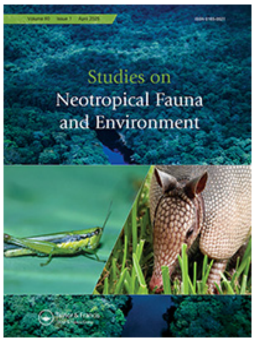

Studies on Neotropical Fauna and Environment

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/nnfe20

Everybody eats chicken: mammal predators of domestic animals in rural Amazonian smallholder properties

Fernanda Michalski, Ricardo Luiz Pires Boulhosa & Darren Norris

To cite this article: Fernanda Michalski, Ricardo Luiz Pires Boulhosa & Darren Norris (15 Apr 2025): Everybody eats chicken: mammal predators of domestic animals in rural Amazonian smallholder properties, Studies on Neotropical Fauna and Environment, DOI: 10.1080/01650521.2025.2478852

To link to this article: https://doi.org/10.1080/01650521.2025.2478852

Published online: 15 Apr 2025.

Submit your article to this journal

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=nnfe20

https://doi.org/10.1080/01650521.2025.2478852

Taylor & Francis
Taylor & Francis Group

Check for updates

Everybody eats chicken: mammal predators of domestic animals in rural Amazonian smallholder properties

Fernanda Michalski [a,b,c], Ricardo Luiz Pires Boulhosa [c] and Darren Norris [a,b,d]

[a]Ecology and Conservation of Amazonian Vertebrates Research Group, Federal University of Amapá, Macapá, Brazil; [b]Postgraduate Programme in Tropical Biodiversity, Federal University of Amapá, Macapá, Brazil; [c]Research Department, Pro-Carnivores Institute, Atibaia, Brazil; [d]School of Environmental Sciences, Federal University of Amapá, Macapá, Brazil

ABSTRACT

Wildlife predation on livestock remains a global challenge for both smallholders and biodiversity conservation. Using in-person semi-structured interviews, we investigated the mammal predators of livestock and domestic animals at smallholder properties in the eastern Brazilian Amazonia. Smallholders raised between zero and four livestock species and the type of livestock raised at these properties was the most important determinant of mammal predation. Across all properties, six domestic species (cattle, chicken, dog, duck, horse and pig) were reported to be predated by 11 terrestrial mammal species. Chicken was the most frequently reported domestic animal and prey, with 87% of smallholders raising chicken, which were reported to be predated by nearly all ($n = 9$) of the mammal predator species. Terrestrial mammals were reported as problematic in two-thirds of properties. The most frequently cited problematic predator species was the small-bodied opossum (*Didelphis* sp.), whereas most predators including large-bodied species such as jaguar (*Panthera onca*) and puma (*Puma concolor*) were cited as problematic in less than 15% of interviews. Capacity building and environmental education are likely to be key to ensuring smallholders can adapt and implement effective management solutions to reduce possible negative human–wildlife interactions.

ARTICLE HISTORY
Received 6 September 2024
Accepted 8 March 2025

KEYWORDS
Carnivores; canid; felid; livestock predation; local perception; human-wildlife interaction

Introduction

The rapid growth and expansion of the human population worldwide (United Nations 2024) coupled with the ongoing and future land-use change (Powers and Jetz 2019; Winkler et al. 2021) will probably increase the proximity between wildlife and people. As humans and wildlife compete for space and resources, human–wildlife interactions are likely to continue to increase through the 21st century (Nyhus 2016). Such interactions can be negative when the needs and behavior of wildlife impact and/or are perceived to impact negatively on the goals of humans (Madden 2004). Most common negative human–wildlife interactions are related to crop damage, the killing of livestock or game, or occasional attacks on people (Thirgood et al. 2005; Inskip and Zimmermann 2009; König et al. 2020; Bombieri et al. 2023).

These interactions are historically best documented with large mammals with a focus on carnivores (Inskip and Zimmermann 2009; Torres et al. 2018), which are more prone to interact with humans because of their large home ranges and diet (Tucker et al. 2014; van Eeden et al. 2018). Mammal predation on livestock remains a global challenge for both smallholders and biodiversity conservation. Indeed, a global review of conflicts between humans and terrestrial vertebrates found that attacks on domestic animals are one of the most common causes of conflicts (Torres et al. 2018). Thus, due to the wide diversity of predators and domestic livestock, detailed local knowledge is needed to inform the development of effective actions to mitigate depredation, reduce negative human–wildlife interactions, and favor a more sustainable coexistence of humans and wild animals.

Most of the literature on wildlife predation in the neotropics is related to large predators on large domestic animals (e.g. cattle) (Michalski et al. 2006; Rosas-Rosas et al. 2008), and in Brazil, this research topic is mainly restricted to biomes such as Pantanal and Atlantic Forest (Palmeira et al. 2015; de Souza et al. 2018). Thus, there is a lack of literature documenting wildlife predation on small and mid-sized livestock, which can be particularly important to rural smallholders across Amazonia (Perreault 2005; de Souza Mello Bicalho and Hoefle 2008).

CONTACT Fernanda Michalski fmichalski@gmail.com
© 2025 Informa UK Limited, trading as Taylor & Francis Group

Published online 15 Apr 2025

Here, we examined the effects of private property and forest cover characteristics on the occurrence of predation events upon domestic animals in a highly conserved region of the eastern Brazilian Amazon. First, we describe mammal predation events as well as the predator–prey species network reported by smallholder landowners. We then evaluate multiple working hypotheses to examine if property characteristics could affect the occurrence of predation on domestic animals. Finally, we examine if forest cover could affect predator species reported. We also contribute with suggestions to reduce human–wildlife negative interactions in small properties across the Amazon.

Materials and methods

Ethics statement

Permission to conduct research and to perform interviews with rural residents was approved by IBAMA/SISBIO (permits 45,034–1, 45,034–2, and 45034–3). Ethical approval to conduct interviews with humans was obtained from the Ethics Committee in Research of the Federal University of Amapá (CAAE 42,064,815.50000.0003, Permit number 1.013.843).

Study area

This study was conducted across 10,000 km^2 in Amapá State, eastern Brazilian Amazon (Figure 1). The state has an extensive network of protected areas, including indigenous lands, strictly protected, and sustainable-use reserves (IUCN & UNEP-WCMC 2024), which represents about 74% of the total area of Amapá state (Michalski et al. 2020). According to the International Union for Conservation of Nature (IUCN) criteria strictly protected areas and sustainable-use reserves are categorized as classes I-IV and V-VI, respectively (Dudley 2008). As a consequence, Amapá is the state

