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## HUMAN-JAGUAR COEXISTENCE: SOCIAL FACTORS INFLUENCING JAGUAR CONSERVATION IN SOUTHERN BOLIVIA

Convivencia humanos-jaguares: factores sociales que influyen en la conservación del jaguar en el sur de Bolivia

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**Abstract:** Jaguar (*Panthera onca*) populations are declining in Bolivia because of human activity. Understanding the attitudes and perceptions of local people toward threatened species and the factors that can influence them is crucial for their protection. This study evaluated how local people's knowledge, attitudes, and perceptions towards jaguars in southern Bolivia varied depending on their gender, level of education, age, and occupation. We interviewed 139 people who live in and around two protected areas: Tariquía National Reserve and Aguaragüe National Park and Integrated Management Natural Area. Positive perceptions and attitudes towards jaguars were found among those who have higher levels of formal education and among those who are currently students. Results show that negative attitudes and perceptions towards the species were more prevalent among farmers, older people or those with no schooling. These negative attitudes were determined by fear as jaguars were seen as a potential threat to life. Socioeconomic factors influencing the level of tolerance towards jaguars were related to other socioeconomic factors besides potential economic loss. Our results can inform the design, orientation, execution, and evaluation of future species conservation projects in Bolivia.

**Keywords:** attitudes, Bolivia, coexistence, human-jaguar conflict, social perceptions.

**Resumen:** Las poblaciones de jaguar (*Panthera onca*) están disminuyendo en Bolivia debido a amenazas antropogénicas. Comprender las actitudes y percepciones de la

población local ante las especies amenazadas y los factores que pueden influir en ellas, es fundamental para su protección. Este estudio evaluó cómo el nivel de conocimiento, actitudes y percepciones hacia los jaguares, entre la población local en el sur de Bolivia, varió según su nivel de educación, edad y ocupación. Entrevistamos a 139 personas que viven dentro y alrededor de dos áreas protegidas: la Reserva Nacional Tariquía y el Parque Nacional y Área Natural de Manejo Integrado Aguaragüe. Las percepciones y actitudes positivas hacia los jaguares se encontraron entre las personas que han alcanzado niveles más altos de educación formal y entre los que son actualmente estudiantes. Los resultados muestran una tendencia que las percepciones y actitudes negativas hacia la especie fueron más prevalentes entre las personas sin educación formal, adultos mayores y granjeros. Estas percepciones negativas estaban determinadas por el miedo; la gente veía a los jaguares como una amenaza potencial para sus vidas. Los factores socioeconómicos que afectan el nivel de tolerancia hacia los jaguares no se relacionan solo con las pérdidas económicas como lo han indicado otros estudios. Nuestros resultados pueden informar el diseño, orientación, ejecución y evaluación de futuros proyectos de conservación de especies en Bolivia.

**Palabras clave:** actitudes, Bolivia, coexistencia, conflicto humano-jaguar, percepciones sociales.

## INTRODUCTION

Throughout its range in Latin America, the jaguar *Panthera onca* is threatened by the loss and fragmentation of their habitat, prey depletion, persecution, and conflict as a result of coexistence with people (Castaño-Uribe *et al.* 2017). These factors have led to a widespread range reduction and local population extinctions in approximately 50% of its historical distribution (de la Torre *et al.* 2018). Conflicts between humans and jaguars are prevalent throughout the species range and are the product of a variety of ecological and socio-economic factors (Medellín *et al.* 2002, Macdonald & Sillero-Zubiri 2002, Castaño-Uribe *et al.* 2017). The species is categorized as Near Threatened by the International Union for Conservation of Nature Red List (Quigley *et al.* 2017).

Bolivia is an important country for jaguars (U. S. Fish and Wildlife Service 2018, Romero-Muñoz *et al.* 2019), containing high priority populations and habitats (Sanderson *et al.* 2002). Nevertheless, the species is under multiple threats associated with relatively high human population densities and human activities, including road construction, gas exploration and the advance of the agricultural frontier (Thompson & Martínez Martí 2015, Romero-Muñoz *et al.* 2019). In addition, direct threats include degradation of the species habitat, poaching for the illegal international trade in jaguar body parts and persecution associated with attacks on livestock (Nuñez & Aliaga-Rossel 2017). For these reasons the species is categorized nationally as Vulnerable (Tarifa & Aguirre 2009, MMAyA 2020).

