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Research Letters

# Why some management practices determine the risk of livestock predation by felids in the Selva Maya, Mexico? Conservation strategies

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ABSTRACT

The conservation of large carnivores has been undermined in areas where livestock herding is conducted. Livestock becomes potential prey, leading to conflicts, which is one of the main causes of carnivore extinction. We analyzed the management practices and characteristics of the ranches, in the communities around Calakmul Biosphere Reserve, where livestock predation by large felids occurs. We interviewed ranchers about socioeconomic aspects, losses and livestock management. One hundred one ranches with predation cases were compared with 40 without predation. The ranches with cases of predation had more water sources, although more distant, as well as a greater proportion of forest area, compared with ranches without predation. Only 25% of ranchers reported attacks to the authorities and at least 50% opted to kill the predator to solve the problem. The availability of water near ranches or in low-risk areas, mainly during dry season, could be a measure to reduce the losses by predation. Other measures to reduce retaliation are necessary, in addition to the compensation, mainly related to management of livestock.



## Introduction

The conservation of large carnivores has been undermined in areas where livestock herding is conducted. In these areas the exploitation of natural resources is intensive and results in fragmentation of the habitat and hunting, which reduce the populations of potential prey for carnivores (Stahl et al., 2002; Polisar et al., 2003; Woodroffe et al., 2005; Kolowski and Holekamp, 2006). Another perturbation is the introduction of domestic animals that transmit diseases to the wildlife and, in the case of livestock, becomes potential prey for wild predators. This encourages their hunting, which is one of the main causes of carnivores extinction in the world (Ogada et al., 2003; Inskip and Zimmermann, 2009; Zarco-González et al., 2012; Zarco-González et al., 2013).

Livestock predation has been associated with management practices in studies carried out in Namibia (Marker et al., 2003), Kenya (Ogada et al., 2003), Botswana (Gusset et al., 2009), Brazil (Mazzolli et al., 2002; Conforti and Azevedo, 2003; Michalski et al., 2006; Lopes et al., 2015: Tortato et al., 2015), Slovenia (Van Liere et al., 2013), India (Karanth et al., 2013), Nepal (Aryal et al., 2014) and Cameroon (Van et al., 2007). Some authors have mentioned that improvement in livestock management can contribute to the conservation and recovery of large carnivores (Ogada et al., 2003; Van et al., 2007; Gusset et al., 2009). High levels of livestock losses are related with extensive management and lack of vigilance; while the presence of shepherds, dogs and sheltering livestock in corrals overnight, are potentially effective techniques for the mitigation of predation (Jackson et al., 1996; Ogada et al., 2003; Wang and Macdonald, 2006). In Mexico there are studies that address the impact of livestock predation by puma (*Puma concolor*) and jaguar (*Panthera onca*) and its relationship with environmental

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variables (Chávez and Zarza, 2009; Zarco-González et al., 2012; Zarco-González et al., 2013) however, there are no analyses of the management practices applied in sites where livestock predation occurs.

The Calakmul Biosphere Reserve (CBR), located in Yucatán Peninsula, in the southeast of Mexico, is a priority region for the conservation of jaguar in the country (Rodríguez-Soto et al., 2011) and it is part of the region known as Selva Maya, the largest continuous rainforest in Mesoamerica. Livestock herding was encouraged in this area in the 1980s with support of government programs, however it has not developed widely due to water scarcity. Even so, livestock herding and agriculture are the main causes of habitat fragmentation (García and Pat, 2000; García-Frapolli et al., 2009).

Around 80% of the potential habitat for jaguar in the Yucatán Peninsula is outside the protected areas, on lands of private or communal property, where extensive livestock herding is practiced (Chávez and Zarza, 2009). The high demographic growth rate in the region and the inadequate livestock management have contributed to the conflict between ranchers and felids, mainly around the reserve, where predation has occurred (Chávez and Zarza, 2009) and at least 30 jaguars are hunted per year (CONANP, 2008). The aim was to analyze the management practices and characteristics of the ranches, in the communities around CBR, where livestock predation by puma and jaguar occurs. Practices related to predation risk were identified, and cost-effective livestock management strategies are proposed to reduce the cases of predation and thus contribute to felids' conservation and ranchers' economic well-being in this region of Selva Maya.

