

GABRIELA RIGOTTI FUINI

**ATAQUES DE ONÇA-PARDA SOBRE CRIAÇÕES DOMÉSTICAS NO
OESTE DO ESTADO DE SÃO PAULO**

ASSIS

2016

GABRIELA RIGOTTI FUINI

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OESTE DO ESTADO DE SÃO PAULO**

Dissertação apresentada à Faculdade de Ciências e Letras de Assis – UNESP – Universidade Estadual Paulista para a obtenção do título de Mestra em **Biociências** (Área de Conhecimento: **Caracterização e Aplicação da Diversidade Biológica**)

Orientador(a): Carlos Camargo Alberts

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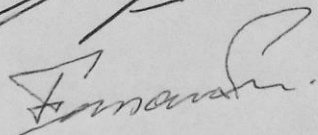
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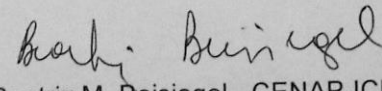
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*"Num bosque, em pleno outono, a estrada bifurcou-se,
mas, sendo um só, só um caminho eu tomaria.
Assim, por longo tempo eu ali me detive,
e um deles observei até um longe declive
no qual, dobrando, desaparecia..."*

*Porém tomei o outro, igualmente viável,
e tendo mesmo um atrativo especial,
pois mais ramos possuía e talvez mais capim,
embora, quanto a isso, o caminhar, no fim,
os tivesse marcado por igual.*

*E ambos, nessa manhã, jaziam recobertos
de folhas que nenhum pisar enegrecera.
O primeiro deixei, oh, para um outro dia!
E, intuindo que um caminho outro caminho gera,
duvidei se algum dia eu voltaria.*

*Isto eu hei de contar mais tarde, num suspiro,
nalgum tempo ou lugar desta jornada extensa:
a estrada divergiu naquele bosque – e eu
seguí pela menos trilhada.
Isso fez toda a diferença."*

Robert Frost

FUINI, Gabriela Rigotti. **Ataques de onça-parda sobre criações domésticas no oeste do Estado de São Paulo**. 2016. 43f. Dissertação (Mestrado em Biociências). – Faculdade de Ciências e Letras, Universidade Estadual Paulista “Júlio de Mesquita Filho”, Assis, 2016.

RESUMO

O conflito entre humanos e carnívoros silvestres devido à predação exercida sobre rebanhos domésticos tem sido um dos precursores mundiais que tornam os carnívoros um dos grupos com espécies mais ameaçados de extinção. No Brasil, a predação por onças-pardas tem sido documentada em diversas regiões e como consequência a perseguição desses animais é fortemente observada. A fim de identificar os fatores que poderiam estar associados a predações aos rebanhos domésticos por onças-pardas no oeste do Estado de São Paulo, realizamos entrevistas com produtores rurais, utilizando questionários semi-estruturados, abordando características das propriedades, do manejo e da paisagem. Realizamos 71 entrevistas e identificamos propriedades que passaram por eventos de predação na última década. Ovinos e bovinos foram os grupos de animais mais frequentemente predados. Através da Regressão Logística foi possível obter um modelo de previsão de ataques com 81% de concordância entre estimado e observado, do qual o número de ovinos e a quantidade de vegetação natural presentes em cada propriedade foi positivamente relacionado aos casos de predação, porém o manejo das criações de risco como ovinos e bezerros pode contribuir significativamente para a redução de perdas de animais domésticos e assim reduzir possíveis conflitos com a fauna silvestre.

Palavras-chave: *Puma concolor*. Predação. Rebanhos domésticos. Manejo. Regressão logística.

FUINI, Gabriela Rigotti. **Puma attacking on domestic livestock in west of São Paulo State, Brazil**. 2016. 43f. Dissertation (Master in Bioscience). – Faculdade de Ciências e Letras, Universidade Estadual Paulista “Júlio de Mesquita Filho”, Assis, 2016.

ABSTRACT

The conflict between humans and wild carnivores due the predation on domestic livestock has been a reason that made the Carnivora one of the groups with most threatened species. In Brazil, predation by pumas has been recorded in various regions and result in a harsh persecution on these animals. In order to identify factors that might be associated with predation on domestic livestock by pumas in the west of São Paulo, we did interviews with farm owners and their regular employees using a semi structured questionnaire, addressing characteristics of the property, the management and landscape. We conducted 71 interviews and identified properties that had gone through predation events in the last decade. Sheep and cattle were the most often attacked species. Using logistic regression it was possible to obtain a predictive model of attacks with 81% agreement between estimated and observed, in which the number of sheep and amount of natural vegetation present in each property was positively related to cases of predation. However, a proper management of individuals under risk for both sheep and calves showed to be effective and can contribute significantly to reduce livestock losses and thus to reduce potential conflicts with wildlife.

Word-keys: *Puma concolor*. Predation. Livestock. Manegment. Logistic Regression.

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INTRODUÇÃO

Os carnívoros, espécies representantes da Ordem Carnívora, são em geral animais que exercem grande fascínio desde os primórdios. Considerados há séculos como seres mitológicos, sendo reverenciados e cultuados como símbolos de beleza e força no imaginário humano (Leite-Pitman et al., 2002), mas também é o grupo com mais espécies ameaçadas de extinção no mundo (Ripple et al. 2014).

Grandes carnívoros, em geral, são naturalmente raros, apresentam baixa taxa reprodutiva e necessitam de uma extensa área de vida e ampla gama de presas para suprir suas necessidades metabólicas (Carbone and Gittleman 2002; Ripple et al. 2014). São animais que, ao longo do processo evolutivo e diversificação, adquiriram adaptações alimentares que levaram a variações do tamanho dos corpos e ocupação de diferentes espaços e nichos, colocando-os na posição de predadores de topo de cadeia. Nessa posição são importantes para a manutenção e balanço ecológico do ecossistema onde vivem, principalmente por exercerem controle sobre as populações de presas dos quais se alimentam, sendo importante manter populações viáveis desse predadores, seja pela sua vulnerabilidade como espécie, seja pela sua importância intrínseca no ecossistema (Ripple et al. 2014).