Understanding how people perceive the jaguar and which factors influence their attitudes will help shape conservation to protect the remaining populations (Castaño-

Uribe *et al.* 2017). **Attitudes** are defined as favorable or unfavorable dispositions towards an action (Dickman *et al.* 2013), and **perceptions** refer to how people interpret their environment and give meaning to it (Bowditch *et al.* 2007). Perceptions are affected by many factors and ultimately affect people's tolerance for wildlife. Assessing public attitudes and perceptions helps to provide knowledge on issues related to human-wildlife coexistence and should be used to establish long-term conservation strategies for large carnivores (Conforti & Azevedo 2003, Davenport *et al.* 2010).

Hostility towards some species, such as large carnivores, or, conversely, positive attitudes towards their conservation can be influenced by emotional (e.g., fear, excitement, Castillo-Huitrón *et al.* 2020), cognitive (e.g., knowledge) and socio-demographic factors including age, occupation and education (Cavalcanti *et al.* 2010, Dickman *et al.* 2013, Lindsey *et al.* 2013). Human–jaguar conflict typically occurs in association attacks on livestock (Dickman 2009) and attacks on humans (Packer *et al.* 2005), for example, some studies have found that negative perceptions have been associated with economic losses due to jaguar attacks on cattle, while other studies have found that young people with a higher level of education tend to have positive perceptions of jaguars (Arispe *et al.* 2009, Porfirio *et al.* 2016, Negrões *et al.* 2017). In addition to age and level of education, it has been shown that aesthetics is an important determinant of perceptions of endangered species and of people's support for their conservation (Knight 2008, Caruso & Jiménez Pérez 2013). Recognition and understanding of the multiple ecosystem services (e.g., the benefits) of carnivores allows a more comprehensive assessment of the benefits of coexisting with these species (Marchini & Macdonald 2012). However, rural people who coexist with jaguars may be less likely to consider the broader benefits of this predator's role in the ecosystem (Engel *et al.* 2017a, Marchini & Macdonald 2018, Caruso *et al.* 2020) and are more concerned with their short-term relationship with the cat.

Human attitudes and emotions have an effect on the presence, absence, and recovery of wildlife populations (Herzog & Burghardt 1988). Emotions, such as fear, happiness, sadness and indifference, have also been associated with human attitudes and perceptions towards jaguars (Engel *et al.* 2017b, Amit & Jacobson 2017, Caruso *et al.* 2020). Fear will depend on the degree to which the encounter with the animal is perceived as dangerous (Johansson *et al.* 2012) and may be linked to the influence of popular beliefs (Cuéllar & Noss 2014) that can generate negative attitudes and perceptions. In Bolivia, jaguars are the protagonist of many indigenous legends, where they are given supernatural qualities (Cuéllar & Noss 2014), which may in turn influence social attitudes, generating feelings of either admiration or fear (Hoogesteijn *et al.* 2015). In contrast, the feeling of joy when cherished species are seen, or sadness about the vulnerability of such species, may generate positive attitudes for their conservation (Jacobs & Vaske 2019).

In Bolivia, little is known about the social factors that influence people's perception of and attitudes towards jaguars. A recent study found that communities in the northwestern region of the Bolivian Amazon disliked (48.9%) jaguars or felt neutral toward them (26.8%; Knox *et al.* 2019). Other studies that addressed the typical jaguar-cattle conflict found that attitudes towards the species are negative even if there is no

damage to cattle (Cavalcanti *et al.* 2010, Negrões *et al.* 2017). In this context, our objective was to identify emotional, cognitive, and socio-demographic factors that influence the perceptions and attitudes regarding jaguars in two important jaguar habitat areas in southern Bolivia; Tariquía National Reserve and Aguaragüe National Park and Integrated Management Natural Area. We hypothesized that (1) negative perceptions and attitudes towards jaguars would more likely be found among older people and, based on previous studies, we also expected that (2) negative perceptions would be found among farming communities and those with lower educational levels.

