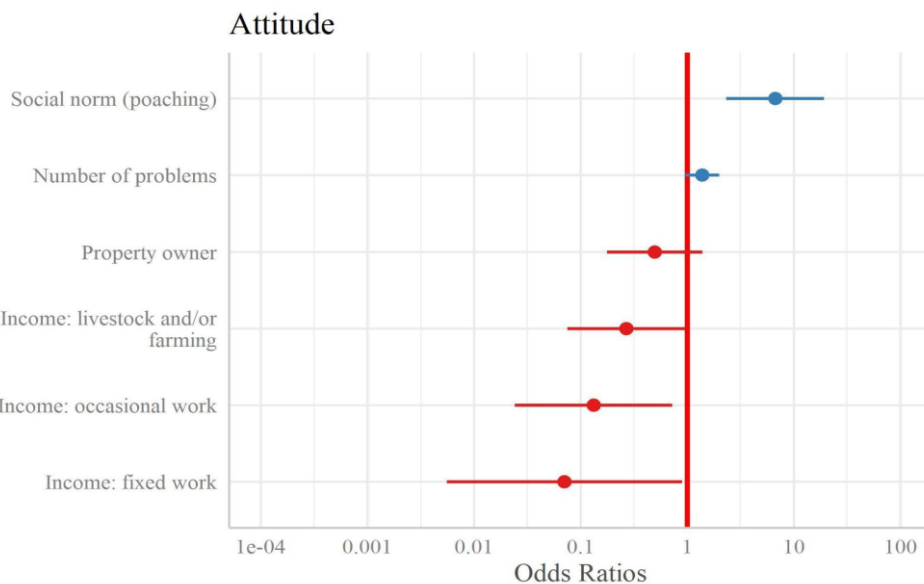


Figure 2: Odds ratios of factors influencing attitudes towards jaguars and pumas in Caatinga

To assess human dimensions of HWC beyond socioeconomic aspects, questions on beliefs towards co-occurrence with jaguar and puma and perception of abundance of these species' populations were applied. Regarding beliefs about co-occurrence with jaguars or pumas, 80.9% and 82.9% of respondents, respectively, mentioned to expect more problems than benefits, with 74.5% believing in the increase of both species' populations due to the establishment of protected areas. Table 2 and Figure 2 shows from the highest to the lowest, the factors that determined attitudes towards jaguars and pumas in the Brazilian dry forest.

The model predicts attitudes through 'number of problems' (events of loss, from themselves or neighbours), 'social norms', 'land tenure' and 'source of income'. The probability of negative attitude towards carnivores increased 39% with each event of predation by a jaguar (or puma), being his

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own livestock or reported by an acquaintance. Someone who would get approval for a behaviour of persecution and poaching of jaguar (or puma) from at least one of his acquaintances, had 6.7 more chances to display a negative attitude towards the species. If the person did not own the land, the chance of displaying a negative attitude towards the species increased 3.6 times ($=1/0.28$). People depending on a retirement pension had more negative attitudes towards the species.

To assess relationships between people and institutions, questions on knowledge about institutions working for jaguar or puma conservation, and about institutions working for people facing problems caused by jaguar or puma, were applied. Of respondents, 64.9% were unaware of the presence in the region of institutions working for jaguar or puma conservation, and 88.8% of institutions working for people facing problems caused by jaguar or puma. Among those who answered, 80.2% also declared not feeling capable of controlling the threat that jaguar or puma may become.

4. DISCUSSION

Results tend to draw our attention from the business-as-usual aspects that make someone vulnerable to conflict with carnivores, even though the features of Caatinga socio-ecological system provide us a set of variables improbable to find out of semi-arid environments, to aspects that depend more on interpersonal and person-institutions relationships, such as those that may undermine or promote “good” governance.

Jaguar population in “Boqueirão da Onça” is estimated at approximately 30 individuals, and puma population, approximately 120 individuals (Campos, 2019, pers. comm.). Puma’s behaviour contrasts with jaguar behaviour also in aspects related to proximity to human settlements and their properties, puma being more confident in approaching than jaguar. From all the South American felids, puma is the most plastic,²⁵ which translates into more sights of pumas and more encounters of pumas and livestock, many ending with depredation. Kansky and Knight²⁶ distinguish two human dimensions of human-wildlife conflicts: species characteristics and experience species. Species characteristics relate to species attributes, including the perceptions on presence versus absence, abundance or frequency of sightseeing or reports from a third party. Experience species concern the kind of experience that one may have in the encounter (personal or his property) with one individual of that species or the impact of one’s perception of abundance of that species. Less residents saw or heard reports about jaguar compared to puma. Consistently, respondents highlighted the elusiveness of jaguar compared to puma. People having trouble with jaguar

²⁵ ICMBio, ‘Sumário Executivo Do Plano De Ação Nacional Para a Conservação Da Onça-Parda’ 1 <<http://www.icmbio.gov.br/portal/images/stories/docs-plano-de-acao/pan-onca-parda/sumario-oncaparda-icmbio-web.pdf>> accessed 4 August 2021.