Atualmente, com o aumento global da população humana e a necessidade cada vez maior por áreas agricultáveis e para moradias, essas características dos grandes predadores os têm colocado com maior frequência em conflitos com os humanos (Conover, 2002), principalmente pela redução e fragmentação do habitat natural e conseqüentemente redução das presas naturais, agravados ainda pela perseguição em resposta à predação sobre rebanhos domésticos, uma competição por recursos compartilhados e limitados, tornando-os vulneráveis e acentuando a

dificuldade de resposta rápida à recuperação populacional, conduzindo muitos à beira da extinção (Graham et al. 2005; Morrison et al. 2007; Ripple et al. 2014).

O conflito entre carnívoros e rebanhos domésticos é documentado desde que os primeiros animais foram domesticados pelos humanos, há mais de 9.000 anos, processo pelo qual muitas dessas espécies podem ter perdido seu comportamento natural anti-predador, sendo assim facilmente predados (Nowell and Jackson 1996; Linnel, Odden and Mertens, 2012). Esse conflito, que por vezes é resolvido de maneira ilegal e por atitudes drásticas contra o predador, tipicamente ocorre globalmente dentro de toda a área de distribuição dos grandes predadores e pode ser exemplificado pela predação por lincês e lobos na Europa e América do Norte (Fritts et al. 1994; Stahl et al. 2002; Dondina et al. 2014; Gazzola et al., 2008), Leopardo-das-neves e cães selvagens na Ásia (Bagchi and Mishra 2006; Li et al. 2013), hienas e leões na África (Patterson et al. 2004; Kolowski and Holekamp 2006; Kissui 2008), e onças-pintadas e onças-pardas nas Américas Central e do Sul (Rosas-Rosas et al. 2008; Soto-Shoender and Giuliano 2011; Amit et al. 2013; Zanin et al. 2015).

Onças-pardas (*Puma concolor*) são predadores generalistas e de hábitos alimentares oportunistas, uma vez que em sua dieta são incluídos uma grande variedade de presas conforme a disponibilidade das mesmas no ambiente, o que pode ter contribuído com a persistência da espécie às extinções de grandes felinos na América do Norte durante o Pleistoceno (Nowell and Jackson 1996). Além disso é também o felino com a mais ampla distribuição, ocupando diferentes ambientes e climas, desde desertos áridos à florestas tropicais e florestas de coníferas congeladas, podendo viver em áreas de florestas densas até áreas abertas com o mínimo de cobertura vegetal, tornando-o o grande predador mais comum do

Hemisfério Ocidental (Sunquist and Sunquist, 2009). São animais flexíveis, que apesar da preferência por habitats com vegetação natural e de alta qualidade (Burdett et al. 2010), são capazes de suportar e habitar áreas alteradas por humanos (Miotto et al., 2012; 2014; Magioli et al. 2014). Ainda que poucos estudos tenham contribuído para o entendimento das razões pelos quais pumas persistem nesses ambientes e por vezes até em elevadas concentrações (Miotto et al., 2012; 2014) sugere-se que a ausência de competidores diretos como a onça-pintada (*Panthera onca*), predadores mais sensíveis às alterações ambientais, e uma grande disponibilidade de presas presentes na matriz agrícola, por exemplo, pode contribuir com sua estabilidade (Miotto et al., 2014), assim ocupando a posição de predador de topo (Moreno et al., 2006).

No Brasil, a predação por onças-pardas às criações domésticas é documentada em diferentes regiões (Mazzolli et al. 2002; Azevedo, 2008; Palmeira et al. 2008; Palmeira et al. 2015), levando em muitos casos como resposta a perseguição e abate de indivíduos. A inclusão de animais domésticos na dieta dos predadores pode refletir algum tipo de desequilíbrio no ecossistema local, sendo que, sobretudo, os felinos não têm como hábito predação de animais domésticos se o ambiente em que vivem suprir suas necessidades espaciais e alimentares (Hoogesteijn 2003; Polisar et al. 2003; Azevedo 2008; Burgas et al. 2014).

Características da paisagem, como por exemplo a quantidade e a distância de florestas e corpos de água e habitações humanas são considerados alguns pontos importantes para que a predação por onças a rebanhos domésticos aconteça (Azevedo and Murray 2007; Palmeira et al. 2008; Soto-Shoender and Giuliano 2011).

Azevedo e Murray (2007), no Pantanal Mato-Grossense, verificaram que existe uma correlação entre a distância da cobertura florestal com o risco de predação ao gado, constatando que o risco de predação aumenta à medida que a distância da cobertura florestal diminui. No entanto, Palmeira *et al.* (2008), no centro-oeste do Brasil, não encontrou diferença significativa entre áreas de pastagem que fazem fronteiras com florestas e sofreram predação com as que não fazem fronteira e também sofreram predação, verificando apenas que na porção central, onde há residências e as pastagens não fazem fronteiras com as florestas, não ocorreram ataques. Já no Chile, Rau and Jiménez (2002) evidenciou que a ausência de predação de animais domésticos por pumas pode ser devido ao fato de as áreas estudadas estarem cercadas por extensões amplamente arborizadas com plantas nativas o que ainda podem manter um estoque de presas naturais, o que teria evitado o consumo de presas alternativas. O mesmo foi verificado por Azevedo (2008) para os pumas no Parque Nacional do Iguaçu, onde possivelmente as quantidades de presas naturais de médio porte são suficientes para que esse predador não necessite utilizar de presas alternativas, como estoques domésticos.

As condições biológicas do predador, como idade, doença e ferimentos, além de comportamentos inatos ou aprendidos também integram as variáveis e podem ser fundamentais na motivação para a predação (Nowell and Jackson 1996).

Outro ponto-chave é o manejo dos animais domésticos, indicado por Inskip and Zimmermann (2009) como uma das maiores causas dos conflitos entre homens e felinos, sendo o uso de medidas preventivas, como recolher os animais mais vulneráveis para locais seguros ao anoitecer, uma estratégia considerada eficiente (Amador-Alcalá 2013). Práticas de manejo do rebanho também são um elemento chave quando se busca medidas preventivas para evitar ou reduzir as perdas de

rebanhos domésticos para um predador silvestre (Polisar et al. 2003; Hoogesteijn and Hoogesteijn 2008; Rigg et al. 2011; Li et al. 2013).

Identificar as reais causas que levam o rebanho doméstico a ser atacado por grandes predadores não é simples, principalmente se considerarmos a interdependência entre o manejo do rebanho, fatores ambientais e a ecologia comportamental do predador (Stahl et al. 2002).

O Estado de São Paulo é o Estado mais industrializado do País e conta com boa parte do seu território tomado pelas áreas agrícolas, monoculturas de cana-de-açúcar e eucalipto ou pastagens para a pecuária, práticas estas que ao longo do tempo ocasionaram a quase extinção da vegetação nativa (Rodrigues *et al.*, 2008).