### Study area

Tariquía National Reserve (TNR, 2,469 km<sup>2</sup>) is situated in the southeast of the department of Tarija (Figure 1), containing Tucumano-Boliviano forest, one of the least known and most threatened ecoregions in Bolivia (Ibisch *et al.* 2003, Churchill & Lozano 2009). Some 3,680 people in 10 communities live inside the reserve, and 13 communities live around it (INE 2002). All these communities depend on crops, domestic animals (swine and poultry) and cattle ranching.

Aguaragüe National Park and Integrated Management Natural Area (ANP, 1,083 km<sup>2</sup>) is located in a transition region lying between Andean foothill woodlands and the Chaco savannas of the Gran Chaco province, Department of Tarija (Campanini *et al.* 2014). There are 15 indigenous communities inside the ANP and 18 around it, with a total population of approximately 5,500 inhabitants (INE 2002). Extensive cattle ranching, agriculture and fishing are among the main economic activities of these communities (Campanini *et al.* 2014). In addition, there are several hydroelectric and hydrocarbon projects in the region (Gallegos *et al.* 2019).

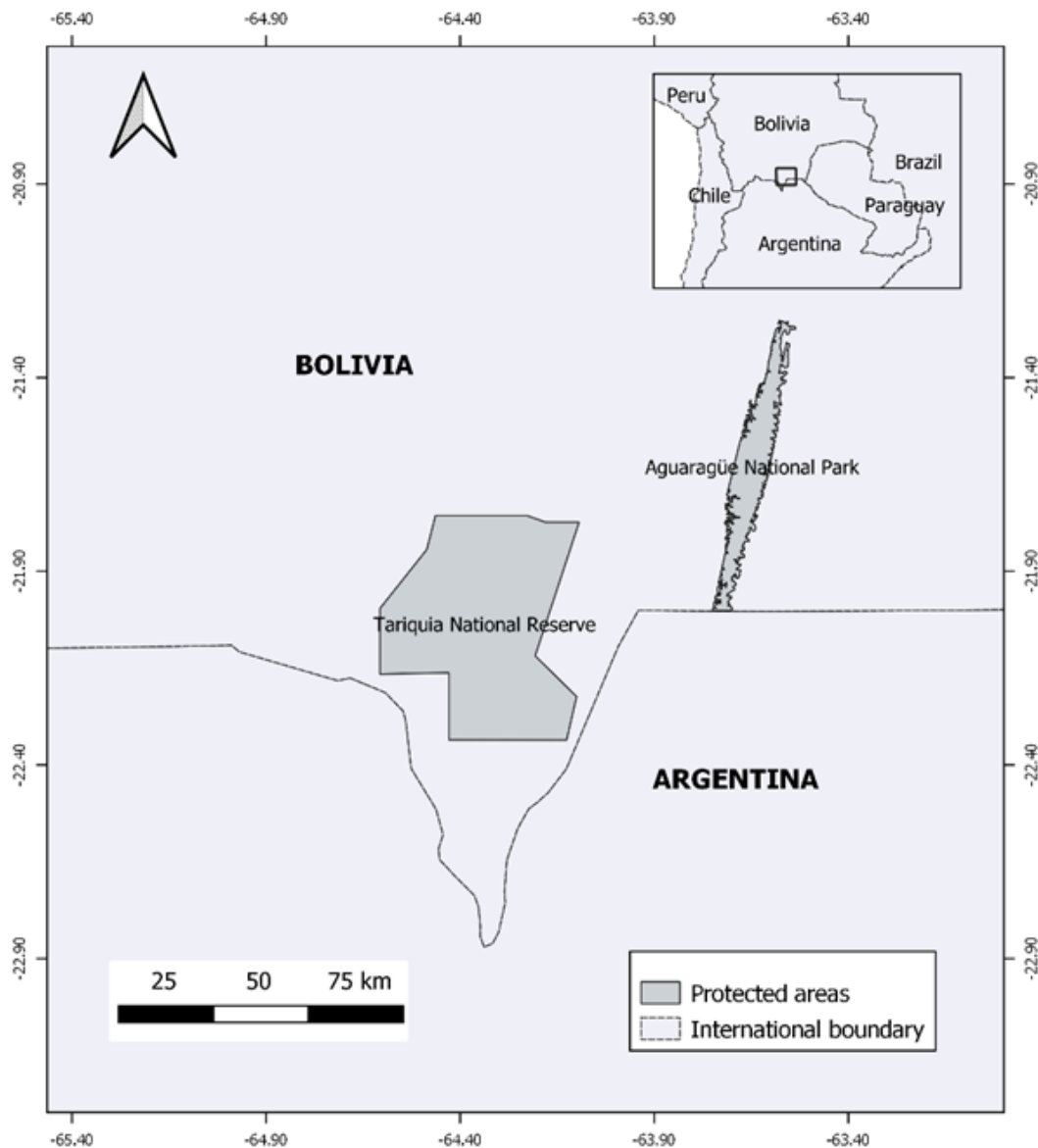
### Methods

We used a structured questionnaire in Spanish. All interviews were face-to-face and conducted by the first author accompanied by a local person. Open and closed questions addressed: (1) the profile of the interviewee (gender, age, occupation and level of education), (2) attitudes towards jaguars, (3) perceptions of jaguars, and (4) knowledge of the ecological role of jaguars.

The independent variables were: (1) education, coded according to the highest level of formal education reached by the interviewees (no school; elementary, 1st–7th grade; secondary, 8th–12th grade; university; (2) age (young, 16–25 years old; adult, 26–55 years old; older, >56 years); and (3) occupation, coded according to how the interviewees used most of their time and/or their main source of income (farming, university or school student, and tourism). As all interviewees whose main activity is agriculture combine crop and livestock farming, these two activities were considered together.

To determine attitudes and perceptions we asked a series of questions and categorized the responses within the range of options identified after the interviews were analyzed (Table 1). The justifications expressed by the interviewees regarding the level of support for the conservation of the jaguar in the region were classified in the following