## Materials and methods

### *Study area*

The Calakmul Biosphere Reserve, enacted in 1989, is the largest tropical protected area in Mexico (7231.85 km$^2$, Galindo-Leal et al., 2000). It is located in the southeast of the State of Campeche (Fig. 1). The climate is tropical sub-humid with summer rains, the mean annual temperature is 24.6 °C and the mean annual precipitation is 1076 mm; elevation varies from 100 to 365 m.a.s.l. (INEGI, 1996). In this region the vegetation types are: tropical rainforest, tropical deciduous forest, savannah and hydrophytes (tular, reedbed, popal; Martínez and Galindo-Leal, 2002). Subsistence agriculture and livestock herding, logging, hunting, apiculture and chicle exploitation are the main economic activities.

### *Collection and analysis of data*

During 2011 we interviewed ranchers in communities bordering the Calakmul reserve. Each respondent was informed of the aim of the study prior to a single interview, which was based on a questionnaire that included: general information about the rancher, socioeconomic aspects, management practices and livestock losses. Only the losses that occurred in the five years prior to the interview were analyzed, this period has been the maximum that has been used in other studies with the aim to increase the likelihood that the informants remember responses accurately (Zhang and Wang, 2003; Kretser et al., 2009; Engeman et al., 2010; Soto-Shoender and Guiliano, 2011; Václavíková et al., 2011). Data from each interviewed rancher was considered an independent data. Some ranchers were interviewed at home, in other cases interviews were held during meetings of the local livestock association or in meetings organized by PRONATURA A.C., a civil association dedicated to environmental issues.

During 2011 we verified reported attacks in situ, the carcasses were examined as per Hoogesteijn (2001) and Shaw et al. (2007) to determine the cause of death. It was considered that the cause of death was predation when the following evidences were presented: if there were tracks, scat, bites to the throat or neck, or dragging. These evidences were also considered to validate the descriptions made by the interviewees. Also during the year of field work (2011), camera-traps were placed in 17 ranches, in which the most recent cases of predation had reported by the ranchers, the total sampling effort was 816 trap-days. Since the aim of the camera-trapping was to validate the information provided in the interviews regarding the presence of felids in the ranches, no bait was used in the camera-traps. The presence of the felids in the ranches did not imply predation, however, their detection with the cameras was another element (in addition to the information obtained in the interviews), to determine the validity of the data provided by the ranchers.

Eighteen variables were used to characterize each ranch (Table 1): number of domestic animals (divided by species, sex and class of age), the proportion of hectares of forest and crops, number of sources of water, both permanent and temporal (i.e. those present only during the rainy season). The variables of distance to temporal water sources, permanent water sources, streams, ranch to forest and ranch to reserve were estimated by interviewees. However, when this estimate was greater than one kilometer, the distance was verified in satellite images on Google Earth, for the year 2011. To observe the water sources that could be covered with vegetation, we used the topographic maps of the area generated by the Institute of Geography and Statistics of Mexico, available in vector format in the web.

Factorial analysis was applied to identify the variables that determine the structure of data. Previously, we verified the data matrix was suitable for this analysis with the Kaiser–Meyer–Olkin sampling adequacy measure (KMO, Kaiser, 1974) and Bartlett's test of sphericity (Bartlett, 1954). Were retained only the factors whose eigenvalues were higher than 1.0, according to the Kaiser criterion. Factorial analysis was run with the method of principal component extraction with varimax rotation. The factor scores were compared with a Student's *t* test between the interest groups (i.e. ranches with predation and ranches without predation). The quantitative variables were compared with a Mann–Whitney *U* test and categorical variables were compared with contingency tables and xi$^2$ test. All the analyses were carried out with a significance level of $p < 0.05$ in Statistical Package for the Social Sciences (SPSS).

## Results

### *General information about respondents*

A total of 141 interviews were conducted in 41 communities of four municipalities: Calakmul, Champotón, Escárcega and Hopelchén. Of the informants, 75% were men, aged from 21 to 78 years, with an average of 47.7 ± 12.3 years. The 29.8% belong to a livestock herding association and 24% are natives and the not natives had an average time of residence of 27.7 ± 9.4 years. The level of education of 56.75% of respondents was primary school; 22.7% high school and 17% had no formal education. The family size is on average 5 ± 3 individuals.