A Mata Atlântica Legal Paulista, por exemplo, passou a sofrer maior pressão com a redução da cobertura florestal para dar lugar a produções agrícolas, principalmente à cultura cafeeira, no século XVIII. Ainda nesse período o Estado de São Paulo apresentava mais da metade de seu território coberto pela vegetação, no entanto, com o avanço da industrialização em meados de 1973 o declínio da Mata Atlântica atingiu níveis alarmantes, onde a ocupação do território pela floresta primitiva foi reduzida a 8,75% (Brito, 2006). Concomitantemente, nas décadas entre 60 e 80, as diferentes formas do Cerrado Paulista também passaram a sofrer fortes pressões oriundas da urbanização desenfreada e expansão de áreas agrícolas, principalmente da cana-de-açúcar e da citricultura. Originalmente este bioma ocupava cerca de 14% do Estado (Kronka *et al.* 1998) e hoje resta menos de 1% de remanescente. Desde 2009 o Estado passou a ter uma lei específica para a conservação do Cerrado, Lei 13550/2009, que implementou restrições mais severas para a concessão de licenciamento nas regiões desse tipo.

Atualmente, incluindo a Mata de Araucárias e as matas de galeria, além da Mata Atlântica e do Cerrado, o Estado de São Paulo apresenta cerca de 17% de seu território coberto por vegetação natural, no entanto, distribuídos em fragmentos (Kronka *et al.*, 2005) com diferentes graus de complexidade e imersos em uma matriz com diferentes níveis de perturbação antrópica.

Ainda são pouco conhecidas as variáveis e condições específicas que implicam na predação por onças às criações domésticas em áreas altamente fragmentadas e com diferentes influências antrópicas circundantes. Investigar se há um padrão ou características ambientais que possam estar envolvidos nesse processo é muito importante para a conservação da espécie e mitigação de conflitos com proprietários dos rebanhos. Estudos que busquem esses fatores contribuem agregando valores conservacionistas e educacionais junto aos produtores, vez que identificadas as principais causas pode-se criar medidas ou grupo de medidas mais eficientes na tentativa de reduzir os danos, principalmente quando esses forem realmente satisfatórios para a produção.

Dentro desse contexto o presente estudo teve como finalidade investigar a predação por onças-pardas sobre animais domésticos na região do Oeste Paulista, uma das mais importantes na criação de rebanhos bovinos de corte e leite e que recentemente tem registrado inúmeros incidentes envolvendo onças-pardas, seja atropelamentos, visualizações de filhotes em canaviais e predação em rebanhos domésticos.

Houve o objetivo de identificar os fatores que podem influenciar a predação e se há preferência de presas. Outro objetivo foi entender o por que algumas propriedades sofrem mais eventos do tipo e outras nem tanto, (ou nunca) mesmo quando próximas umas das outras. Para isso realizamos entrevistas em

propriedades rurais utilizando um questionário semi-estruturado, incluindo propriedades com e sem casos de predação nos últimos seis anos até o momento do estudo. Analisamos os dados com o uso de Regressão Logística, uma técnica capaz de criar um modelo estatístico visando a predição dos ataques e, assim, oferecer uma ferramenta auxiliar na prevenção dos eventos de predação por onças-pardas baseado nas variáveis envolvidas no estudo.

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Capítulo 1

Puma attacking on domestic livestock in west of São Paulo State, Brazil

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Introduction

Large carnivores usually occur in low densities, require large home ranges and an array of prey items to provide for their metabolic needs (Carbone and Gittleman 2002; Ripple et al. 2014). These characteristics often cause them to be in conflict with humans as they sometimes prey on domestic animals and subsequently make themselves vulnerable to human persecution and population decline (Morrison et al. 2007; Ripple et al. 2014). As top predators are important for maintaining ecological balance in ecosystems, their populations need to be sustained (Ripple et al. 2014). However, this group compared with most species is most threaten by extinction (Ripple et al. 2014). The conflict with humans is one of the main causes for carnivores populations to decline (Woodroffe 1998), a trend reinforced by natural habitat alteration, reduction and loss. This situation is exacerbated by the steady human population expansion, requiring more tillable areas, which decreases wild prey, and also by the intolerance as a response to predation on domestic animals (Polisar et al. 2003; Holmern et al. 2007; Kissui 2008; Gusset et al. 2009; Ripple et al. 2014), especially in the case of felids.

The puma (*Puma concolor*) is a solitary felid with a wide distribution and is one of the most adaptable mammalian species to different environments and climates. This makes it one of the most common large predators in the western hemisphere (Sunquist and Sunquist, 2009). It is very flexibility and capability of inhabiting areas altered by humans (Magioli et al. 2014). Even the cougars appearing be more tolerant than jaguars (*Panthera onca*), that is locally extinct in some highly-fragmented forest areas in Brazil, the pressure about native preys, poaching, and loss of the habitat could have a negative influence about the population health status this big predator (Castilho et al. 2011). Taking into account, some areas where the

Panthera onca already were extirpated, especially in Sao Paulo State, lately the cougar is the only top predator it has been considered a trigger for a trophic cascade effect (Ripple and Beschta 2008; Ripple et al. 2014), so the presence is extremely important for local general conservation and maintenance of the biodiversity.

Predation on cattle and other domestic animals by pumas has been documented in different countries of the Americas, including Venezuela, Costa-Rica and Mexico and constantly observed in several regions in Brazil (Michalski and Peres 2005; Azevedo 2008; Palmeira et al. 2008; Schulz et al. 2014; Palmeira et al. 2015; Zanin et al. 2015). Invariably, each geographic area affected shows a certain variability compared to others and among cattle properties as well. Many variables influence the vulnerability of domestic herds including environmental characteristics just as percentage of forests, distance to urban centers, declivity, abundance and distribution of wild prey (Polisar et al. 2003; Azevedo and Murray 2007; Palmeira et al. 2008; Zarco-González et al. 2013). Additionally, biologic conditions of the predator such as age, illness, and injuries may contribute as well (Nowell and Jackson 1996).