categories: (1)- aesthetic considerations; (2)- legal restrictions on killing jaguars; (3)- personal safety and; (4)- attacks on livestock (See Table 1: Summary of questions and response variables used in the study).



**Figure 1.** Study area, within and around Aguara Güe National Park and Tariquia National Reserve.

Data were collected during January-February 2017. We interviewed people living in and around (<5km) the two protected areas, using a combination of snowball and random sampling. Snowball sampling technique is effective for facilitating access to populations or interest groups that may be challenging to reach (Atkinson & Flint 2001). To avoid bias we did not interview more than one member of any household. We carried out preliminary tests of the questionnaire and made any necessary revisions.

### Data analysis

To test our hypotheses and identify factors (level of education, age, occupation) that could potentially explain the response variables, we built a series of multinomial

logistic regression models for response variables with more than two categories, and a logistic regression model for binary responses. The Akaike information criterion (AIC; Akaike 1974) was used to evaluate the best model. The R (R Core Team 2017) package *net* was used for building multinomial logistic regression models, package *MuMIn* for model selection (Kuznetsova *et al.* 2015), and the *glm* function with a binomial family for logistic regression.

**Table 1.** Summary of questions and response variables used in the study.

	Questions	Responses	Justifications
Attitudes towards jaguars	Level of support of jaguar conservation in the region	Support No support Undecided	- Beauty, aesthetics or physical appreciation - It is illegal to kill them - Fear for personal safety - Attacks on livestock
Perceptions towards jaguars	Feelings about jaguar extinction	Sadness Happiness/Indifference	-
	Feelings about an encounter with a jaguar	Fear Happiness Indifference	-
Knowledge about jaguars	Identification of the ecological role that the jaguar plays in the ecosystem as predator (of natural preys, not livestock)	Correct identification Incorrect identification	-