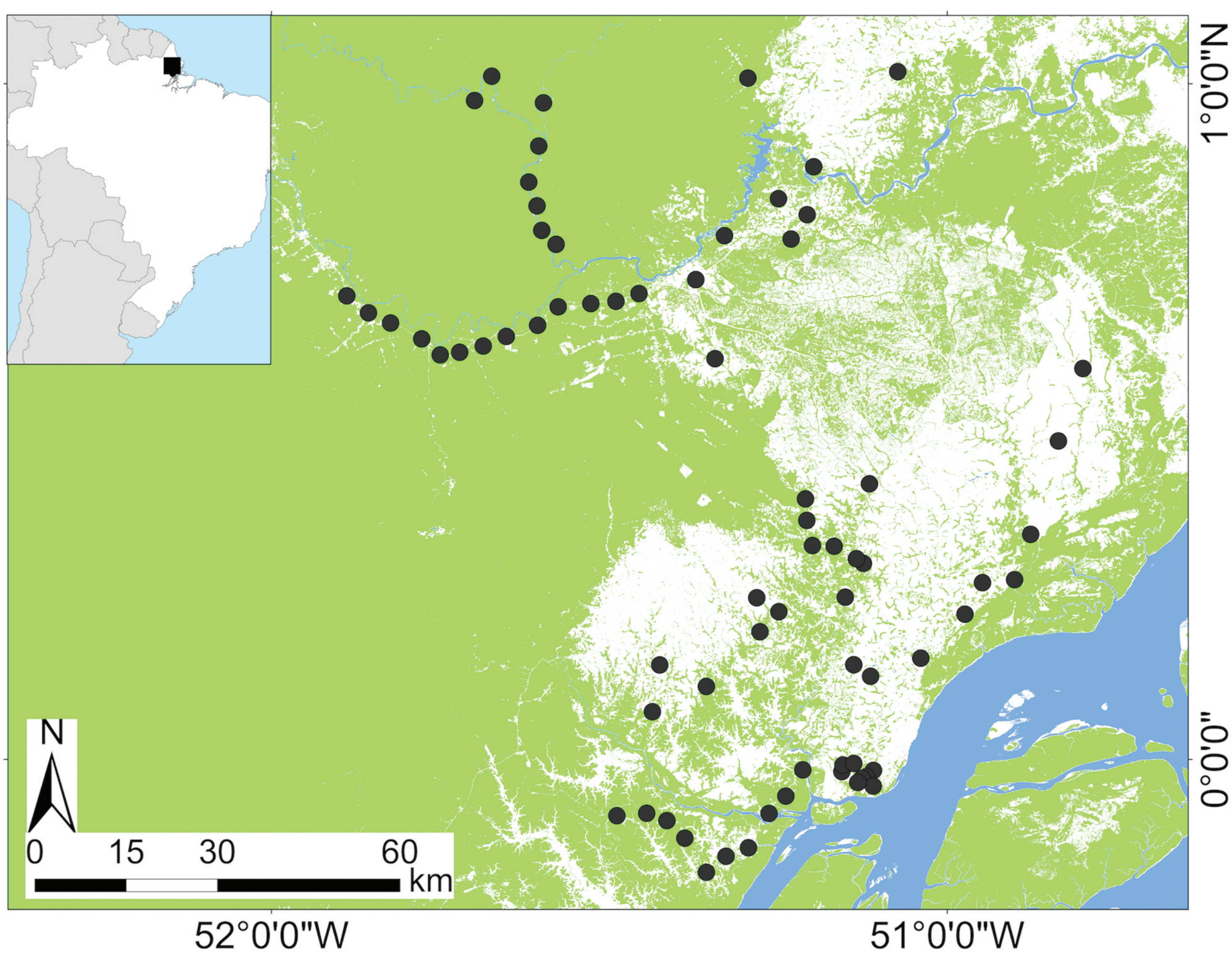

Figure 1. Location of the study region in Amapá, eastern Brazilian amazon (inset map), showing the distribution of the 71 interviews (dark gray circles) conducted from May to August 2015. Green, white and blue areas represent forest, non-forest area, and open water, respectively.

with the lowest deforestation rate among all states of the Legal Brazilian Amazon. From 1988 to 2023, Amapá state contributed to an accumulated deforestation rate of only 0.34% (1,687.00 km^2) within the Legal Brazilian Amazon, whereas neighboring Pará state, contributed to an accumulated deforestation rate of 34.64% (170,073.00 km^2) over the same period (INPE 2024). The Legal Brazilian Amazon is a political-administrative region created by a Decree in 1953 to promote economic and social development of nine states (Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Mato Grosso, Tocantins and part of Maranhão) sharing the Amazon biome (Cabral et al. 2018; IBGE 2022).

Even with a large proportion of its territory under protection, Amapá state is facing emerging threats such as hydroelectric dams (Fearnside 2009; Norris et al. 2018) and continued agricultural expansion that is driving land cover change (Schneider et al. 2021; IBGE 2024c). Additionally, the population of Amapá has experienced significant growth, rising from 669,526 in 2010 to 733,759 in 2022, and is projected to nearly double to 1,312,240 by 2060 (IBGE 2024b). Thus, as per many regions across Amazonia, interactions between rural people and wildlife species have been recorded inside and outside protected areas (Michalski et al. 2012, 2020; Norris and Michalski 2013).

Study design

Locations of interviews across the 10,000 km^2 study area were initially selected using Google Earth (GE) to obtain approximate coordinates of local communities supported by key landmarks such as rivers, roads, and other visual features that could be clearly distinguished by GE images. The potential locations were stratified between two habitat types: savanna and forest [Guianan savanna and Uatumã-Trombetas moist forest ecoregions, respectively, following Dinerstein et al. (2017)]. To provide a standardized comparison between habitat types, all potential sampling locations that had been previously identified using GE images were associated with at least one person from the local community, usually a long-term resident or landowner, who was (1) willing to be interviewed, (2) was thoroughly familiar with the history of the area, (3) had knowledge of the local wild fauna, and (4) had been living on the property or close to it for at least 1 year. This sampling technique of representative sampling, where a sample is chosen to be representative of the total population, involves stratification and has been widely adopted in studies with interviews in conservation science research (Young et al. 2018). Our sample followed the property size distribution for the region, where most properties are relatively small family farms. In a census in 2017, from a total of 8,319 rural properties across Amapá, more than half (54.9%) were less than 50 ha and 99% were less than 1,000 ha (IBGE 2024a). Our interviews followed a similar distribution with 40.1% of the properties with less than 50 ha and 97% with less than 1,000 ha.

Data collection

From May to August 2015 we used pre-elaborated semi-structured questionnaires to interview rural residents (Figure 1). Interviews were carried out on a one-to-one basis with researchers asking questions and taking notes of the responses. We recorded the socio-economic characteristics of the respondents, including gender, age, level of education, number of years living on the property, total number of people living on the property, total monthly income, property size, and information on livestock (e.g. poultry, pig, cattle) raised at the property. We acknowledge that several vertebrate species (including raptors, and reptiles) can prey on domestic animals (Zuluaga and Echeverry-Galvis 2016; Champagne et al. 2024), but mammals were chosen to represent wild predators in our study region as a previous detailed study evaluating diverse wildlife groups, ranging from invertebrates to large-bodied vertebrates, mammals were by far the most perceived group predating domestic animals/livestock by local people (Michalski et al. 2020). To examine patterns of mammal predation on domestic animals we focused on replies to two questions considering the previous 5 years: (1) Do you have any predation problem?; (2) If yes, which mammal predators did you identify and which domestic animals they preyed upon? All interviews were aided by color plates in field guides (Eisenberg and Redford 1999) and photographs (Michalski et al. 2015) of the most common terrestrial mammals known from the region. The taxonomy of terrestrial mammals follows the IUCN Red List of Threatened Species (IUCN 2024).

Forest cover

To obtain forest cover in 2015, we used the Global Forest Change Database (GFCD) (Hansen et al. 2013). This database has the flexibility to derive forest cover maps based on different requirements and can be adjusted for different applications (Defries et al. 2000). Forest was defined as pixels with greater than 60% tree cover following the classification developed by the

International Geosphere-Biosphere Programme Data and Information System (IGBP-DIS) (Loveland and Belward 1997). Using the threshold of >60% tree cover, we conducted a reclassification in ArcGIS (ESRI 2011) and obtained a tree canopy cover for the reference year 2000. We then calculated the percentage of forest within 1-km and 10-km buffers around the central point where each interview was conducted by subtracting the cumulative deforestation from 2001 to 2015 from the tree canopy cover reference year 2000.

Data analysis

Mammal predator–prey network

The predator–prey network showing the interactions between terrestrial mammals and predated domestic animals was established using the bipartite package in R (Dormann et al. 2008).

Explaining patterns in predation

Three responses were used to examine patterns in predation by terrestrial mammals. First, the occurrence of predation, and then two additional responses to characterize the mammal predator assemblage at each property: number of species and maximum weight of species. Maximum weight was included as this is strongly correlated with prey choice and it is also likely to dictate necessary management actions (Torres et al. 2018).

A model selection approach was adopted to examine support for seven non-mutually exclusive working hypotheses that were likely to explain variation in the reported mammal predator assemblage (see Table 1 for the working hypotheses) (Burnham and Anderson 2004). Variation in the three responses was modeled as a function of each of the seven models using Generalized Additive Models [GAMs, (Marra and Wood 2011)]. Each model contained uncorrelated variables (all pair-wise correlations <0.7) that were selected as relevant for each hypothesis. Some variables were repeated in different models (e.g. distance to city) as they represented important components of multiple hypotheses. As our aim was to establish support for the different hypotheses and not cause-effect of any individual variable, we did not include variable selection analysis. The support for each model was compared using information criteria (Burnham and Anderson 2002, 2004).

Patterns in mammal predator species

To explain patterns in mammal predators, we focused on the seven most commonly reported species representing >95% of records. We excluded from this analysis *Puma concolor* as it was reported as a mammal predator in only two interviews. We classified each terrestrial mammal predator into one of the three habitat use classes: generalist, intermediate and specialist. Generalist species included small and mid-sized mammals that are known to use and/or persist in open and disturbed habitats (Michalski et al. 2006; Michalski and Peres 2007), intermediate species included larger-bodied mammals that could also use some disturbed areas (Michalski and Peres 2005), whereas specialist species included those with a strong association with forested areas (Oliveira 1998; Michalski and Peres 2005; Michalski et al. 2006).