Sao Paulo State is the most industrialized in Brazil and also has the most agriculture as well. A great portion of the agricultural area is composed of monocultures; mostly sugarcane, soy beans, oranges and eucalyptus and pasture, that has led to the near extinction of native vegetation. More recently, better laws have reduced this process and some recovery of highly threaten areas has occurred (Rodrigues and Bononi 2008). From this history of intense degradation, a new landscape pattern has been born with fragments of protected vegetation among agriculture areas, a pattern capable of sustaining a diverse of fauna and flora.

The southeast region of Sao Paulo State stands out for cattle farming and beef cattle rearing has been one of the most important economic activities since the beginning of the twentieth century. It is believed that pumas have lived along with cattle for many generations and have endured numerous environmental alterations. However, puma predation on cattle was never studied and was only reported in the local news and among farmers. Even though the many organizations offered folders and pamphlets containing information as to how to minimize the risk of predation by wild animals, studies in specific regions are important for identifying the factors contributing to attacks and to enable the testing of methods to reduce damage to both cattle and pumas (Rosas-Rosas et al. 2010).

The primary objectives of this study were to investigate predation on cattle and other domestic animals by pumas, to identify whether there is a preferred domestic prey species, and to understand why some ranchers had recurring predation problems, while others never experienced such depredations, although their farms were only a short distance apart.

Methods

Study area

This study covered six counties in the west of São Paulo State, Brazil - Iepê, João Ramalho, Nantes, Quatá, Rancharia and Taciba - in the macro region of Presidente Prudente (Figure 1). The vegetation physiognomy in this region is characterized as a transition from mesophytic semi-deciduous forest to dry savanna woodlands (Cerradão), with a CWA type climate (Köppen, 1948), that is mesothermic, with a humid summer and a dry winter (IBGE, 2013). The area is about 200km away from Morro do Diabo State Park, an important fragment of mesophytic semi-deciduous forest in the far west of the State.

Beginning in the twentieth century, cities developed in this region specializing in globalized agricultural processes, resulting in deforestation, the development of cyclical farming practices specializing in monocultures, and the arrival of roads and railroads. Spaces opened by agriculture slowly turn to pasture and today the regional economy is based on integrated agribusiness and livestock farming especially beef cattle, that has made the region one of the most important areas in the Brazil for this activity (Emubra, 2003). This high agricultural development in this area was the primary motive for us to choose this location for our study.

Associated with this development are more and more incidents with pumas (*Puma concolor*) including visualizations, finding cubs in the field, road kills, and individual pumas entering backyards in the cities' outskirts. These events often are recorded by the public, local press and environmental agencies (Unica, 2015). Recently the region is undergoing a trend of changing land use in which cattle husbandry is giving way to sugar cane agribusiness due to the demand raised by alcohol as fuel, a tendency seen in the whole São Paulo State.

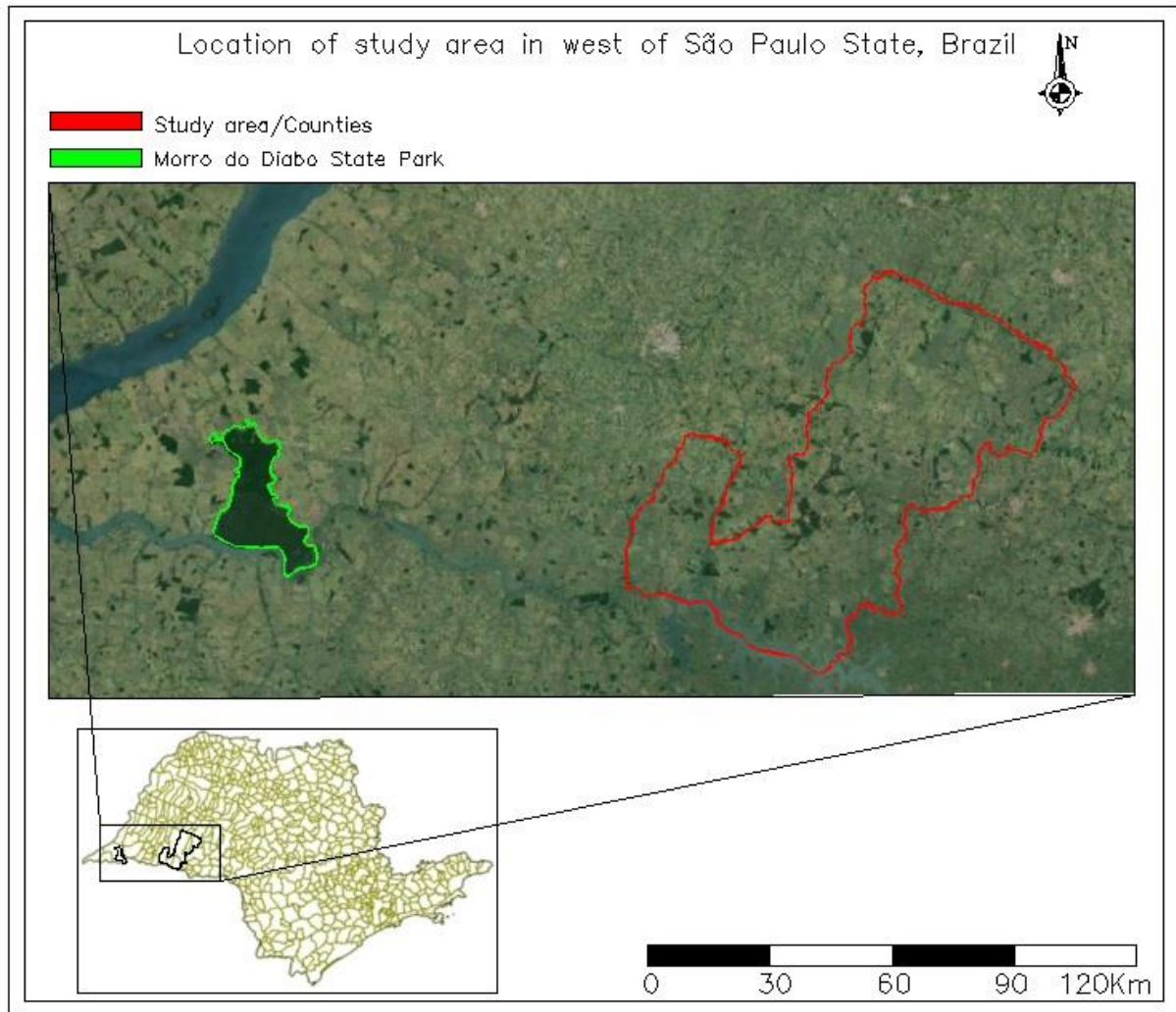


Figure 1. Location of the counties (red line) included in this study - Iepê, João Ramalho, Nantes, Quatá, Rancharia and Taciba and Morro do Diabo State Park (green line) in the west of São Paulo State, Brazil.