²⁶ Ruth Kansky and Andrew T Knight, ‘Key Factors Driving Attitudes towards Large Mammals in Conflict with Humans’ (2014) 179 *Biological Conservation* 93 <<https://linkinghub.elsevier.com/retrieve/pii/S0006320714003255>> accessed 4 August 2021.

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(all predation events) is less than half of those having problems with puma (predominantly predation events). However, the intolerance is higher towards jaguar proximity. That may be a consequence of the impact of a predation event caused by a jaguar (or the attack to humans, which is present in few accounts from the elders only and related to rare events that took place decades ago). Thus, it is not the frequency, it is not the number of lost animals - it is the strength printed in one's mind,²⁷ comparably higher with jaguar, a large carnivore, rarely seen, with the size of a man, with impressive strength and beauty.

Once we match this with the belief of majority of respondents that not only lack knowledge about the potential benefits of co-occurrence with charismatic species (mammal-watching tourism, scientific tourism, among others) but also belief that management agency prioritize jaguar and puma abundance and welfare in detriment to villagers safety and life quality, a weakness of governance seem exposed in the shape of unequal knowledge about the purpose of the protected area and imbalance in decision-making about wildlife management that may compromise human well-being and traditional livelihoods. The main economic activity in Caatinga and the second source of families' income (the first is retirement pension) is extensive livestock growing (mainly goats and sheep). Herds have few animals, and they represent the savings for a family emergency. The traditional husbandry with animals grazing in the wild expose livestock to many threats, including depredation. Few families have appropriate corrals as night-shelters, despite 96% of the respondents stating their perception of the importance of an improved pen to prevent attacks. Their socioeconomic vulnerability arises masked as perception of risk for co-occurrence with the predator, compromising their livelihoods. Social benefits availed in the last two decades by the central government, especially 'bolsa-família' and 'retirement pension for small farmers', allowed an upgrade in human development in the rural communities residing within or surrounding natural areas.²⁸ Many became less dependent on natural resources, in theory less dependent on bushmeat to have animal protein in the family menu. A lower hunting pressure on jaguar and puma natural prey would help to mitigate the HWC, but in Caatinga that is to be assessed still. Governmental assistance prevents more frequent hunting, thus, supposedly, less exposure to free-ranging wild animals. Combined with the acknowledgement of elusiveness of jaguar (puma too, however less), paves the path for a low perception of risk to personal safety. A "good" governance of natural resources benefits people and biodiversity and must provide a framework that mitigate biodiversity conflicts and eliminate or reduce diffuse aspects that ease broader social conflicts.²⁹

²⁷ Daniel Kahneman, 'Pensar Depressa e Devagar' [2012] Maia: Círculo de Leitores.

²⁸ Carlos Fioravanti, 'A Corrosão Da Caatinga' (2018) 266 Revista Pesquisa Fapesp 60. <<https://revistapesquisa.fapesp.br/a-corrosao-da-caatinga/>> accessed 4 August 2021.

²⁹ Borrini and others (n 1).

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Biodiversity conflicts goes beyond the impact that wildlife causes on humans and the impact that humans cause on wildlife and includes the conflicts between humans either for dissonant opinions about species and/or wildlife management.³⁰ The opposing values gridlock of nature protectionists and social conservationists³¹ has fostered biodiversity conflicts when the issues are protected areas and wildlife management. Economic rationalism suggests that communities within and surrounding protected areas respond firstly to economic triggers, either for the enforcement (negative) or for leisure opportunities, economic aid to conservation and educational programs related to benefits provided by the protected area (positive)³² However, previous studies have shown that transparency in the relations established between institutions and between institutions and communities is key for interests' conciliation,³³ and trust between stakeholders determines acceptability (or intolerance) towards protected areas.³⁴ In Brazil many protected areas were established during the military regime and the wildlife management agency performing managerial programs, projects and plans within and surrounding protected areas (ICMbio) is fourteen years old only and demands time and effort withdrawing from its progenitor (IBAMA) whose role is control and law enforcement. The lack of engagement and the novelty of call for participation, plus the reflexivity on truth, justice and equity guiding governmental decision-making processes, from its initial phases, are becoming subject and routine recently.³⁵ Caatinga is in the early stages of engagement, once responses indicate the fact that the majority of those who cooperated with the research did not know about the existence of institutions responsible for wildlife or wildlife management.