As per the analysis of mammal predator assemblage, a model selection approach was also adopted to examine support for non-mutually exclusive working hypotheses that were likely to explain variations in the reported presence of mammal predators (Table 2). Variations in the binary response of mammal predator species presence were modeled as a function of each of the models for each species using Generalized Additive Models [GAMs, (Marra and Wood 2011)]. Models differed from those

Table 1. Predator assemblage working hypotheses and variables.

Model	Variables	Working hypotheses explaining variation in mammal predators
intercept	Intercept only.	
location	†Geographic coordinates, †distance to city, ‡forest type.	Geographic differences.
respondent	†Age, †years resident at property, †level of schooling.	Differences among respondents.
property	†Property size, †property age, †distance to city.	Differences among properties.
economic	†Household income, †number of residents, †distance to city.	Differences among households.
livestock	†Number of domestic species, †presence of chicken, †presence of duck, †presence of cattle, †presence of pigs.	Differences among livestock.
forest cover 1 km	* Forest cover percent within 1 km, †property age.	Differences among local scale forest coverage.
forest cover 10 km	* Forest cover percent within 10 km, †property age.	Differences among meso-scale forest coverage.

† Obtained during interviews.
‡Uatumã-Trombetas moist forests or Guianan savanna ecoregions, obtained from Dinerstein et al. (2017).
* Derived from Hansen et al. (2013).

Table 2. Predator species working hypotheses and variables.

Model	Variables	Working hypotheses explaining variation in mammal predators
intercept	Intercept only.	
location	†Geographic coordinates.	Geographic differences.
habitat type	‡Forest type, †distance to city.	Habitat differences.
respondent	†Age, †years resident at property, †level of schooling.	Differences among respondents.
property	†Property size, †property age, †distance to city.	Differences among properties.
economic	†Household income, †number of residents, †distance to city.	Differences among households.
livestock	†Number of domestic species.	Differences among livestock.
small livestock	†Presence of chicken, †presence of duck.	Differences among livestock.
large livestock	†Presence of cattle, †presence of pigs.	Differences among livestock.
forest cover 1 km	* Forest cover percent within 1 km, ‡forest type.	Differences among local scale forest coverage.
forest cover 10 km	* Forest cover percent within 10 km, ‡forest type.	Differences among meso-scale forest coverage.

† Obtained during interviews.
‡Uatumã-Trombetas moist forests or Guianan savanna ecoregions, obtained from Dinerstein et al. (2017).
* Derived from Hansen et al. (2013).

Table 3. Predator assemblage model selection. Results from generalized additive models used to identify the most strongly supported working hypotheses explaining patterns in terrestrial mammal species reported as predators across 71 rural properties. Models ordered by AICc.

Model	R^2_{adj}	Deviance explained (%)	AICc	Delta AICc	Weight AICc	BIC	Delta BIC	Weight BIC
Presence of mammal predators (binomial)								
livestock	0.22	0.22	81.62	0.00	0.82	92.01	0.00	0.50
forest cover 10 km	0.17	0.16	84.74	3.12	0.17	93.19	1.18	0.28
property	0.03	0.03	92.32	10.70	0.00	96.42	4.41	0.06
economic	0.04	0.05	92.32	10.71	0.00	98.10	6.09	0.02
intercept	0.00	0.00	92.90	11.28	0.00	95.10	3.09	0.11
forest cover 1 km	0.01	0.01	93.59	11.97	0.00	97.76	5.75	0.03
location	0.00	0.02	95.55	13.93	0.00	101.82	9.81	0.00
respondent	0.04	0.08	96.89	15.27	0.00	109.02	17.01	0.00
Mammal predator species count (tweedie)								
livestock	0.14	0.23	375.70	0.00	1.00	389.76	0.00	1.00
location	0.13	0.18	419.00	43.30	0.00	440.75	50.98	0.00
forest cover 10 km	0.09	0.10	448.54	72.83	0.00	460.50	70.74	0.00
property	0.09	0.11	451.61	75.91	0.00	463.87	74.10	0.00
economic	0.02	0.02	468.14	92.44	0.00	476.37	86.61	0.00
respondent	0.02	0.04	468.58	92.87	0.00	484.01	94.25	0.00
forest cover 1 km	0.01	0.02	473.60	97.90	0.00	481.71	91.95	0.00
intercept	0.00	0.00	489.08	113.37	0.00	495.51	105.74	0.00
Maximum predator weight (tweedie)								
livestock	0.47	0.39	461.32	0.00	1.00	477.08	0.00	1.00
property	0.11	0.26	478.07	16.75	0.00	494.64	17.55	0.00
economic	0.05	0.09	484.96	23.63	0.00	494.53	17.45	0.00
forest cover 10 km	0.07	0.12	486.81	25.48	0.00	499.76	22.68	0.00
forest cover 1 km	0.07	0.09	487.10	25.77	0.00	498.35	21.27	0.00
location	0.17	0.30	488.94	27.61	0.00	512.96	35.87	0.00
intercept	0.00	0.00	490.10	28.78	0.00	496.53	19.45	0.00
respondent	0.03	0.14	492.25	30.92	0.00	510.11	33.02	0.00

adopted for the mammal predator assemblage to more closely reflect individual species and provide numerically stable model convergence. This was achieved by the inclusion of separate models for small (duck and chicken) and large (cattle and pigs) domestic livestock (Table 2). The support for each model was compared using information criteria (Burnham and Anderson 2002, 2004).

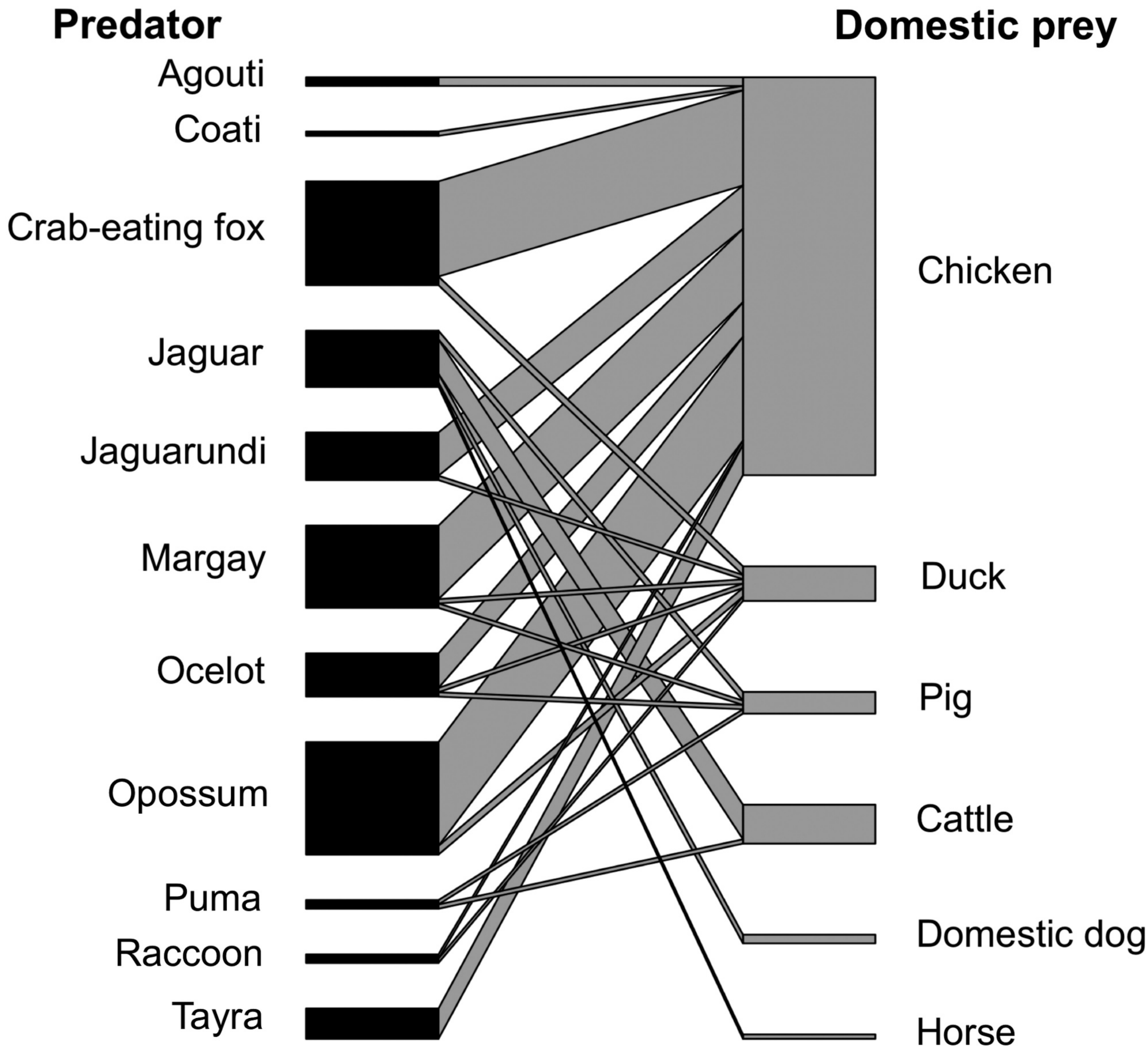

Figure 2. Pairwise interactions in the predator-domestic prey network in the eastern Brazilian amazon. Each black box represents a mammal species while color boxes represent domestic prey species. The lines represent the interactions and the thickness of the line reflects the number of interactions.