Field work

Our main tool for data collection was to interview farm owners and their regular employees in order to gather old and current information. This is a good method to retrieve data on vertebrates ranging from medium to large body size (Michalski and Peres 2005; Prist et al. 2012) and it is also cost effective. We obtained information for the last six years (2010 to 2015) and with the aid of staff and principals from the Casa da Agricultura de Rancharia (local agricultural agency) and conducted several visits to a number of properties reported to have had cattle predation by pumas. The remaining informers were obtained using a snowball sampling method (Bailey, 1982), where from the initial contact, one informer is

acknowledged and designates another one that, by his/hers turn, points out to other one and so on until an adequate number of informers are reached. Informers were told about the purposes of our work and the importance of the interview and interviews were also made on properties where no puma predation reports had been received or knowledge of their presence occurred. Only properties where the handling cattle had not changed drastically in the last six years were chosen for interviews.

Information was gathered using a semi structured questionnaire (Annex 1), with questions related to the property including: size; the presence and size of native woodlands; presence of springs and other water bodies; types of animals raised; types of handling for each species raised; number of animals raised at the time of the questioning and during the last decade; data on puma predation such as date and time of occurrence (night was characterized as between 18:00-05:59, morning 06:00-11:59 and afternoon 12:00-17:59). Information was also gathered for the area where each property was found including the distance to forests, roads and crops. The questionnaire application was made only for one researcher to keep a coherence in all interviews and interpretations of them. When predation was reported, we additionally collected information about the livestock species attacked, date and weather conditions (if no certain about the exact date, at least the month) and what actions the farm staff took regarding changes in cattle management.

Usually the pumas kill their preys by suffocation, biting their throat and could leaving marks of their claws in the shoulders and back of their preys. They start eating their prey through the ventral part, reaching the ribs and the muscles of the posterior legs and usually, when it ca not eat all at once they can cover the carcass with leaves (Leite-Pitman et al., 2002). To assure the authenticity of the information gathered, we asked those interviewed to share all details about the predation, including the exact configuration of the scene, what parts of the carcass consumed and the description of the predator, if observed. When predation occurred while we were performing fieldwork, we visited the site and identified the predator through the carcass, analyses of footprints, hairs and/or feces. The location and types of lesions found on the carcass were recorded and for each property visited, the farm house position and the spot were a carcass was found were also recorded.

These points were taken with the aid of a XR Trimble Pro GPS unit and using maps of GoogleEarthPro®. The captured points were plotted via Topo ENV CAD 6.0

software and AutoCad® software was used to construction a map and areas delimitation such as vegetation, natural sources of water and anthropogenic land use. The points from five properties in Nantes County were not plotted on the map due to the lack of geographic coordinates.

Data analysis

To find out the possible causes why some properties in our study had cattle predated upon by pumas, while others did not, we analyzed our data using a logistic regression (Ludeke et al. 1990; Hosmer and Lemeshow 2000; Pearce and Ferrier 2000a; Pearce and Ferrier 2000b; Elith et al. 2006). This is an adequate methodology since it allowed for the analysis of the effects of one or more independent variables, the discrete or continuous one over a dichotomic dependent one, characterized by the presence (1) or absence (0) of predation over domestic animals. From the data, we build a matrix with predation as dependent variable, present (1) or absent (0), and with biotic, abiotic and anthropic factors as independent variables. From this matrix, we did Logistic Regression Analyses, using NCSS 9.0 software. The independent variables used were:

- Size of the property in hectares (ha)
- Size of forested area inside each property (ha)
- Distance from the nearest natural vegetation reserve in meters (m) (including vegetation associated with water bodies – permanent protect area).
- Number and species of livestock, including beef cattle, milk cattle, sheep, pig, equines and poultry
- Location of predation site (in the pasture adjoining woods; in the pasture far from woods, > 200m)

Only variables that did not present collinearity were included in the analyses, i.e., variables that had variance inflation factor (VIF) ≤ 10 . For our prediction model, we accept variables with $p \leq 0.05$. The area under the ROC curve (AUC) and Confusion Matrix we used to determine the accuracy of the test, i.e. model's ability to differentiate the values of true positives and false positives, while values close to 1.0 is better model prediction power and values close to 0.5 the worst. It helps us to find the accuracy of the model and avoid overfitting.

Season when predation occurred (dry or rainy), time when predation took place (morning, afternoon or night), presence of woods, forestry, pastures, sugar cane cultivation, other types of monocultures, type of livestock management, as well presence or absence of dogs were analyzed separately. To determine possible association between predation and seasonal calves' births we conducted a Chi-square test (significance value 5%).

Results

From June 2014 to July 2015, we interviewed 71 property owners and/or their employees, 45 of them in Rانcharia County. The average size of the researched properties was 497.2ha (from 2.18 to 6,534ha) and 33 of these farms had forest fragments (Legal Reserve Areas) within their borders, with sizes ranging from 1.2 to up to 300ha. In 9 ranches, there were not any natural sources of water, like rivers, streams or springs. The analyses of the neighborhood of each unit showed that 44 of them bordered on natural woods, with or without natural water sources; 11 bordered on forested areas; 69 bordered on pastures, 29 on sugar cane monocultures, 13 on the margins of different grain cultures or monocultures, 9 bordered on roads and 2 on margins of the city (Figure 2).

Most properties had more than one type of livestock. In general, beef cattle are the main economic activity, often associated to milk cattle, sheep, pigs, equines, and poultry (Table 1).

Table 1. Distribution and range of the domestic livestock.

Domestic livestock	Properties (%)	Individual (range)
Beef cattle	82	30 – 6000
Milk cattle	28	2 – 120
Sheep	27	4 – 160
Pig	15	3 – 120
Horses	94	2 – 80
Poultry	37	6 – 100

Nutritional management of beef cattle included pasture rotation with supplementary nourishment in the dry season. Similar management strategies were used for sheep on 17 properties and they were free to pasture and not gathered into an enclosure at night.

Generally, beef cattle calves were born in open pasture and in only two properties were they are kept indoors until 40 days of age. Twenty-four percent of the properties used a scheduled birth program for beef cattle, which took place between July and January. Additionally, 21% of the farms specialized in fattening cattle, keeping no breeders with the animals arriving at the age of 8 months. For the remaining ranches, births occurred through the whole year, with no defined birthing season. Usually, cattle inspection routines take place daily and all properties strictly followed vaccination guidelines from the regional agricultural agency.