Sensitivity increases when Caatinga' history and economic policies and its priorities are acknowledged. Due to frequent and severe droughts that caused mass migrations and thousands of deaths, at the end of the 19th century, the first ideas of the São Francisco River transposition emerged. For

³⁰ Beatrice Frank, 'Human–Wildlife Conflicts and the Need to Include Tolerance and Coexistence: An Introductory Comment' (2016) 29 *Society & Natural Resources* 738 <<https://doi.org/10.1080/08941920.2015.1103388>> accessed 4 August 2021.

³¹ Adrian Phillips, 'Turning Ideas on Their Head: The New Paradigm For Protected Areas' (2003) 20 *The George Wright Forum* 8 <<http://www.jstor.org/stable/43599027>> accessed 4 August 2021.

³² Katrina Eadie Brandon and Michael Wells, 'Planning for People and Parks: Design Dilemmas' (1992) 20 *World Development* 557 <<https://www.sciencedirect.com/science/article/pii/0305750X9290044V>> accessed 4 August 2021.; John F Oates, *Myth and Reality in the Rain Forest: How Conservation Strategies Are Failing in West Africa* (University of California Press 1999) <<https://www.nhbs.com/myth-and-reality-in-the-rain-forest-book>> accessed 4 August 2021.

³³ Thaddeus R Miller, Ben A Minter and Leon-C Malan, 'The New Conservation Debate: The View from Practical Ethics' (2011) 144 *Biological Conservation* 948 <<https://linkinghub.elsevier.com/retrieve/pii/S0006320710001448>> accessed 4 August 2021.

³⁴ Marc J Stern, 'The Power of Trust: Toward a Theory of Local Opposition to Neighboring Protected Areas' (2008) 21 *Society & Natural Resources* 859 <<http://www.tandfonline.com/doi/abs/10.1080/08941920801973763>> accessed 4 August 2021.

³⁵ Charles R Warren and others, "'Green On Green": Public Perceptions of Wind Power in Scotland and Ireland' (2005) 48 *Journal of Environmental Planning and Management* 853 <<http://www.tandfonline.com/doi/abs/10.1080/09640560500294376>> accessed 4 August 2021.

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the engineering project to be implemented (meaning the creation of the sixth largest artificial lake in the world, “Sobradinho” Dam) many villages were resettled from river margins to places where people had no history, connection or skills to dwell. It was not their choice, it happened as a top-down decision and process with irreversible impacts on livelihoods. Memory of that is still alive with many elders and their descendants. With democracy and human development reaching regions for decades inaccessible and excluded from the right to be inquired and partaking in decision-making on projects, programs and policies that impact their lives - governance -, now they demand to articulate their needs and claims when it comes to the uses of their territories.

For the public administration and management agencies it is necessary to distinguish among public support to a goal (such as conservation) from public support to public policies to achieve that goal (such as the establishment of protected areas coexisting with traditional livelihoods and quality of life for human populations). It also requires from the management agencies to break the patterns that caused power imbalances and nowadays are present in residents' speeches displaying their perception of vulnerability and unheard voices.

The high potential for energy generation from renewable sources in Caatinga matches the increasing demand for energy and the need to change the energetic matrix in Brazil. Wind and solar farms are the newest uses of territory, with economic incentives and support from central and state governments. The weak governance takes form as perception of vulnerability and perpetuation of inequality, injustice and negligence. Informal comments such as, “I have to change traditional husbandry practices to prevent the livestock from grazing in the wild and thus diminish the chance of encountering the predator, even not having economic conditions to do it?”; “I have to change hunting behaviour and habits of growing, to set livestock aside from natural areas and protect wildlife. But wind farms are being installed in pristine areas...”; “Will I be forced to move from here, like my ancestors were by government decision?”; were articulated by respondents, displaying feelings and uncertainties on what the future may be.