### *Livestock losses and management practices*

The total extension of the ranches included in the study was 10,195 hectares, each ranch had an average size of 73 hectares, the area of the polygon delimited by the most external ranches was 8828 km$^2$, 33% of this area was within the CBR. The most common species of livestock were sheep with 4103 animals (average = 47.2 ± 37.8 animals/ranch) and cattle with 2484 animals

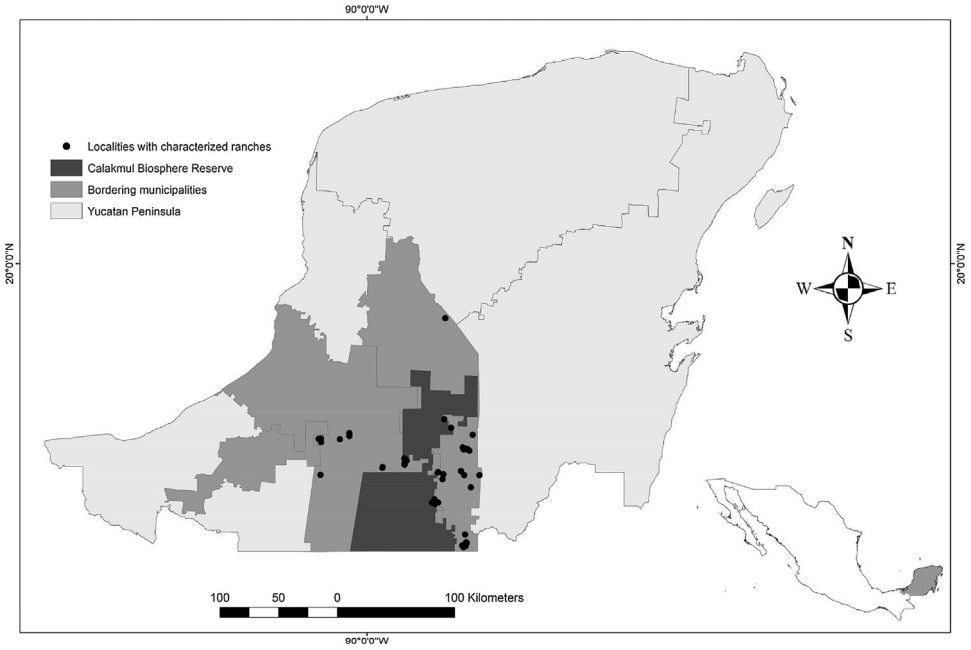


**Fig. 1.** Calakmul Biosphere Reserve and bordering municipalities: Calakmul, Champotón, Escárcega and Hopelchén. The black points are the locations of the characterized ranches.

**Table 1**
Analyzed variables in each ranch in communities bordering the Calakmul reserve during 2011. Matrix of rotated components, the most important variables of each component are distinguished.

| Variable | Component | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Total sheep | **0.87** | −0.11 | 0.05 | 0.02 | −0.03 | 0.02 | 0.03 | −0.05 |
| Total cattle | −0.53 | 0.26 | −0.01 | 0.12 | 0.57 | 0.18 | 0.13 | −0.27 |
| Total goats | 0.03 | 0.01 | **0.93** | 0.01 | −0.06 | 0.06 | 0.02 | 0.19 |
| Total pigs | −0.04 | 0.03 | −0.03 | **0.84** | 0.10 | −0.08 | 0.01 | 0.35 |
| Hectares of forest | 0.11 | **−0.97** | 0.01 | 0.02 | −0.08 | 0.04 | −0.01 | −0.01 |
| Hectares of crops | −0.08 | **0.96** | −0.06 | −0.01 | 0.11 | −0.02 | 0.03 | −0.01 |
| Distance to permanent water sources | 0.04 | 0.01 | −0.10 | −0.07 | **0.78** | −0.01 | −0.02 | 0.13 |
| Distance to temporal water sources | −0.10 | −0.13 | −0.08 | −0.04 | −0.10 | −0.05 | **0.85** | 0.07 |
| Distance to streams | 0.03 | 0.01 | 0.25 | 0.14 | 0.10 | 0.20 | 0.08 | **0.77** |
| Ranch-rainforest distance | 0.05 | 0.08 | −0.00 | −0.03 | 0.05 | **0.79** | −0.15 | −0.05 |
| Ranch-reserve distance | −0.19 | −0.16 | 0.02 | −0.09 | −0.09 | 0.68 | 0.15 | 0.25 |
| Number of dogs | 0.19 | −0.06 | 0.17 | 0.57 | 0.01 | 0.36 | 0.01 | −0.42 |
| Number of permanent water sources | −0.05 | 0.09 | 0.02 | 0.10 | **0.76** | −0.05 | 0.02 | 0.01 |
| Number of temporal water sources | 0.20 | 0.27 | 0.14 | −0.01 | 0.25 | 0.00 | 0.68 | −0.03 |
| Offspring/year cattle | −0.44 | 0.32 | 0.01 | 0.06 | 0.47 | 0.15 | 0.20 | −0.37 |
| Offspring/year sheep | **0.92** | −0.01 | −0.03 | −0.01 | −0.01 | −0.05 | 0.04 | −0.01 |
| Offspring/year goats | −0.01 | −0.06 | **0.94** | 0.04 | −0.03 | −0.04 | −0.01 | −0.00 |
| Offspring/year pigs | −0.04 | −0.03 | 0.02 | **0.87** | −0.01 | −0.11 | −0.06 | −0.06 |