Puma predation was reported in 25 properties during the last six years (2010-2015) resulting in 294 domestic animals killed, equivalent to 1.3% of total animals for each ranch in this period. Most of the interviewed personnel (73%) believed that puma attacks had become more frequent in recent years. They said that most of the killings occurred during September to March and the results of the Chi-square test showed a dependency between calves births and predation ($X_0^2 = 75,87$; $p=0,0001$) (Table 2) simultaneously on the more precipitation season. The killings always took place at night or the first hours after midnight. Five out of fourteen killings occurred on properties where farm animals had access to and sought out natural water sources. This included both cattle and sheep. Killings were assigned to pumas due to carcass characteristics, associated tracks or direct visualization. Some farmers reported female with cubs and footprints were got during the fieldwork by the researcher.

Table 2. Number of losses of calves and sheep in properties with beef cattle production (NSB=No seasonal birth; SD= Seasonal birth; NB= no births)

Attack total			
Calves birth	Calves	Sheep	Properties(n)
NSB	14	63	12
SB	44	33	7
NB	1	94	6

* $X_0^2 = 75,87$ $p=0,0001$

Sheep were the farm animal most attacked by pumas ($n=190$; 64%), on 15 properties including young and adult weighting 60kg in average. It was reported that pumas might kill more than one sheep during each attack, including the killing of more than 10 animals in one night. The distance to woods from the point where predation occurred varied from 100m to 1500m, often near to residences and with the presence of dogs. Due to puma predation, 5 farmers changed their management of

sheep, confining them indoors at night. One farmer quitted sheep raising altogether. After the change in management strategy, the number of attacks decreased considerably. It is important to stress that on those properties, sheep rearing was not the main income source for the farmer.

Beef cattle were the second most predated on group of animals ($n=57$, 20%), and on 12 properties, the age of killed cattle ranging from newborn to 90 days old calves. Attacks occurred mostly when animals were at pastures bordered by woods at a distance of 200m at most. Predation took place in the rainiest period of the year and coincided with the time of calving on these properties.

On all properties where sheep were attacked, the most numerous animals raised were cattle and the opposite occurred only on 4 properties.

Poultry predation was reported on only 3 properties ($n=42$), followed by equines and milk cattle ($n=3$; $n=2$, respectively). No one pig was related. Equines were killed at an average age of 90 days, when they strayed into nearby dense woods. Calves of milk cattle were preyed in the corrals, near the farm house. Poultry were also preyed on near farm houses. No preyed animals were reported as having any physical problems or disease.

Logistic Regression Analysis was used to understand the relationship among variables to explain the likelihood of predation on farm animals by pumas. Because of having a correlation ($VIF>10$), the variables, "distance of the site of predation to woods for poultry" and "distance of the site of predation to woods for equines" were removed from later analysis. According to the results in Table 3, two variables presented significance in the model ($p\leq 0.05$), "average number of sheep per property" ($p=0,006$) and "size of forested area inside each property" ($p=0,007$), Table 4. With these variables, it was possible created an excellent model ($AUC\geq 0.91$) to forecast attacks (Table 5) with 81.2% of agreement between expected and observed probabilities, explained by the Confusion Matrix, a tabular representation of actual versus predicted values in the model from Logistic Regression Analysis (Table 6).

Table 3. Significance Coefficient Test of independent variables to be included in the model for predicting puma attacks using Logistic Regression Analysis (n = average number of farm animals per property; m = meter; ha = hectare).

Variable	Coefficient of regression b(i)	Standard Error Sb(i)	Wald statistic H0: $\beta=0$	p Wald $p \leq 0.05$
BEEFcattle(n)	0.00103	0.0014	0.735	0.46205
MILKcattle(n)	-0.29274	0.15464	-1.893	0.05835
DistPredwoods_cattle(m)	-0.00023	0.00053	-0.432	0.66602
DistPredwoods_sheep(m)	-0.00028	0.00052	-0.535	0.59271
Equines(n)	0.01774	0.02469	0.718	0.47249
Poultry(n)	0.01608	0.01539	1.044	0.29638
Sheep(n)	0.05844	0.02148	2.720	0.00652
Pig(n)	0.01977	0.02671	0.74	0.45924
Tamprop(ha)	-0.00106	0.00276	-0.385	0.70014
Vegetation(ha)	0.14411	0.05355	2.691	0.00712

Table 4. Significant variables used to build the Logistic Regression model for predicting puma attacks on cattle (n = average number of farm animals per property; ha = hectare).

Variable	Wald statistic H0: $\beta=0$	p Wald $p \leq 0,05$	Odds Ratio	Lower 95% Confidence Limit Odds Ratio	Upper 95% Confidence Limit Odds Ratio
Sheep(n)	2.656	0.00790	1.04153	1.01072	1.07327
Vegetation(ha)	3.196	0.00139	1.12389	1.04621	1.20734

Table 5. Attained model from Logistic Regression Analysis for predicting puma attacks on cattle. (LivPred = probability of puma predation on cattle; shp= sheep; veg= vegetation (ha); AUC= Area under ROC Curve).

Model's name	Model	AUC
LivPred	$1 / [1 + \exp(-1.6163 + (0.04068 * shp) + 0.1167 * veg)]$	0.91304

Table 6. Confusion Matrix of the model from Logistic Regression for predicting puma attacks on cattle.