## RESULTS

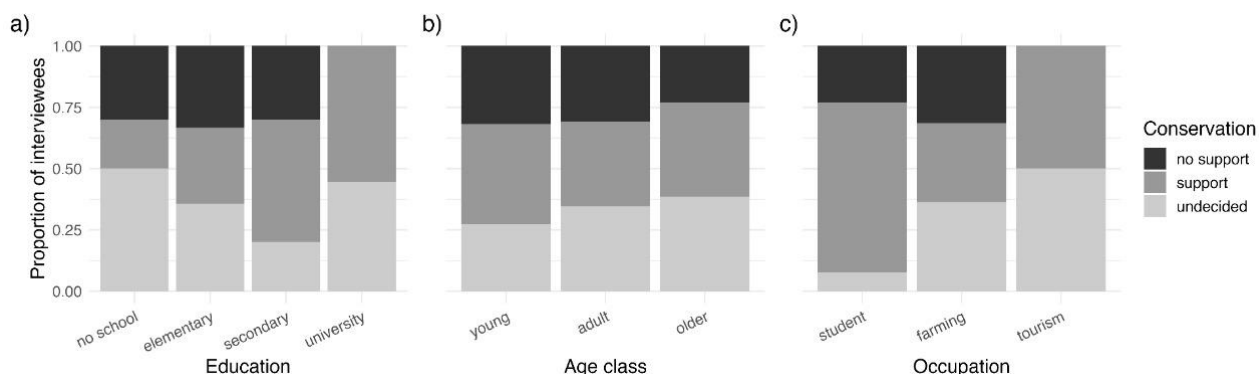
We surveyed a total of 139 people (TNR; n=35; ANP; n=104, Table 2). In general, 48% of the interviewees supported the conservation of jaguars because of their beauty, aesthetic value or physical appearance, and 6% because it is illegal to kill them. In contrast, fear for personal safety (35%) and attacks on livestock (11%) were among the justifications for not supporting their conservation. When asked about the role of the jaguar in the ecosystem, the majority (98%) did not mention anything that pointed toward its role as top predator of natural preys. Sadness at the possible extinction of the jaguar was the response of 46% of the interviewees, and 75% would be afraid of a possible encounter with a jaguar in the forest. The level of education and the occupation of the interviewees were important predictors of three of the four response variables, but not their age or gender.

**Support for jaguar conservation:** Occupation influenced the level of support (Appendix 1a), with students (69%) more likely to support the protection of jaguars (Figure 2c). Those in favor of conservation were better represented among students than among farmers (odds\_ratio<sub>student</sub>=10.13; p=0.03).

**Table 2.** Gender, age, level of education and main activity of interviewees in absolute numbers (N) and percentage.

Profile of the interviewees		N	Percentage
Gender	Female	72	52
	Male	67	48
Age class	Young	22	16
	Adult	104	75
	Older	13	9
Education	No school	10	7
	Elementary	90	65
	Secondary	30	22
	University	9	6
Occupation	Farming	124	89
	Student	13	9
	Tourism	2	1

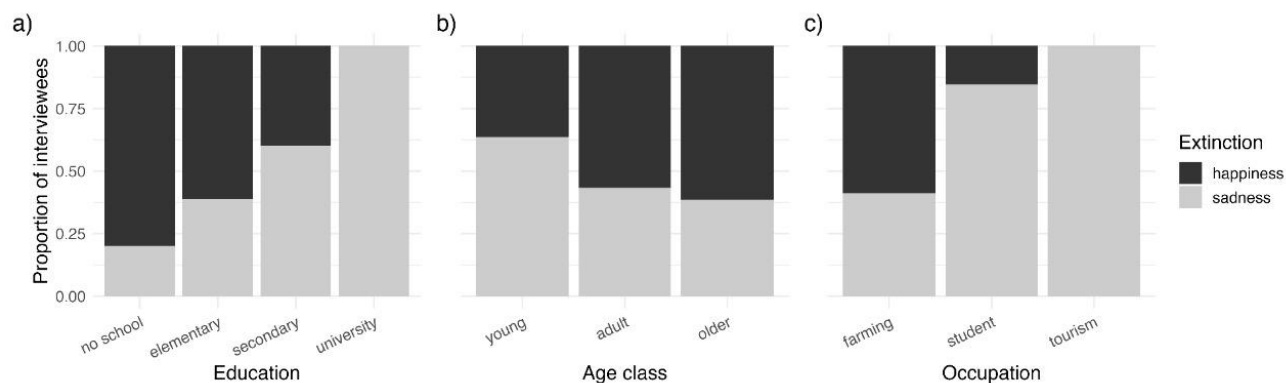
**Identification of the jaguar’s ecological role:** Only a handful (2%) of interviewees mentioned anything related to the role of jaguars as top predators in the ecosystems, affecting natural prey abundance. The rest did not recognize jaguars’ ecological role, regardless of their level of education, age and occupation, hence, no inferential analysis was conducted.