This complex and rapidly changing scenario, driven by external forces, fosters intolerance towards the major representatives of conservation initiatives, the charismatic jaguar and puma, ironically subject to the same external forces and out of its control. It helps to understand why none of the assessed human dimensions in the scale of individual (schooling level, knowledge on ecology and behaviour of jaguar and puma, or habits related to traditional husbandry practices) explained attitudes towards jaguar, puma, protected areas or wildlife management. It helps to understand the incoherence between the perception of the importance of an improved pen as night-shelter for livestock to prevent attacks from most respondents (96%) and the almost one third of respondents unwilling to change traditional

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practices (30.8%). Kahneman³⁶ would label this as gambler's fallacy, that happens when people evaluate the probability of a certain event by assessing how similar it is to events that they have experienced before. People acknowledging their socioeconomic constraints, public administration negligence and power imbalances when corporations and government interests seem to prevail over their livelihoods, do not rely on any external support to enable conditions for behaviour change - furthermore feel incapable to control the threat that carnivore may become and retaliate (intentionally or unintentionally) with inaction.

Historically Caatinga was the backyard for sugarcane producers in the coastal North-eastern capitals, like Olinda, Recife and Salvador, that depended on livestock as draught-animals and as a second source of income. Cowboys (“*vaqueiros*”) lead those animals to native pastures, leave them in the higher altitudes for five to six months, and then lead them back.³⁷ This transhumance in the “*sertões*”, no one's land, built a nomadic-gathering-hunter man, until the golden age of sugar in north-eastern reached its end. The nomadic-state-of-mind and the utilitarian value of the natural resources seems to prevail, despite the increase in human settlements in number and size. “*Vaqueiros*” became small farmers (in the rainy season) and goat and sheep growers, species very well adapted to the environment. Jaguars and pumas continue to be a problem, like they were in the past, a threat to livelihood, and losing an animal is an economic loss and a reminder of that dispute of territory, resources and strength, between man and carnivore. Belief that co-occurrence with jaguar and puma brings more problems than benefits persist as an inherited memory. A “good” governance would help to improve present and future co-occurrence with carnivores.

Furthermore, Caatinga biome is the less protected Brazilian biome, only 7.4% of the region is within protected areas,³⁸ less than 2.0% belongs to the full protection category (Brazilian System of Conservation Units that allows only research, environmental education and tourism regulated by the Management Plan of the area) and even though inadequate to safeguard its biodiversity.³⁹ It is recent the accessibility to villages and communities in this extensive region, and energy and communication is still unstable in many of them. To engage residents in a participatory consultation and decision-making process that will lead to the creation of conservation units within the timeframe required is a challenge for both parties: government and civil society, for financial, logistic, language and preparedness constraints to deal fairly and with transparency with social and cultural diversity. Thus many expressed their concern with the potential increase of jaguar and puma populations abundance because they were not clarified neither about the

³⁶ Kahneman (n 27).

³⁷ Manuel Correia de Andrade, *A Terra e o Homem No Nordeste* (Editora Universitaria UFPE 1998).

³⁸ José Maria Cardoso da Silva and others, *Caatinga* (José Maria Cardoso da Silva, Inara R Leal and Marcelo Tabarelli eds, Springer International Publishing 2017)

<<http://link.springer.com/10.1007/978-3-319-68339-3>> accessed 4 August 2021.

³⁹ *ibid.*

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meaning of conservation units (categories, purposes and shared responsibilities); nor about the fact that large roaming animals, demanding vast areas to survival, do not acknowledge borders; nor about tangible and intangible benefits that neighbouring protected areas with occurrence of charismatic species may bring to people.⁴⁰ A strategy of stakeholders' engagement since the planning for novel uses of territory and land could pave the path for a better and stronger governance, mitigating biodiversity conflicts and conciliating nature and social conservationists aims. Brookfield⁴¹ said that decision-makers base their decisions in an environment according to their perceptions about it, which may or not match with what the environment actually is. However, actions based on their decisions are played in a real environment. Mature institutions performing public policies in a diverse socio-ecological system like the Brazilian semi-arid need to reinforce this mindset.

Finally, among the human dimensions influencing attitudes towards jaguar, puma, protected areas or wildlife management, social norms came first. Understanding the history of Caatinga occupation and land-use patterns, the consequence of large-scale projects, government policies and residents' adjustments and development are steps to improve governance of natural resources. Nevertheless, despite Caatinga human populations highly depend on natural resources, the exercise of power and responsibilities over it and the participation in decision-making, are not determined just by ecological or economic aspects influencing individuals.⁴² Norms and institutions underlie perceptions and attitudes. This research highlighted the socioeconomic vulnerability of Caatinga inhabitants, their perception of risk and their economic loss as consequence of co-occurrence with jaguar and puma, but also unveiled how conservation initiatives and management agencies from public administration failed to address human dimensions of human-wildlife conflicts beyond economic factors. An effective and fair governance hopefully will acknowledge the strong cultural features of Brazilian semi-arid dwellers, the "*sertanejo*" traditional livelihood, whose history and relationship with nature are as old as the rocky paintings in Caatinga domains. And will allow jaguars and pumas to thrive.