Actual	Predicted		Total
	0	1	
0	39	7	46
1	6	17	23
Total	45	24	69

Percent Correctly classified – 81,2%

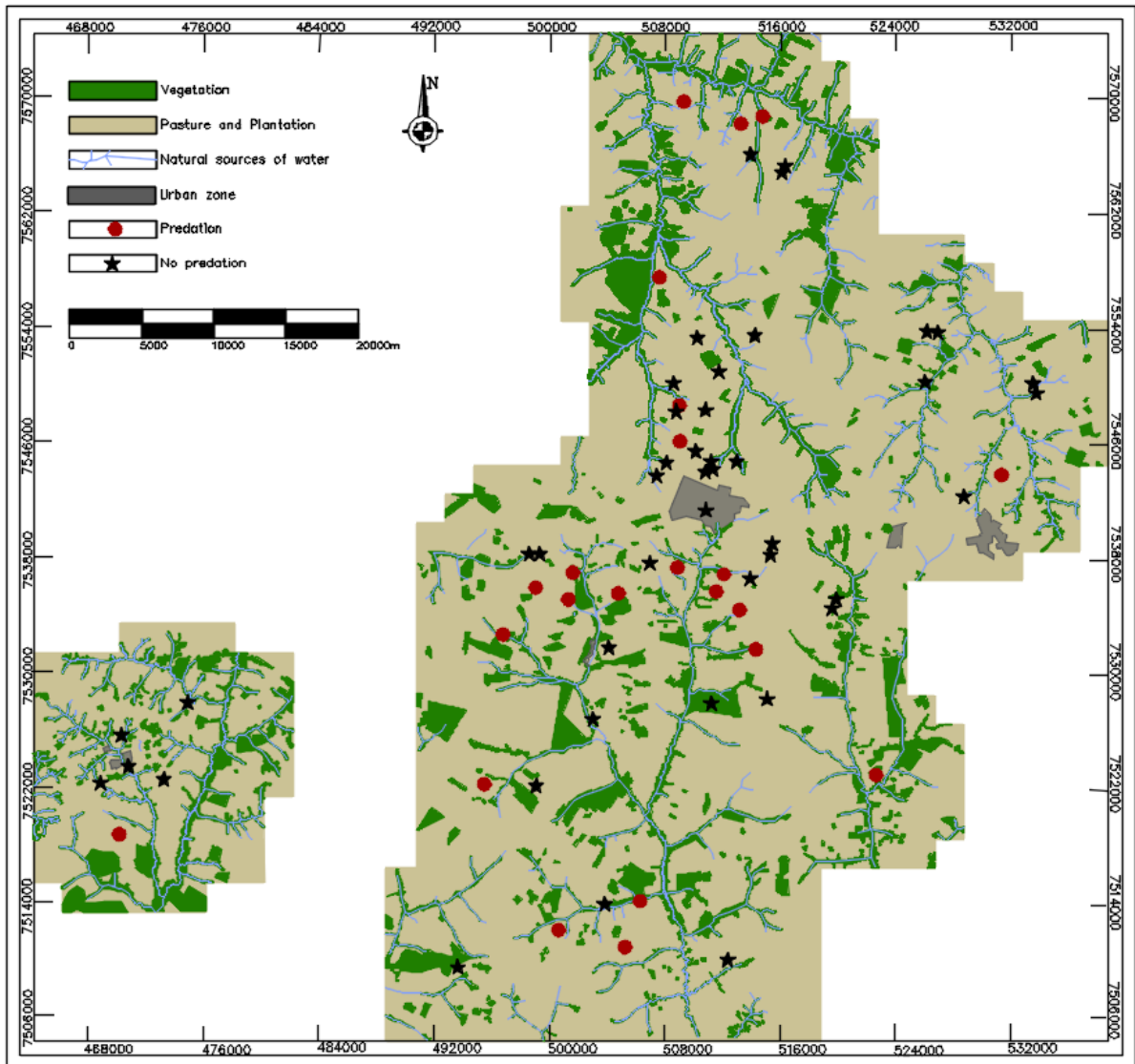


Figure 2. Map of study area, showing forest cover, sources of water like rivers, streams or springs, anthropogenic land use and researched properties, with predation and no predation.

Discussion

Predation can be erroneously reported or overrated for different species of predators (Kissui 2008; Gusset et al. 2009). However, the evidence gathered using the type of bites, disposition of the carcass, eaten parts, footprints, etc., confirm that pumas were the one predator in this study (Leite-Pitman et al., 2002; Azevedo and Murray 2007).

The total number of attacked animals was relatively low during the six year included in the research (1.3%) and the literature confirms that losses attributed to wild predators is most often low, not exceeding 3% annual (Graham et al. 2005; Azevedo and Murray 2007; Azevedo 2008; Palmeira et al. 2015). However, other

livestock mortality causes are commonly reported in the literature and is considered the main reason for losses, including diseases, malnutrition, snake bites and ingestion of harmful plants (Mazzolli et al. 2002; Palmeira et al. 2008). However, when cattle rearing is the main income item, any loss by predation, whenever for the cattle herd itself or other farm animals, is perceived as very negative, triggering conflicts to or adverse attitudes towards the predators (Rosas-Rosas et al. 2008; Rosas-Rosas et al. 2010; Soto-Shoender and Giuliano 2011). Some animals, like sheep or poultry, normally stay nearer to habitations and that increases the fear that a human, perhaps a child, could also be attacked.

We found that sheep and younger calves (0-5 months) were the most vulnerable groups, which is consistent with other studies from different regions (Andelt and Hopper 2000; Polisar et al. 2003; Azevedo 2008; Palmeira et al. 2008; Zarco-González et al. 2012; Amador-Alcalá et al. 2013; Amit et al. 2013; Schulz et al. 2014; Palmeira et al. 2015). The larger number of attacked sheep in our area was likely related to the fact that pumas sometimes kill more than one animal per event, often leaving most of the carcasses untouched. Leyhausen (1965) and Adamec (1976) suggested that cats in the absence of strong resistance would kill as much as they can eat at one time to maximize the benefit of a plentiful resource, even if they cannot ingest it at one time. This it would appear be ecologically and physiologically rewarding, especially when easy prey are hard to find. Others predators have been reported to act similarly, as wolves studied by Fritts et al. (1994) who reported that for every 1.1 cattle killed per event, wolves killed 4.4 sheep. Dondina et al. (2014), on the other hand, thinks that this overkill is due to the fact that sheep live in herds, that facilitates extra killings by the predator (Kruuk 1972).

Most of the attacks occurred during the rainy season, a trend also found by other authors (Palmeira et al. 2008; Soto-Shoender and Giuliano 2011; Kuiper et al. 2015). As well described by Palmeira et al. (2008), in our study, attacks were too correlated with calves' births peaks, both co-occurring at the rainy season. A temporal correlation between peaks of calves births and predation was also reported in others studies (Polisar et al. 2003; Michalski et al. 2006), independent the season, because that is a time when there is an indirect increase of prey available. The search efforts per prey by a predator is reduced when the location of a specific prey is predictable (Scheel, 1993; Scognomillo et al., 2003). However, calves location is more predictable than that of natural prey (Scognomillo et al. 2003) which may be

leading pumas to include more cattle in its diet, once they are an opportunistic predator. Although young calves weight much more than a natural prey, they lack some defenses, especially behavioral ones, which natural prey has. Is possible too that during heavy rain or storms, both prey and humans may have more difficulty in detecting predators or yet may be due to farm employees spending less time in the field on very humid days (Mazzolli et al. 2002; Soto-Shoender and Giuliano 2011). Some studies suggest that predation upon farm animals may be associated with a shortage of natural prey species (Valeix et al. 2012; Khorozyan et al. 2015; Shehzad et al. 2015). This last assumption can lead to the notion that predation rates by felids can fall when the numbers of natural prey rise.