Results

Mammal predator–prey network

We conducted 71 interviews with rural residents in Amapá State (Figure 1). From this total, 60 interviewees reported some predation problem. Terrestrial mammals were cited as problematic in 47 properties (66.2% of all interviewed) and were cited as problematic in the majority of properties with predation problems (78.3%, 47/60). More than half of households (60.6%, $n = 43$) had multiple sources of income and only five respondents identified livestock ('pecuaria,' 'agropecuaria') as a source of household income and only one respondent identified livestock as representing their only source of household income. The principal income of the 11 households without predation problems was not related to rearing livestock with household income obtained from other employment, agriculture, fishing, and/or government benefits.

There were nearly twice as many mammal predator species as domestic prey. Across all properties interviewed, six domestic animals were reported to be predated by terrestrial mammals, with chicken as the most frequently reported domestic prey (Figure 2). A total of 11 terrestrial mammals were reported as predators (Figure 2), with opossum (*Didelphis* sp.) most cited at 24 (33%) of 71 interviews, followed by crab-eating fox (*Cerdocyon thous*).

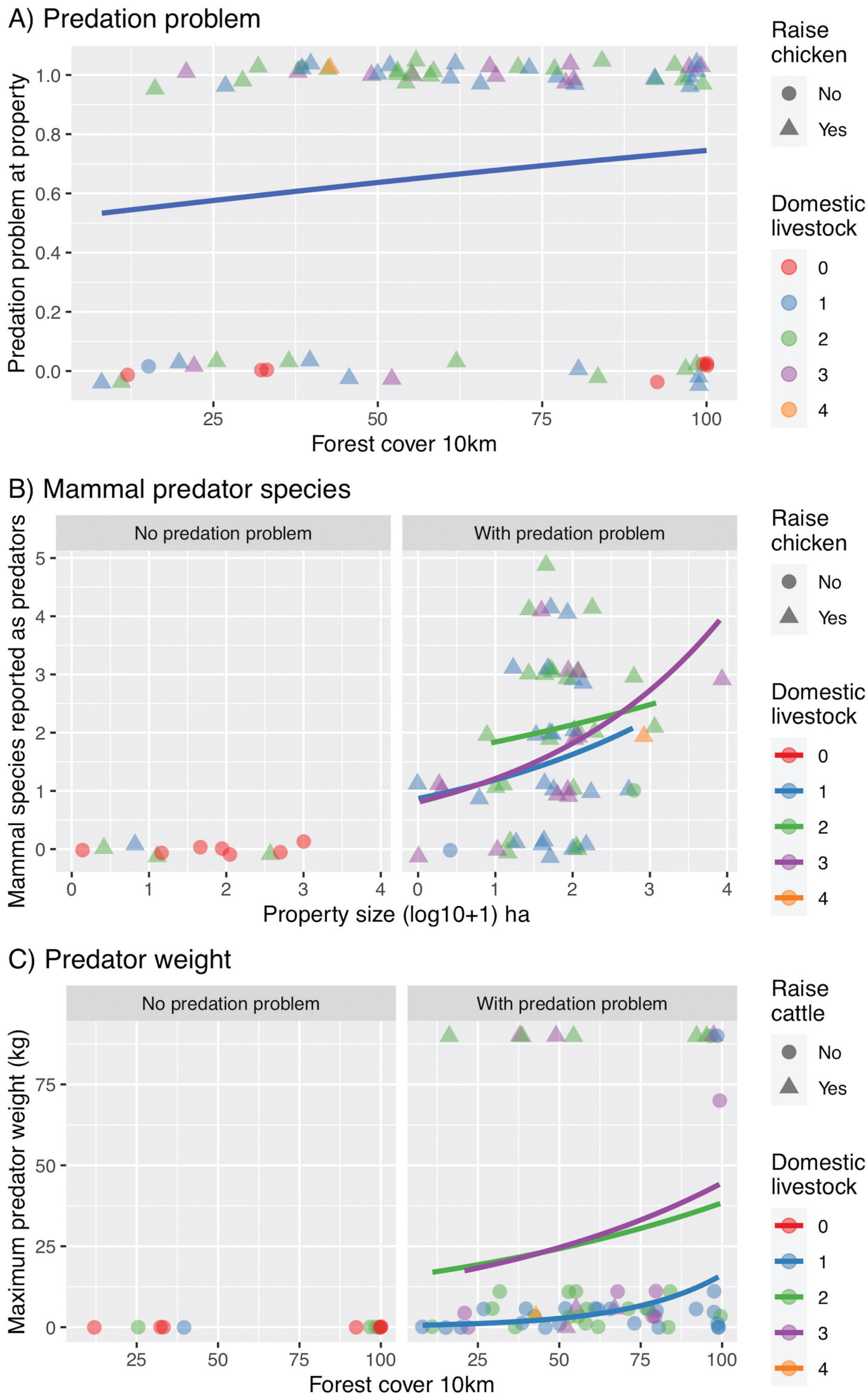

Figure 3. Predation by terrestrial mammals. Patterns of predation by terrestrial mammals in 71 rural properties. Circle colors show the number of different livestock species raised at each property. Solid lines are predictions from generalized additive models to aid visual interpretation of trends. To reduce overlapping points and aid visual interpretation the 11 properties where no predation problems by any species (mammal or otherwise) were reported are presented separately in (B) and (C).

Table 4. Species model selection. Showing models with AICc values less than the associated intercept only models (complete model selection Table 5). Table organized by species grouped as generalist, intermediate and specialist.