**Figure 2.** Relationships between the proportion of interviewees supporting jaguar conservation (Y axis) and independent variables a) education, b) age and c) occupation (X axis).

**Feelings about jaguar extinction:** The best model to predict feelings about potential extinction of jaguars was related to education and occupation (Appendix 1b). Although not statistically significant, there was a trend indicating that people with higher levels of education feel sadness at their possible extinction. All interviewees who had studied at university (100%) and more than half of those with secondary education (60%) responded that they were saddened at the possible extinction of the jaguar (Figure 3a). In comparison, the majority of interviewees with no schooling (80%) or with elementary education (61%) expressed indifference or happiness at the possible extinction of the jaguar. There was a higher proportion of adults (57%) and older people (62%) that

expressed happiness or indifference to the extinction of jaguars in comparison with young people (36%), although not statistically significant. Occupation was a significant predictor; sixty percent of farmers expressed happiness or indifference towards the extinction of jaguars (Figure 3c). The probability of a person feeling happiness at the possible extinction of the jaguar, was eight times higher among farmers (odd\_ratio<sub>farming</sub>=7.9, p=0.024) compared to students (Appendix 1b).



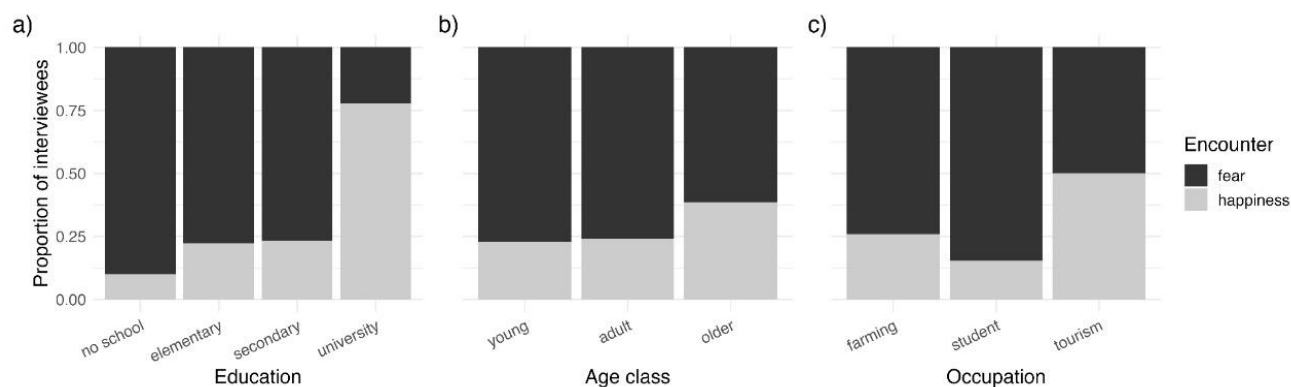
**Figure 3.** Relationships between the proportion of interviewees expressing feelings about jaguar extinction (Y axis) and independent variables of a) education, b) age and c) occupation (X axis).

**Feelings about encountering a jaguar:** Education and occupation of the interviewees were the main of predictors of feelings about encountering a jaguar (Appendix 1c). Most interviewees indicated they would feel fear if they encountered a jaguar. The likelihood that a person would feel happiness at an encounter with a jaguar was higher among those with university education than those with no formal education (odds\_ratio<sub>university</sub>=54; p=0.01; Figure 4a).