Although in other studies, attacks on cattle were frequently linked to a lack of sanitary and prophylactic care of the animals, what made the animals more susceptible to disease and consequently predation (Polisar et al. 2003; Azevedo and Murray 2007; Cavalcanti et al. 2010). In this region, vaccination control and prophylactic care were followed strictly, for all ages and not a single attacked animal had been considered ill or injured.

In this study, it was found that newborns were rarely maintained in special pastures or protected patches near stables or farmhouses, although Michalski et al. (2006) noted that to be effective, the period of close protection for these animals had to be extended to at least the 3rd month of age.

It is difficult to identify the causes which cause cattle to be preyed upon by large carnivores, due to the interdependence between livestock rearing, environmental factors and behavioral ecology (Stahl et al. 2002). However, our work managed to identify two important characteristics that may explain why puma attacks are not homogeneously distributed, as some farmers are affected, while others are not, even when properties are near each other.

Our results suggest that there are correlations between anthropic and environmental factors related to cattle husbandry that encourage attacks by puma. The Odds Ratio value (Table 4) show that for every unit increase in the variable "Sheep(n)" increase the chances of predation in 1.04 times and 1.12 times to "Vegetation(ha)". In other words, the bigger the number of sheep on a farm and the larger the vegetation fragment in the same area, the greater the risk of attacks on cattle. Other authors have suggested that predation may be associated with the abundance of sheep (Michalski et al. 2006; Zarco-González et al. 2013). The number

of sheep may be an important factor affecting predation considering that juveniles are noisier than most other animals and represent low risk to predators considering the docility of most breeds and their comparatively lower agility and strength (Amador-Alcalá et al. 2013). Another possible factor may be the loss of defense behaviors during domestication, since other ungulate species often engage in group strategies in response to imminent attacks (Howery and DeLiberto 2004; Zarco-González et al. 2012).

We also found that ranchers could benefit by implementing better management strategies to avoid predation. As the majority of predation occurred at night, confinement of sheep in indoor enclosures distant from the woods would help reduce attacks. Other studies also point out that the lack of night shelter enhance the nocturne occurrences of predation, due to the nocturnal and crepuscular habits of pumas (Mazzolli et al. 2002; Holmern et al. 2007; Zarco-González et al. 2012).

Our model was consistent with the literature as it showed that predation was also associated with environmental characteristics, such as vegetation cover. Zarco-González et al. (2012) found an increase of 25% in puma predation in areas where forest cover was present. Other authors suggested that the proportion of forests to pastures and its proximity and the distance to water were determinant factors affecting the probability of predation by felids (Stahl et al. 2002; Michalski et al. 2006; Rosas-Rosas et al. 2010; Soto-Shoender and Giuliano 2011; Zarco-González et al. 2012). Even when adapted to human altered environments, pumas need these forest fragments to move about and feed, thus cattle are more vulnerable when nearby these areas (Crawshaw and Quigley 1991; Scognamillo et al. 2003; Vynne et al. 2011; Magioli, et al. 2014).

Through model, simulations generated by logistic regression can be performed in order to inform and guide the farmers in relation to the potential risk of predation by pumas in his herd in areas where the predator is present.

Maintaining newborns in nursery pastures close to farmhouses and away from woods, as well as enclosing sheep and other smaller animals at sunset are the recommendations to lower predation on domestic animals. Similar conclusions have been presented by Hoogesteijn and Hoogesteijn (2008) and Rigg et al. (2011).

Additionally, eliminating or reducing sheep rearing when cattle are the main business should be reconsidered on properties where predation is frequent,

considering that the presence and the number of sheep are directly linked to the frequency of attacks.

Financial support programs would also be promoted and help build safer places for animals. Crawshaw (2004) suggested that the Government, environmental NGOs, farmers, proprietors and society in general, should take the responsibility for this type of development. Financial compensation to farmers that have suffered losses may not be the best alternative, since that it could lead to a reduction of prevention efforts and to encourage farmers to use higher risk areas to profit from the situation and thus increasing the conflict with predators (Bulte 2005; Dickman et al. 2011). Educative campaigns may also be beneficial to make people aware of the importance of maintaining predators and their natural prey in the ecosystem.

Conclusion

This study has shown that there is variation in puma predation; however, predation is associated with the presence of sheep and woods on the property. Additionally, suitable management practices can significantly reduce losses of domestic animals and decrease conflicts with wild predators (Amador-Alcalá et al. 2013). Our study was the first to investigate puma predation on domestic animals in the Sao Paulo region and other work could be done to evaluate other factors not addressed here like prey available, poaching and especially comparing long-term data in order to unravel other aspects related to predation by puma.

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Annex

Annex 1. Semi structured questionnaire used to interview livestock breeders about puma predation on their livestock

Property and respondent profile

1. Name of property owner
2. Property size (ha):
3. Main house (UTM):
4. Name of respondent:
5. Age:
6. Position: () owner () employee

Livestock and Predation by puma

7. Number and type of livestock reared:
() beef cattle () milk cattle () horses () pig () sheep () poultry () dog () others
 8. Purpose each livestock
 9. Husbandry practices: () extensive () nightly confinement () total confinement
 10. Inspection routines: () daily () each 2 days () other
 11. Sources of water
 12. Supplementary nourishment in dry season (cattle)?
 13. Vaccination
 14. Birthday program () yes – When? () no
 15. Where they are born and newborns are kept?
 16. Did already have livestock losses due to puma? () yes () No
 17. Number and type of livestock attacked by puma:

Date	Livestock	Age	Livestock conditions
	Carcass condition (covered or not)	Parts Consumed	
Kill site (X/Y) or Livestock site (next to vegetation <200m or not)			
 18. Did you see the puma? () yes () no
If no, how you know was a puma?
 19. What did you do after the attack? () changed husbandry practices () nothing () others:
 20. Do you know someone or some place that had livestock losses due to puma?
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