Species	Model	K	R^2_{adj}	Dev. Exp. (%)	AICc	Delta AICc	Weight AICc	BIC	Delta BIC	Weight BIC
generalist										
Crab eating fox	livestock large	2	0.10	0.11	84.97	0.00	0.44	91.40	0.00	0.29
	livestock small	2	0.05	0.09	86.32	1.35	0.23	92.74	1.35	0.15
	livestock count	1	0.04	0.05	87.31	2.34	0.14	91.57	0.17	0.26
	intercept	0	−0.00	−0.00	89.95	4.98	0.04	92.16	0.76	0.20
Jaguarundi	economic	2	0.06	0.10	56.67	0.00	0.39	61.55	0.00	0.41
	local	5	0.13	0.19	58.96	2.29	0.12	70.46	8.91	0.00
	livestock count	1	0.02	0.04	59.50	2.83	0.09	63.52	1.98	0.15
	property	4	0.07	0.13	59.54	2.87	0.09	68.74	7.20	0.01
	intercept	0	0.00	−0.00	59.78	3.11	0.08	61.98	0.44	0.33
Opossum	livestock small	2	0.07	0.11	87.59	0.00	0.60	94.02	0.00	0.26
	forstcover1km	3	0.06	0.09	90.85	3.26	0.12	98.93	4.91	0.02
	forstcover10km	2	0.04	0.05	92.61	5.02	0.05	98.94	4.92	0.02
	intercept	0	−0.00	0.00	92.90	5.31	0.04	95.10	1.08	0.15
Tayra	property	5	0.13	0.27	46.40	0.00	0.24	58.39	8.41	0.00
	intercept	0	0.00	0.00	47.78	1.38	0.12	49.98	0.00	0.28
intermediate										
Ocelot	livestock small	3	0.10	0.17	51.00	0.00	0.58	57.43	0.00	0.35
	livestock count	2	0.04	0.10	54.61	3.61	0.09	60.59	3.16	0.07
	forstcover1km	2	0.04	0.09	55.26	4.25	0.07	61.46	4.02	0.05
	forstcover10km	3	0.07	0.11	55.94	4.94	0.05	63.92	6.49	0.01
	habitat	2	0.04	0.07	56.00	5.00	0.05	61.78	4.35	0.04
	intercept	0	−0.00	0.00	56.04	5.04	0.05	58.25	0.82	0.23
specialist										
Jaguar	livestock large	2	0.47	0.46	37.70	0.00	1.00	44.13	0.00	1.00
	property	3	0.14	0.20	54.33	16.63	0.00	62.59	18.46	0.00
	economic	1	0.07	0.10	56.07	18.37	0.00	60.36	16.23	0.00
	forstcover10km	3	0.11	0.16	56.18	18.47	0.00	63.83	19.70	0.00
	livestock count	2	0.06	0.11	57.21	19.50	0.00	63.30	19.17	0.00
	habitat	2	0.06	0.11	57.94	20.24	0.00	64.32	20.18	0.00
	intercept	0	0.00	−0.00	59.78	22.08	0.00	61.98	17.85	0.00
Margay	forstcover10km	4	0.20	0.23	72.52	0.00	0.46	82.44	3.23	0.10
	livestock small	3	0.15	0.17	72.78	0.26	0.40	79.21	0.00	0.49
	livestock count	1	0.10	0.11	75.91	3.39	0.08	80.23	1.02	0.30
	respondent	4	0.09	0.14	77.59	5.07	0.04	86.04	6.83	0.02
	intercept	0	0.00	0.00	82.45	9.94	0.00	84.66	5.45	0.03

Explaining patterns in mammal predator assemblage

Properties raising more domestic livestock species tended to have a higher number of mammal predator species (Pearson's correlation 0.29, $p = 0.0148$, Figure 3). Model selection showed that the type of livestock raised at the properties was by far the most important determinant of the three responses used to represent mammal predation at the properties (presence, species count and maximum weight; Table 3). Mammal predator size increased on properties with cattle, indeed large-bodied jaguars and cougars were mainly reported from properties raising cattle (Figure 3C).

Patterns in mammal predator occurrences

Overall, there was a low probability (<0.5, Figure 4) of any individual mammal species being cited as a predator. Most species were rarely cited, with Tayra (*Eira barbara*), Jaguarundi (*Herpailurus yagouaroundi*), Ocelot (*Leopardus pardalis*), Puma (*Puma concolor*) and Jaguar (*Panthera onca*) all being cited 10 or less times (i.e. cited in less than 15% of all interviews).

Models were able to explain patterns in the specialist species (Jaguar – *P. onca* and Margay – *Leopardus wiedii* deviance explained = 46% and 23%, respectively), but only weakly for the more generalist (Tables 4, and 5). The type of livestock at the properties was supported as explaining predation by all species

Table 5. Full model section table for species. Table organized by species grouped as generalist, intermediate and specialist.

Species	*Model*	*K*	R^2_{adj}	Dev. Exp. (%)	AICc	Delta AICc	Weight AICc	BIC	Delta BIC	Weight BIC
generalist										
Crab eating fox	livestock large	2	0.10	0.11	84.97	0.00	0.44	91.40	0.00	0.29
	livestock small	2	0.05	0.09	86.32	1.35	0.23	92.74	1.35	0.15
	livestock count	1	0.04	0.05	87.31	2.34	0.14	91.57	0.17	0.26
	intercept	0	−0.00	−0.00	89.95	4.98	0.04	92.16	0.76	0.20
	habitat	5	0.07	0.10	90.09	5.12	0.03	100.76	9.36	0.00
	property	2	0.03	0.04	90.22	5.25	0.03	95.78	4.38	0.03
	local	10	0.23	0.27	90.29	5.32	0.03	110.62	19.22	0.00
	economic	1	0.01	0.01	90.53	5.56	0.03	94.30	2.90	0.07
	forstcover10km	5	0.07	0.11	91.35	6.38	0.02	103.28	11.88	0.00
	forstcover1km	2	0.00	0.02	92.28	7.31	0.01	98.51	7.11	0.01
	respondent	4	−0.02	0.02	94.90	9.93	0.00	103.34	11.94	0.00
Jaguarundi	economic	2	0.06	0.10	56.67	0.00	0.39	61.55	0.00	0.41
	local	5	0.13	0.19	58.96	2.29	0.12	70.46	8.91	0.00
	livestock count	1	0.02	0.04	59.50	2.83	0.09	63.52	1.98	0.15
	property	4	0.07	0.13	59.54	2.87	0.09	68.74	7.20	0.01
	intercept	0	0.00	−0.00	59.78	3.11	0.08	61.98	0.44	0.33
	livestock small	2	0.01	0.06	60.51	3.85	0.06	66.94	5.40	0.03
	respondent	4	0.07	0.14	60.62	3.95	0.05	70.89	9.34	0.00
	habitat	4	0.04	0.09	61.06	4.40	0.04	69.58	8.04	0.01
	forstcover1km	2	−0.01	0.00	61.62	4.95	0.03	65.96	4.42	0.04
	forstcover10km	3	0.01	0.05	62.48	5.81	0.02	69.84	8.29	0.01
	livestock large	2	−0.02	0.01	63.32	6.65	0.01	69.75	8.20	0.01
Opossum	livestock small	2	0.07	0.11	87.59	0.00	0.60	94.02	0.00	0.26
	forstcover1km	3	0.06	0.09	90.85	3.26	0.12	98.93	4.91	0.02
	forstcover10km	2	0.04	0.05	92.61	5.02	0.05	98.94	4.92	0.02
	intercept	0	−0.00	0.00	92.90	5.31	0.04	95.10	1.08	0.15
	local	1	−0.00	0.00	92.90	5.31	0.04	95.10	1.08	0.15
	economic	1	−0.00	0.00	92.90	5.31	0.04	95.10	1.08	0.15
	livestock count	1	−0.00	0.00	92.90	5.31	0.04	95.10	1.08	0.15
	property	1	0.01	0.01	93.22	5.63	0.04	96.73	2.71	0.07
	habitat	2	−0.01	0.01	95.10	7.51	0.01	100.36	6.34	0.01
	livestock large	2	−0.00	0.02	95.11	7.52	0.01	101.54	7.52	0.01
	respondent	5	0.02	0.06	97.57	9.98	0.00	108.80	14.78	0.00
Tayra	property	5	0.13	0.27	46.40	0.00	0.24	58.39	8.41	0.00
	intercept	0	0.00	0.00	47.78	1.38	0.12	49.98	0.00	0.28
	livestock count	1	−0.00	0.00	47.78	1.38	0.12	49.98	0.00	0.28
	economic	1	0.00	0.00	47.78	1.38	0.12	49.98	0.00	0.28
	local	6	0.18	0.26	48.04	1.63	0.11	60.83	10.84	0.00
	forstcover10km	2	−0.00	0.02	49.20	2.80	0.06	53.55	3.57	0.05
	habitat	2	−0.00	0.02	49.20	2.80	0.06	53.55	3.57	0.05
	forstcover1km	2	−0.00	0.02	49.20	2.80	0.06	53.55	3.57	0.05
	respondent	9	0.24	0.39	49.70	3.30	0.05	67.60	17.62	0.00
	livestock small	3	−0.01	0.05	49.72	3.32	0.05	56.15	6.17	0.01
	livestock large	3	−0.02	0.02	51.24	4.84	0.02	57.67	7.69	0.01
intermediate										
Ocelot	livestock small	3	0.10	0.17	51.00	0.00	0.58	57.43	0.00	0.35
	livestock count	2	0.04	0.10	54.61	3.61	0.09	60.59	3.16	0.07
	forstcover1km	2	0.04	0.09	55.26	4.25	0.07	61.46	4.02	0.05
	forstcover10km	3	0.07	0.11	55.94	4.94	0.05	63.92	6.49	0.01
	habitat	2	0.04	0.07	56.00	5.00	0.05	61.78	4.35	0.04
	intercept	0	−0.00	0.00	56.04	5.04	0.05	58.25	0.82	0.23
	property	1	0.00	0.01	56.31	5.31	0.04	59.14	1.70	0.15
	economic	1	0.01	0.01	56.62	5.61	0.03	60.18	2.75	0.09
	respondent	4	0.02	0.12	57.41	6.40	0.02	66.95	9.51	0.00
	local	5	0.07	0.12	58.66	7.65	0.01	69.38	11.95	0.00
	livestock large	3	−0.02	0.01	59.78	8.78	0.01	66.21	8.78	0.00
specialist										
Jaguar	livestock large	2	0.47	0.46	37.70	0.00	1.00	44.13	0.00	1.00

(*Continued*)

Table 5. (Continued).