## DISCUSSION

We sought to address emotional, cognitive and socio-demographic factors that influence people's perceptions of jaguars in the most southerly area of its distribution. This is an important region for the conservation of the species, where protected areas are inhabited by indigenous and other traditional peoples. Thus, the conservation of the species depends in large part on local people's support. In general, we found that positive perceptions and attitudes towards jaguars were influenced by people's level of education, while negative perceptions and attitudes towards jaguars were influenced by fear, the occupation of the interviewees and lack of knowledge about the jaguar's ecological role.





**Figure 4.** Relationships between the proportion of interviewees expressing feelings about an encounter with a jaguar (Y axis) and independent variables a) education, b) age class and c) occupation (X axis).

Even though the sample size is small, our results show evidence in support of our two hypotheses: we found negative perceptions and attitudes towards jaguars among the majority of farmers, and those with lower formal education levels. Although the interaction with age was not statistically significant, more adults and older people showed negative perceptions and attitudes. Similar to previous studies, we found that people with higher levels of education support jaguar conservation and are saddened by the idea of jaguars becoming extinct (Caruso & Jiménez Pérez 2013, Caruso *et al.* 2020). This is in line with other studies showing that formal education can improve attitudes and increase tolerance levels toward large carnivores (Parker *et al.* 2014, Consorte-McCrea *et al.* 2017). However, the support for the conservation of jaguars seems to be based on aesthetics rather than knowledge, since most of the interviewees, even people with a higher level of education, were unaware of the jaguar's ecological role. Caruso *et al.* (2020), did not find a similar positive relationship between education and attitudes and perceptions towards jaguars in northern Argentina, instead, support for jaguar conservation was related to the economic benefits that people might receive from the presence of the species, such as ecotourism.

While most of the literature on human-wildlife interactions has focused on conflict (Bhatia *et al.* 2020), recent research indicates that attitudes towards carnivores are often related to social and cultural values that are rooted in traditional histories (Nattrass *et al.* 2020), thus, large carnivores may also have aesthetic value for local communities (Herrmann *et al.* 2013). In our study area, the fact that almost half of the interviewees expressed a feeling of sadness related to the extinction of the species indicates that there may be cultural values that could be potentially exploited to increase conservation support.

Throughout the species range, negative attitudes and perceptions towards jaguar among farmers are common (Castaño-Uribe *et al.* 2017), and are often attributed to loss of livestock and the resulting economic cost (Arispe *et al.* 2009, Porfirio *et al.* 2016, Negrões *et al.* 2017). However, other studies have also reported negative perceptions towards jaguars in contexts where jaguar predation on livestock was not considered a

problem, such as in the Bolivian Amazon (Knox *et al.* 2019), Venezuela (Jędrzejewski *et al.* 2017) and Brazil (Cavalcanti *et al.* 2010, Negrões *et al.* 2017, Bredin *et al.* 2018). Thus, negative attitudes and perceptions are context-specific and have to be understood and addressed at a local level. In our study area, a small proportion of interviewees mentioned predation on livestock as a reason to not support jaguar conservation. Based on our observations, farmers lose livestock due to causes such as robbery or disease resulting from poor sanitation (Pers. obs.). Research is needed to assess perceived versus actual jaguar damage.

Emotions, such as fear for personal safety, reported by those interviewed in this study, when added to the lack of knowledge of the ecological importance of a predator, can increase negative social perceptions and, therefore, the persecution and killing of jaguars (Soto-Shoender & Main 2013). Studies conducted outside protected areas and on private properties in the Pantanal, Brazil show that jaguars do not usually pose a real danger to humans (Hoogesteijn *et al.* 2015), and unprovoked attacks on humans are remarkably rare (Perovic & Herrán 1998, Quigley & Herrero 2005, Altrichter 2006) compared to those by other felids like leopard (*Panthera pardus*), lion (*Panthera leo*) and tiger (*Panthera tigris*). Nevertheless, we found that, with the exception of students, most people were afraid of the prospect of meeting a jaguar in the forest. This fear is an emotion that coincides with the results obtained by Knox *et al.* (2019) in the Bolivian Amazon. This fear may be linked to a healthy respect for a large carnivore, or to the influence of popular beliefs of jaguars as human predators (Cuéllar & Noss 2014). Jaguars are the protagonist of many indigenous legends, where they are given supernatural qualities, which may in turn influence social attitudes (Cuéllar & Noss 2014). The underlying factors affecting fear need further investigation.