(average = 37.1 ± 24.2 animals/ranch). The most frequent aim was trade, including the sale of meat, milk or animals for breeding (75%), 25% of the respondents used livestock for subsistence.

The main cause of losses was predation, for which 1030 animals were lost, compared to 641 that died from diseases, the species depredated in 55% of the cases were sheep. The predators listed by respondents were jaguar (64% of cases) and puma (28%), in 30% of the cases mentioned both species when asked about predators that causes damages in their propriety. Most predation losses occurred at night (71.91%), mainly in the forest (56.17%) and grasslands (40.44%). When livestock deaths occurred, 31.46% of ranchers used the carcass to attract and kill the supposed predator, while 29.21% burned it. The majority (74.15%) of respondents took their own measures to prevent or mitigate the damage caused by predators, mainly hunting or poisoning (49.43%) them, while others moved the livestock away from the site of attack (33.7%).

*Characteristics of the ranches with predation and variables related to the risk*

KMO test indicated that the factorial analysis was adequate, with a value of 0.54. Likewise, Bartlett's test of sphericity was significant ($p < 0.0001$). According to the factorial analysis, eight components explain 77% of the variance. The most important variables in the different components were the total number of sheep; the number of offspring per year of this specie (component 1); proportion of hectares of forest and crops (component 2); the total number of goat adults and offspring (component 3); the total number of pig adults and offspring (component 4); distance to and number of permanent water sources (component 5), distance from ranch to forest (component 6); distance to temporal water sources (present only during the rainy season, component 7); and distance to permanent streams (component 8, Table 1).

**Table 2**
Variables statistically different between ranches with and without predation.

| Variable | Without predation | ($n$ = 40) | With predation | ($n$ = 101) |
|---|---|---|---|---|
| | Mean | Standard deviation | Mean | Standard deviation |
| Distance to temporal water sources (m)[a] | 763.3 | 983.7 | 1847.7 | 3377.3 |
| % of hectares of forest[a] | 41.7 | 28.8 | 51.5 | 27.5 |
| Number of temporal water sources[a] | 0.3 | 0.5 | 0.5 | 0.8 |
| | *Percentage of ranches* | | | |
| Free grazing[b] | 12.5 | | 41.6 | |
| With corrals[b] | 52.5 | | 42.6 | |

[a] For continuous variables, we show the mean and standard deviation of each.
[b] For categorical variables show the percentage of ranches in each category.

A total of 101 ranches with predation events where identified based on interviews, verification of predation events during 2011 ($n$ = 8) and occurrence of predator trough camera traps ($n$ = 10). Differences in scores of variables was only significant in component 7, so the variables that differs between ranches with and without predation ($n$ = 40) was distance to temporal water sources ($t$ = −2.46, d.f. = 139, $p$ < 0.05, Table 2).

The ranches with predation had a greater proportion of hectares of forest ($U$ = 2390, $p$ < 0.05) and more temporal water sources ($U$ = 2671.5, $p$ < 0.05) compared with ranches without predation (Table 2).

Regarding the variable of free grazing livestock, in the group of ranches with predation, this type of management was presented in 41.6%, which is a high percentage compared to 12.6% in the group of ranches without predation ($x^2$ = 18.9, d.f. = 1, $p$ < 0.05). On the other hand, in the group of ranches with predation, 42.6% had corrals, that is, less than in the case of ranches without depredation (52.5%, $x^2$ = 16.6, d.f. = 1, $p$ < 0.05, Table 2).