Species	*Model*	*K*	R^2_{adj}	Dev. Exp. (%)	AICc	Delta AICc	Weight AICc	BIC	Delta BIC	Weight BIC
	property	3	0.14	0.20	54.33	16.63	0.00	62.59	18.46	0.00
	economic	1	0.07	0.10	56.07	18.37	0.00	60.36	16.23	0.00
	forstcover10km	3	0.11	0.16	56.18	18.47	0.00	63.83	19.70	0.00
	livestock count	2	0.06	0.11	57.21	19.50	0.00	63.30	19.17	0.00
	habitat	2	0.06	0.11	57.94	20.24	0.00	64.32	20.18	0.00
	intercept	0	0.00	−0.00	59.78	22.08	0.00	61.98	17.85	0.00
	livestock small	3	0.02	0.07	59.86	22.16	0.00	66.29	22.16	0.00
	local	10	0.28	0.38	61.08	23.38	0.00	81.03	36.90	0.00
	forstcover1km	3	0.02	0.04	61.89	24.19	0.00	68.41	24.27	0.00
	respondent	4	−0.01	0.06	62.75	25.05	0.00	71.20	27.06	0.00
Margay	forstcover10km	4	0.20	0.23	72.52	0.00	0.46	82.44	3.23	0.10
	livestock small	3	0.15	0.17	72.78	0.26	0.40	79.21	0.00	0.49
	livestock count	1	0.10	0.11	75.91	3.39	0.08	80.23	1.02	0.30
	respondent	4	0.09	0.14	77.59	5.07	0.04	86.04	6.83	0.02
	null inter	0	0.00	0.00	82.45	9.94	0.00	84.66	5.45	0.03
	property	1	−0.00	0.00	82.45	9.94	0.00	84.66	5.45	0.03
	forstcover1km	2	0.03	0.05	82.60	10.08	0.00	88.74	9.53	0.00
	economic	1	0.00	0.01	82.80	10.28	0.00	85.92	6.71	0.02
	habitat	2	0.01	0.02	82.84	10.32	0.00	87.19	7.98	0.01
	livestock large	2	−0.01	0.02	85.28	12.76	0.00	91.71	12.50	0.00
	local	5	0.08	0.10	85.32	12.80	0.00	97.49	18.28	0.00

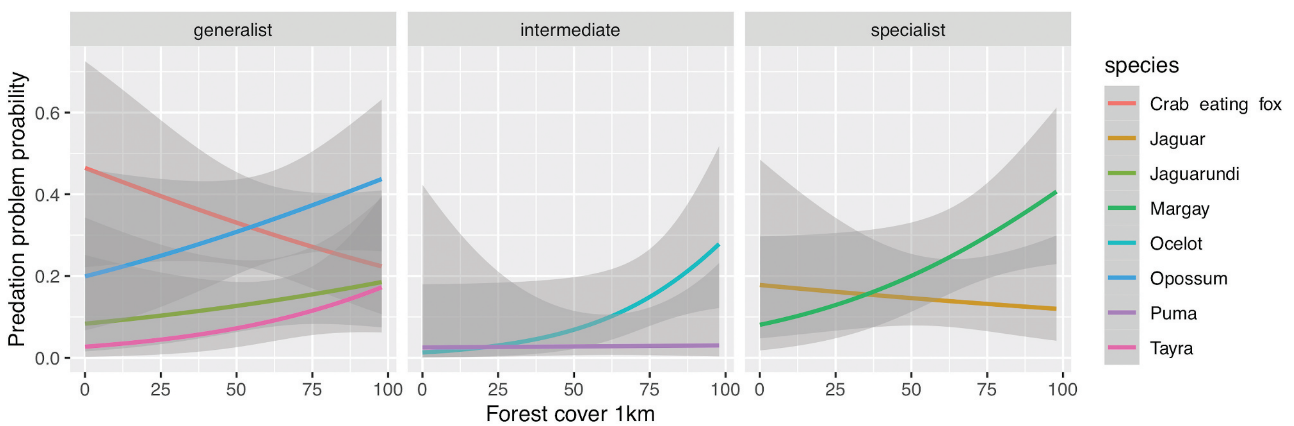

Figure 4. Predation probability of generalist, intermediate and specialist mammal species. Lines represent mean predation probability (shaded areas represent ±95% CI) of four generalist, two intermediate and two specialist mammal species in 71 rural properties as a function of proportion of forest cover within 1 km radius, predicted using logistic regression models based on the reports of the species predation reported.

except for Tayra. Margay predation increased with the presence of small livestock (chicken or ducks) and increasing forest cover within a 10 km radius.

Discussion

Our analysis of rural residents' problems related to terrestrial mammal predation of domestic animals showed that a large number of mammal predators preyed upon a relatively small number of domestic species, but the most frequently reported problems were concentrated on predators of a single species – chicken. Interviews in our study region, located in one of the most preserved regions of the Brazilian Amazon and with a large coverage of protected areas, showed that problems related to terrestrial mammals preying upon domestic animals were predominantly concentrated in small and mid-sized generalist species mainly dominated by opossum (*Didelphis* sp.) and crab-eating fox (*Cerdocyon thous*). We first turn to highlight the mammal predator–prey network and then explore variables affecting the predations reported by residents. Finally, we discuss potential suggestions to reduce human–wildlife negative interactions in small properties across the Amazon.

Our results showed that chicken was by far the most frequently reported predated species and that almost all terrestrial mammals were reported to be predators. In fact, poultry commonly constitutes the main target of wild predators in tropical regions (Amador-Alcalá et al. 2013). In the central Brazilian Cerrado (savanna), chicken were also commonly reported by residents to be predated by wild canids such as foxes and maned wolves (Bickley et al. 2020).

Overall, we found a lower proportion of residents reporting predation problems compared with other Amazonian regions. For example, 58% to 86% of interviewees reported problems with large cats (*Puma concolor* and *Panthera onca*) in the southern 'arc of deforestation' (Michalski et al. 2006), while in our study region, only 66% of people reported predation problems with any of the mammal predators. Indeed, less than 15% of all interviews identified large cats as livestock predators. This can be a result of several non-mutually exclusive factors. Firstly, the remaining forest cover retains diverse and abundant native prey (Michalski et al. 2015), which in turn reduces the probability of large cats encroaching into properties and predating on cattle (Polisar et al. 2003). A recent study in Mexico comparing two phases (I – phase before, and II – phase after the augmentation of prey) with Global Positioning System-collared jaguar and puma and prey identification from scats using molecular DNA found a significant reduction in the consumption of bovids and a significant increase in the consumption of peccaries during phase II (Cassaigne et al. 2021). Currently, Amapá State has a very low deforestation rate compared with other regions in the Brazilian Amazon (INPE 2024), with a high coverage of protected areas, which represents ca. 74% of the total State area (Michalski et al. 2020). Secondly, the relatively low number of cattle raised in the State. For example, by 2017, Amapá State registered a cattle herd of approximately 36K (IBGE 2024c), while Mato Grosso, located in the 'arc of deforestation' registered 24MK cattle herd (IBGE 2024d). This is a hundredfold difference when accounting for differences in territorial area, Mato Grosso State has 26.9 herds/km^2 compared with 0.26 herds/km^2 in Amapá State. Thus, it is not surprising that problems related to large cat predation were relatively rare in our study region and restricted to a small number of properties rearing large livestock (e.g. cattle).

The most common mammal predator reported by our interviewees was opossum (*Didelphis* sp.), which is a frequent wild predator reported in tropical regions, especially related to poultry predation (Amador-Alcalá et al. 2013). Opossum is a generalist species that can inhabit a variety of habitats and persist even in small disturbed habitat remnants (Michalski and Peres 2007; Adler et al. 2012).