Considering the recent increase of illegal trafficking of jaguar body parts in Bolivia (Nuñez & Aliaga-Rossel 2017, IUCN 2020, Arias *et al.* 2021), and the negative attitudes of farmers towards jaguars reported in our interviews, the hunting of jaguars probably represents a significant threat to their survival in southern Bolivia. Although at the time of the study the hunting of jaguars for this illegal trade was not mentioned, this new threat is increasing rapidly and has the potential to impact negatively on jaguar populations in the country (Arias *et al.* 2021).

Conservation education increases knowledge and improves coexistence between people and big cats (e.g., Marchini & Macdonald 2012, Porfirio *et al.* 2016, Engel *et al.* 2017a). The lack of recognition of the jaguar as an important component of the ecosystem may be limiting the potential for coexistence as well as opportunities for local people to actively engage in conservation (Smith *et al.* 2014, Lute *et al.* 2016). This is arguably linked to inadequate efforts to communicate scientific results to the general public, and a dearth of environmental education programmes among the communities that coexist with jaguars.

In addition, considering the positive attitudes and perceptions of those dedicated to tourism, options developing more tourism should be explored as source of income that could be compatible with jaguar conservation. The prospect of seeing jaguars is an

attraction for tourism in the Ibera region of eastern Argentina significantly improved local support for jaguar conservation (Caruso & Jiménez-Pérez 2013).

## CONCLUSION

Our study provides a better understanding of attitudes and perceptions towards jaguars, and of the socio-economic factors that influence them in southern Bolivia. Although it has been suggested that a reduction in livestock predation can lead to a change in attitudes (Parker *et al.* 2014), our research suggests that predation reduction by itself, without addressing additional factors such as fear and low levels of knowledge about the species, is less likely to produce a substantial change in attitudes.

Case studies like this illustrate the complexity of human-carnivore coexistence, suggest that relationships between people and predators are not always obvious or predictable but are context-specific (Caruso *et al.* 2017). Jaguar conservation could be facilitated by education on its role in ecosystems so generating a change in popular attitudes (Ripple *et al.* 2014), while working with and strengthening those factors that lead to positive attitudes. Environmental education programmes aimed at improving appreciation and knowledge of jaguars should be considered at all educational levels, and could help improve attitudes towards wildlife in general and greater awareness and support of jaguar conservation in particular (Parker *et al.* 2014).

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Supplementary material:

**Appendix 1a.** Results of multinomial logistic regression model with “Support for jaguar conservation” as a response variable (Support, does not support and undecided) and Occupation (Student, tourism, farming) as a categorical predictor. Values are odds ratios (e.g., the exponential value of the logit coefficient).

Support for jaguar conservation			
		Does not support	Support
Occupation	Student	3.46	10.13**
	Tourism	0.00	1.13

Notes: \* $p < 0.05$ , \*\* $p < 0.01$

**Appendix 1b.** Results of binary logistic regression model with “Feelings about jaguar extinction” as a response variable (Happiness and sadness) and Education (No school, elementary, secondary and university) and Occupation (farming, student and tourism) as categorical predictors. Values are odds ratios (e.g., the exponential value of the logit coefficient).

Feelings about jaguar extinction		
		Happiness
Education level	Primary	0.39
	Secondary	0.36
	University	0
Occupation	Farming	7.86*
	Tourism	7.86

Notes: \* $p < 0.05$ , \*\* $p < 0.01$

**Appendix 1c.** Results of binary logistic regression model with “Feelings about an encounter with a jaguar” as a response variable (categories: fear and happiness) and the following categorical predictors: Education (No school, elementary, secondary and university) and occupation (farming, students and tourism).

Feelings about an encounter with a jaguar		
		Happiness
Education level	Primary	2.57
	Secondary	3.57
	University	54**
Occupation	Students	0.44
	Tourism	0.17

Notes: \* $p < 0.05$ , \*\* $p < 0.01$