## Discussion

In addition to the problems of deforestation and the resulting loss of habitat in Calakmul Biosphere Reserve (García and Pat, 2000), livestock herding which coincide spatially with the habitat of the jaguar in the region, are conditions that lead to a conflict of interest with ranchers due to predation, threatening one of the most important populations of jaguar in Mexico (Rodríguez-Soto et al., 2011). In the study area, predation caused the loss of 3% of the livestock annually, however, the impact is often overestimated by the ranchers (Holmern et al., 2007; Gusset et al., 2009; Zarco-González et al., 2012).

Ogada et al. (2003), has shown that in many cases there is a direct relationship between the frequency of cases of predation and the number of predators hunted in retaliation. Identifying livestock management practices that can help to decrease predation can also mitigate jaguar killings. Some studies in other sites have analyzed the influence of management practices on the risk of livestock predation (Conforti and Azevedo, 2003; Marker et al., 2003; Ogada et al., 2003), however, practices and the specific conditions in which predation occurs are different at each site. Therefore it is necessary to analyze the particular patterns of each region to propose changes and potentially more effective strategies in each one. This is key in areas where the populations of felids are in a vulnerable situation, and where there is little information about their interactions with the human communities, as in the case of Selva Maya.

Thirty percent of livestock losses in Calakmul are due to diseases, which is a common problem in rural communities because of the lack of technical training and adequate management programs (Iftikhar et al., 2009). It is likely that, as it has been demonstrated in other areas (Dickman, 2008; Iftikhar et al., 2009), if time and resources are invested to improve sanitary management and decrease the number of animals that die from diseases, the productivity of ranches would increase, at the same time reducing the proportional impact of predation. Extensive management makes it difficult to accurately identify the predator species, in addition to the correct assessment of the causes of death. Despite the fact that respondents point to jaguar and puma as being responsible for most of the attacks, is important to note that, according to data from the livestock insurance in this zone, cases compensated for attacks by jaguar or puma is less than by feral dogs (SAGARPA, 2011).

The most of the attacks occurred during the night coinciding with that observed in other studies (Mazzolli et al., 2002; Ogada et al., 2003; Holmern et al., 2007; Zarco-González et al., 2012), this is relevant because, in cases in which small herds are managed, a feasible measure to reduce losses is sheltering the animals at night. On the other hand, the higher percentage of forest in ranches with predation might indicate that moving livestock away from forest areas can reduce the likelihood of being predated. It is important to modify the livestock herding to a semi-intensive system, using at least the nocturnal corrals that can help to reduce predation cases.

Livestock herding compared with agriculture in Yucatán Peninsula is less vulnerable to climatic conditions and is a mechanism of household saving. However, the environmental conditions are not adequate for this activity to be profitable. The optimal grazing index in the area is one adult animal per hectare per year (Bush and Geoghegan, 2010), which causes high rates of deforestation, mainly near floodable areas identified by locals as suitable for agriculture and grasslands (Porter-Bolland et al., 2007). These areas have been identified as with highest risk of livestock predation (Chávez and Zarza, 2009), which is evidenced with the greatest number of temporal water sources in the ranches in which attacks occurred. In these cases livestock grazes far of human settlements to find water, since in these ranches the distance to water sources was longer compared with ranches without predation. The scarcity of water during the dry season determines the distribution of livestock and wild prey, especially under the extensive management carried out. The availability of water near ranches or in low-risk areas, by placing artificial troughs, mainly during dry season, could be a measure to reduce the losses by predation (Patterson et al., 2004; Treves et al., 2004; Kolowski and Holekamp, 2006; Van et al., 2007).

It is important to emphasize that although the Yucatán Peninsula has received more attention from the livestock insurance to mitigate the impact of predation, only 25% of the ranchers reported the attacks to the authorities and at least 50% opted to kill the predator. Other measures, in addition to the compensation are necessary, mainly related to livestock management. Programs to mitigate predation should include preventive measures in the short and mid-term which consider technical training for ranchers to optimize their production, as well as the implementation of appropriately designed and located corrals. These measures will improve the economic well-being of local ranchers, reducing cases of predation and could reduce the number of hunted felids.

## Conflict of interest

Authors declare no have competing interests.

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