Finally, our models were able to explain patterns in the specialist species (Jaguar – *P. onca* and Margay – *Leopardus wiedii*), but only weakly for the more generalist ones. Jaguar predation was strongly related to properties rearing large-bodied livestock, while Margay predation was associated with forest habitat within a radius of 10 km. Jaguar is a large cat that is frequently associated with predation on cattle and other large livestock such as sheep, pigs, and horses (Michalski et al. 2006; Amador-Alcalá et al. 2013). Margay is a small-bodied arboreal cat that is strongly associated with forested habitats (Oliveira 1998). Thus, our results concur with those available in the literature.

Conclusions

The most frequently reported predated species associated with almost all mammal predators was chicken. We demonstrated that even in a highly preserved region, human proximity to wild animals can generate negative interactions that can potentially generate retaliation and persecution. Thus, to avoid future negative and unsustainable mammal predator–livestock interactions, we highlight that environmental education and management practices must be developed with rural residents. There are a broad range of management practices available to reduce depredation risks depending on each predator and location. For example, confining chickens and other small livestock such as ducks in some form of fenced area at night could reduce levels of depredation and potentialize sustainable coexistence between humans and wild animals. Relocating risky enclosures that are close to forest edges or water sources to safer places when possible can also be a strategy to reduce depredation by wild animals (Amador-Alcalá et al. 2013). The implementation of intermittent light sources, associated with the use of scarecrows and battery-powered radios, in nighttime livestock enclosures can mitigate predation risks (Cavalcanti and Perilli 2015). Keeping dogs outdoors was also another common practice to avoid chicken predation adopted in other regions in Central Brazil (Bickley et al. 2020) and could be another possible alternative for rural residents both in our study region and other areas across Amazonia. However, it is important to keep dogs restricted to areas where the domestic animals are raised and far from natural habitats as domestic dogs can also predate wild animals and/or cause pathogen transmission (Lessa et al. 2016). Economic benefits related to observational ecotourism can induce changes in local peoples' perceptions and have proven to strengthen conservation initiatives for large apex predators such as harpy eagles (*Harpia harpyja*) in the Brazilian Amazon (Miranda et al. 2022). To reduce potential negative wildlife-livestock and human–wildlife interactions, there is a need to expand research into areas that do not necessarily contain large densities of large livestock, and also investigate locally effective management options to minimize depredation by small and mid-sized terrestrial mammals on small domestic animals. Expand studies not only focusing on mammals but also on other groups, such as raptors and reptiles, also known to predate on domestic animals can also improve the knowledge of human–wildlife interactions. This is certainly a gap in the scientific literature and could be even more important in areas across Amazonia, where it seems like the predation on domestic animals at rural smallholdings has been largely overlooked in the past decades.

Acknowledgments

The Federal University of Amapá (UNIFAP) provided logistical support. We are grateful to all rural residents for their invaluable information provided during the interviews. This article is dedicated to the memory of Dr. Peter Crawshaw Jr., whose kindness and passion for carnivores inspired us all.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Funding was provided by the Federal Agency for Support and Evaluation of Graduate Education, Ministry of Education ["Coordenação de Aperfeiçoamento de Pessoal de Nível Superior" – CAPES] [Project 88881.030414/2013-01], and by the National Council for Scientific and Technological Development [CNPq] [Processes 301562/2015-6, 302806/2018-0] to Fernanda Michalski. Fernanda Michalski receives a productivity scholarship from the CNPq [Process 310573/2021-1].

Data availability statement

The data that support the findings of this study are openly available in Figshare at https://figshare.com/s/a8cb03126d3e56ab73f5.

ORCID

Fernanda Michalski http://orcid.org/0000-0002-8074-9964
Ricardo Luiz Pires Boulhosa http://orcid.org/0000-0002-1212-7805
Darren Norris http://orcid.org/0000-0003-0015-8214

References

Adler GH, Carvajal A, Davis-Foust SL, Dittel JW. 2012. Habitat associations of opossums and rodents in a lowland forest in French Guiana. Mamm Biol. 77(2):84–89.

Amador-Alcalá S, Naranjo EJ, Jiménez-Ferrer G. 2013. Wildlife predation on livestock and poultry: implications for predator conservation in the rainforest of south-east Mexico. Oryx. 47(2):243–250.

Bickley SM, Lemos FG, Gilmore MP, Azevedo FC, Freeman EW, Songsasen N. 2020. Human perceptions of and interactions with wild canids on cattle ranches in central Brazil. Oryx. 54(4):546–553.

Bombieri G, Penteriani V, Almasieh K, Ambarlı H, Ashrafzadeh MR, Das CS, Dharaiya N, Hoogesteijn R, Hoogesteijn A, Ikanda D, et al. 2023. A worldwide perspective on large carnivore attacks on humans. PLOS Biol. 21(1):e3001946. doi: 10.1371/journal.pbio.3001946

Burnham KP, Anderson DR. 2002. Model selection and multi-model inference. New York: Springer.

Burnham KP, Anderson DR. 2004. Multimodel inference: understanding AIC and BIC in model selection. Socio Methods Res. 33(2):261–304.

Cabral AIR, Saito C, Pereira H, Laques AE. 2018. Deforestation pattern dynamics in protected areas of the Brazilian Legal Amazon using remote sensing data. Appl Geogr. 100:101–115.

Cassaigne I, Thompson RW, Medellin RA, Culver M, Ochoa A, Vargas K, Childs JL, Galaz M, Sanderson J. 2021. Augmentation of natural prey reduces cattle predation by puma (*Puma concolor*) and jaguar (*Panthera onca*) on a ranch in Sonora, Mexico. Southw Naturalist. 65(2):123–130.

Cavalcanti SMC, Perilli MLL. 2015. Medidas alternativas que podem auxiliar na prevenção e controle de danos. In: Cavalcanti SMC, de Paula RC, Gasparini-Morato R, editors. Conflitos com mamíferos carnívoros - Uma referência para o manejo e a convivência. Atibaia, São Paulo, Brasil: Instituto Chico Mendes de Conservação da Biodiversidade, Centro Nacional de Pesquisa e Conservação de Mamíferos Carnívoros. p. 51–60. https://acervo.socioambiental.org/sites/default/files/documents/L3L00020.pdf

Champagne PS, Herman TB, Rosolie P, Singer D, Horton D, Payne CJ, Dablin L, Colville D, Cardenas J, Quevedo M, et al. 2024. Does the Southern Green Anaconda, *Eunectes murinus*, seek areas of high prey concentration in Southeast Peru? Food Webs. 39:e00348. doi: 10.1016/j.fooweb.2024.e00348

Defries RS, Hansen MC, Townshend JRG, Janetos AC, Loveland TR. 2000. A new global 1-km dataset of percentage tree cover derived from remote sensing. Global Change Biol. 6(2):247–254.

de Souza JC, da Silva RM, Goncalves MPR, Jardim RJD, Markwith SH. 2018. Habitat use, ranching, and human-wildlife conflict within a fragmented landscape in the Pantanal, Brazil. Biol Conserv. 217:349–357.

de Souza Mello Bicalho AM, Hoefle SW. 2008. On the cutting edge of the Brazilian frontier: new (and old) Agrarian questions in the south central Amazon. J Peasant Stud. 35(1):1–38.

Dinerstein E, Olson D, Joshi A, Vynne C, Burgess ND, Wikramanayake E, Hahn N, Palminteri S, Hedao P, Noss R, et al. 2017. An Ecoregion-based approach to protecting half the terrestrial realm. BioScience. 67(6):534–545. doi: 10.1093/biosci/bix014

Dormann CF, Gruber B, Fründ J. 2008. Introducing the bipartite package: analysing ecological networks. R News. 8:8–11.

Dudley N. 2008. Guidelines for applying protected area management categories. Gland: IUCN. Available from: https://portals.iucn.org/library/sites/library/files/documents/PAG-021.pdf

Eisenberg JF, Redford KH. 1999. Mammals of the neotropics, The central neotropics: Ecuador, Perú, Bolivia, Brazil. Vol. 3, Chicago (IL), USA: University of Chicago Press; p. X+609.

ESRI. 2011. ArcGIS desktop: release 10. Redlands (CA): Environmental Systems Research Institute.

Fearnside PM. 2009. Hydroelectric dams in the Brazilian Amazon as sources of 'greenhouse' gases. Environ Conserv. 22(1):7–19.

Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, Thau D, Stehman SV, Goetz SJ, Loveland TR, et al. 2013. High-resolution global maps of 21st-century forest cover change. Science. 342(6160):850–853. Data available on-line from http://earthenginepartners.appspot.com/science-2013-global-forest

IBGE. 2022. Instituto Brasileiro de Geografia e Estatistica. Amazônia legal; [cited 2024 Sep 4]. Available from: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/15819-amazonia-legal.html?edicao=37404&t=acesso-ao-produto.