5. CONCLUSIONS

Framing the assessed human dimensions of HWC in Brazilian Dry Forest within the IUCN concept and aims of natural resources governance allowed to show that jaguar and puma are consciously or unconsciously retaliated by livestock growers and dwellers and neighbours of protected areas, as a response to their perception of vulnerabilities, lack of control of

⁴⁰ Kansky and Knight (n 26).

⁴¹ Harold C Brookfield, 'On the Environment as Perceived' (1969) 1 Progress in Geography: International Reviews of Current Research 51.

⁴² Timothy D Baird, Paul W Leslie and J Terrence McCabe, 'The Effect of Wildlife Conservation on Local Perceptions of Risk and Behavioral Response' (2009) 37 Human Ecology <<http://www.jstor.org/stable/40343988>> accessed 4 August 2021.

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potential threats to their livelihood, lack of transparency from management agencies, power imbalances among stakeholder, and exclusion from decision-making processes. Jaguar and puma become scapegoats for unattained expectations on fundamental rights and wide participation in all stages of processes that impact traditional communities and natural resources that they depend upon.

Similarities with individual aspects of residents and neighbours of protected areas also home to charismatic species in other biomes were found. Nevertheless, this research went further by assessing external aspects that influence one's attitudes, perceptions and beliefs towards jaguar, pumas, wildlife management and protected areas, such as interpersonal relations and people-institutions relationships. Elements from historic occupancy of the semi-arid and socioeconomic dynamics related to priorities in territory and land uses and perceived inequalities were brought to the arena of impacts on jaguar and puma conservation. Results may provide valuable insights for managers of this complex socio-ecological system, a management ideally shared by public administration and citizens.

It is now known that residents of Brazilian Dry Forest co-occurring with jaguar and puma do not tolerate proximity with individuals from these species, with higher intolerance towards jaguars. The perception of risk to their livelihoods as a result of co-occurrence with jaguar and puma was higher than the perception of risk to personal safety.

It is not their schooling level, or knowledge on ecology and behaviour of jaguar and puma, or habits related to traditional husbandry practices that influence attitudes towards jaguar, puma, protected areas or wildlife management. Were social norms, predation events causing livestock loss, land tenure and income that emerged as the human dimensions influencing attitudes towards jaguar, puma, protected areas or wildlife management. Peoples' unawareness about the existence of institutions working for jaguar and puma conservation or for people facing problems caused by jaguar or puma is high, which combined with their perception of lack of control of the threat that jaguar or puma may become, increased their perception of self-vulnerability to conflict with these carnivores.

The belief that co-occurrence with jaguar and puma brings more problems than benefits prevailed, and most residents articulated their certainty that the establishment of protected areas would favour the increasing of jaguar and puma populations. If certain aspects may change by one's decision and power, others depend on projects, programs and policies being discussed, built, availed, implemented, monitored and adjusted through the dialogical, fair and inclusive process of democracy.

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AUTHORS' DECLARATIONS AND ESSENTIAL ETHICAL COMPLIANCES

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4
Conceived and designed the research or analysis	Yes	No	No	Yes
Collected the data	Yes	No	No	No
Contributed to data analysis & interpretation	Yes	No	No	Yes
Wrote the article/paper	Yes	Yes	Yes	Yes
Critical revision of the article/paper	Yes	Yes	Yes	Yes
Editing of the article/paper	Yes	Yes	Yes	Yes
Supervision	Yes	No	Yes	Yes
Project Administration	Yes	No	No	No
Funding Acquisition	No	No	No	No
Overall Contribution Proportion (%)	50	15	15	20

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Ethical Committee Approval

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Research involving human bodies (Helsinki Declaration)

Has this research used human subjects for experimentation? No

Research involving animals (ARRIVE Checklist)

Has this research involved animal subjects for experimentation? No

Research involving Plants

During the research, the authors followed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora. Yes

Research on Indigenous Peoples and/or Traditional Knowledge

Has this research involved Indigenous Peoples as participants or respondents? No

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

Have authors complied with PRISMA standards? Yes

Jaguar and Puma in Brazilian Semi-Arid Region – scapegoats for weak governance?

Competing Interests/Conflict of Interest

Authors have no competing financial, professional, or personal interests from other parties or in publishing this manuscript.

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