IBGE. 2024a. Instituto Brasileiro de Geografia e Estatistica. Censo Agropecuário 2017; [cited 2024 Nov 18]. Available from: https://sidra.ibge.gov.br/pesquisa/censo-agropecuario/censo-agropecuario-2017/resultados-definitivos#caracteristicas-estabelecimentos.

IBGE. 2024b. Instituto Brasileiro de Geografia e Estatistica. Cidades; [cited 2024 Sep 4]. Available from: https://cidades.ibge.gov.br/brasil/ap/panorama.

IBGE. 2024c. Instituto Brasileiro de Geografia e Estatistica. Estados; [cited 2024 Sep 4]. Available from: https://cidades.ibge.gov.br/brasil/ap/pesquisa/14/101.

IBGE. 2024d. Instituto Brasileiro de Geografia e Estatistica. Estados; [cited 2024 Sep 4]. Available from: https://cidades.ibge.gov.br/brasil/mt/pesquisa/24/76693.

INPE. 2024. Programa de monitoramento da Amazônia e demais biomas. Taxas de desmatamento - Amazônia Legal; [cited 2024 Sep 4]. Available from: https://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/rates.

Inskip C, Zimmermann A. 2009. Review human-felid conflict: a review of patterns and priorities worldwide. Oryx. 43(1):18–34.

IUCN. 2024. The IUCN red list of threatened species. Version 2024-1; [cited 2024 Sep 4]. Available from: https://www.iucnredlist.org.

IUCN & UNEP-WCMC. 2024. The World Database on Protected Areas (WDPA). International Union for Conservation of Nature & UN Environment Programme World Conservation Monitoring Centre. http://www.protectedplanet.net

König HJ, Kiffner C, Kramer-Schadt S, Fürst C, Keuling O, Ford AT. 2020. Human–wildlife coexistence in a changing world. Conserv Biol. 34(4):786–794.

Lessa I, Corrêa Seabra Guimarães T, de Godoy Bergallo H, Cunha A, Vieira EM. 2016. Domestic dogs in protected areas: a threat to Brazilian mammals? Natureza Conservação. 14(2):46–56.

Loveland TR, Belward AS. 1997. The IGBP-DIS global 1km land cover data set, DISCover: first results. Int J Remote Sens. 18(15):3289–3295.

Madden F. 2004. Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. Hum Dimens Wildl. 9(4):247–257.

Marra G, Wood SN. 2011. Practical variable selection for generalized additive models. Comput Stat Data Anal. 55(7):2372–2387.

Michalski F, Boulhosa RLP, Faria A, Peres CA. 2006. Human–wildlife conflicts in a fragmented Amazonian forest landscape: determinants of large felid depredation on livestock. Anim Conserv. 9(2):179–188.

Michalski F, Boulhosa RLP, Nascimento YN, Norris D. 2020. Rural wage-earners' attitudes towards diverse wildlife groups differ between tropical ecoregions: implications for forest and savanna conservation in the Brazilian Amazon. Trop Conserv Sci. 13:1940082920971747.

Michalski F, Conceição PC, Amador JA, Laufer J, Norris D. 2012. Local perceptions and implications for giant otter (*Pteronura brasiliensis*) conservation around protected areas in the Eastern Brazilian Amazon. IUCN OSG Bulletin. 29:34–45.

Michalski F, Crawshaw PG, Oliveira TG, Fabián ME. 2006. Notes on home range and habitat use of three small carnivore species in a disturbed vegetation mosaic of southeastern Brazil / Notes sur le territoire et l'utilisation de l'habitat de trois espèces de petits carnivores dans une végétation mosaïque perturbée au Sud Est du Brésil. Mammalia. 70(1–2):52–57.

Michalski F, Peres CA. 2005. Anthropogenic determinants of primate and carnivore local extinctions in a fragmented forest landscape of southern Amazonia. Biol Conserv. 124(3):383–396.

Michalski F, Peres CA. 2007. Disturbance-mediated mammal persistence and abundance-area relationships in Amazonian forest fragments. Conserv Biol. 21(6):1626–1640.

Michalski LJ, Norris D, de Oliveira TG, Michalski F, Russo D. 2015. Ecological relationships of Meso-scale distribution in 25 neotropical vertebrate species. PLOS ONE. 10(5):e0126114.

Miranda EBP, Peres CA, Downs CT. 2022. Landowner perceptions of livestock predation: implications for persecution of an Amazonian apex predator. Anim Conserv. 25(1):110–124.

Norris D, Michalski F. 2013. Socio-economic and spatial determinants of anthropogenic predation on yellow-spotted river turtle, *Podocnemis unifilis* (Testudines: Pelomedusidae), nests in the Brazilian Amazon: implications for sustainable conservation and management. Zoologia (Curitiba). 30(5):482–490.

Norris D, Michalski F, Gibbs JP. 2018. Beyond harm's reach? Submersion of river turtle nesting areas and implications for restoration actions after Amazon hydropower development. PeerJ. 6:e4228.

Nyhus PJ. 2016. Human–wildlife conflict and coexistence. Annu Rev Environ Resour. 41(1):143–171.

Oliveira TG. 1998. Leopardus wiedii. Mamm Species. 579 (579):1–6.

Palmeira FBL, Trinca CT, Haddad CM. 2015. Livestock predation by puma (*Puma concolor*) in the highlands of a southeastern Brazilian Atlantic forest. Environ Manag. 56(4):903–915.

Perreault T. 2005. Why Chacras (Swidden Gardens) persist: agrobiodiversity, food security, and cultural identity in the Ecuadorian Amazon. Hum Organ. 64(4):327–339.

Polisar J, Maxit I, Scognamillo D, Farrell L, Sunquist ME, Eisenberg JF. 2003. Jaguars, pumas, their prey base, and cattle ranching: ecological interpretations of a management problem. Biol Conserv. 109(2):297–310.

Powers RP, Jetz W. 2019. Global habitat loss and extinction risk of terrestrial vertebrates under future land-use-change scenarios. Nat Clim Change. 9(4):323–329.

Rosas-Rosas OC, Bender LC, Valdez R. 2008. Jaguar and puma predation on cattle calves in Northeastern Sonora, Mexico. Rangeland Ecol & Manag. 61(5):554–560.

Schneider M, Biedzicki de Marques AA, Peres CA. 2021. Brazil's next deforestation frontiers. Trop Conserv Sci. 14:19400829211020472.

Thirgood S, Woodroffe R, Rabinowitz A. 2005. The impact of human–wildlife conflict on human lives and livelihoods. In: Rabinowitz A, Woodroffe R, Thirgood S, editors People and wildlife, conflict or Co-existence? Cambridge: Cambridge University Press. pp. 13–26.

Torres DF, Oliveira ES, Alves RRN. 2018. Conflicts between humans and terrestrial vertebrates: a global review. Trop Conserv Sci. 11:1940082918794084.

Tucker MA, Ord TJ, Rogers TL. 2014. Evolutionary predictors of mammalian home range size: body mass, diet and the environment. Global Ecol Biogeogr. 23(10):1105–1114.

United Nations. 2024. World population prospects 2024: summary of results (UN DESA/POP/2024/TR/NO. 9). New York: United Nations: Department of Economic and Social Affairs, Population Division.

van Eeden LM, Crowther MS, Dickman CR, Macdonald DW, Ripple WJ, Ritchie EG, Newsome TM. 2018. Managing conflict between large carnivores and livestock. Conserv Biol. 32(1):26–34.

Winkler K, Fuchs R, Rounsevell M, Herold M. 2021. Global land use changes are four times greater than previously estimated. Nat Commun. 12(1):2501.

Young JC, Rose DC, Mumby HS, Benitez-Capistros F, Derrick CJ, Finch T, Garcia C, Home C, Marwaha E, Morgans C, et al. 2018. A methodological guide to using and reporting on interviews in conservation science research. Methods Ecol Evol. 9(1):10–19. doi: 10.1111/2041-210X.12828

Zuluaga S, Echeverry-Galvis MA. 2016. Domestic fowl in the diet of the black-and-chestnut eagle (*Spizaetus isidori*) in the Eastern Andes of Colombia: a potential conflict with humans? Ornitol Neotrop. 27:113–120.