OBSERVATIONS AND PRELIMINARY TESTING OF JAGUAR DEPREDATION REDUCTION TECHNIQUES IN AND BETWEEN CORE JAGUAR POPULATIONS

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ABSTRACT

Due largely to their success in undisturbed areas, the conservation of large carnivores is tied to protected areas. However, because of their large area requirements, large carnivores – and their conservation – will also always be linked to areas outside of protected areas. Retaliatory killing of jaguars near reserves and in corridors between reserves threatens to severely decrease jaguar populations in protected areas and their corridors, thus decreasing the ecological viability of protected areas for the species. Resolving this conflict will allow jaguars to utilize the human-dominated landscape, provide opportunities for corridor conservation, and enhance the effectiveness of protected areas. We review methods to reduce depredation of livestock and prevent lethal control of jaguars. Approaches to mitigate conflict include insurance schemes, management of wild prey, and above all, improving livestock husbandry and management. Improvements that are recommended for specific problem farms and ranches might include electric fencing, night enclosures, designs for newborn holding pens, the use of guard animals, and partial herd immersion of creole cattle races or water buffalo. We describe multiple testing scenarios and results from throughout Latin America for reducing livestock depredation across protected areas and agricultural landscapes.

Key words: Jaguar, carnivore conflict, livestock conflict, Latin America

INTRODUCTION

The management and conservation of large carnivores is one of the most challenging wildlife conservation issues of our time. The global decline of large carnivores is tied to the direct hunting of carnivores and their prey, along with the loss and degradation of their habitat (Nowell & Jackson, 1996; Hilty et al., 2006; Foster et al., 2010; Estes et al., 2011; Ripple et al., 2014; Rabinowitz, 2015). Whether the loss of large carnivores is direct or indirect, and whether their loss is intentional or unintentional, the effect on the communities in which they were resident can have both immediate and long-term impacts (Estes et al., 2011).

Protected areas play an important role in the conservation of large carnivore populations by supporting a wild prey base and often providing refuge from direct persecution by people. However, large carnivores range widely, often beyond the boundaries of protected areas, where they may threaten livestock and thus face increased risk of lethal control (Mills, 1991; Woodroffe & Ginsberg, 1998; Payan et al., 2013). The backlash from human residents near the protected areas in such situations can be harmful to the conservation of the carnivore population in the protected area, and it can threaten the acceptance and purpose of the protected area by local communities, who are mostly engaged in

Jaguars still occur over more than 40 per cent of their historic range, and more than 50 per cent of that range is in or within 10 km of protected areas. Retaliatory killing of jaguars, due to their killing of livestock, is one of the most important threats to jaguar existence in Latin American ecosystems © S. Winter, Panthera

economic production unrelated to conservation (Treves, 2008). The resolution of this human-wildlife conflict issue is dependent on the development of strategies to decrease the conflict that carnivores create in the landscapes surrounding protected areas. In Latin America, there is a pressing need for solutions to conflicts created by jaguars (*Panthera onca*) in the landscapes surrounding protected areas.

Jaguars are the largest felid in Latin America. They currently exist over more than 40 per cent of their historic range (Rabinowitz & Zeller, 2010), much of which is encompassed within protected areas, or near them. In fact, our analysis, using the new IUCN range map for jaguars[1] and World Database on Protected Areas (UNEP-WCMC, 2014) indicates that just over 50 per cent of jaguar range is in protected areas or within 10 km of a protected area (Petracca et al., unpublished data). Thus, for both jaguars and humans, the mutually beneficial results of reducing jaguar–human conflict in and around protected areas can affect a large portion of Latin America. The most prevalent and direct source of conflict is between jaguars and livestock producers; most jaguars are killed in retaliation for livestock depredation, or the perceived threat of it (Rabinowitz, 1984; Marchini & Macdonald, 2012; Zarco-Gonzalez et al., 2013). The losses of these jaguars – particularly those that are resident in both the protected area and the surrounding multi-use lands – threaten the integrity of the natural communities of flora and fauna the protected areas are designed to protect. Other primary reasons for jaguar loss are habitat loss and opportunistic hunting (Nowell & Jackson, 1996).

In this paper, we address the questions surrounding jaguar survival in and around protected areas, particularly those landscapes in which livestock production is an important human activity. Using preliminary data from farms currently being monitored, plus a literature review, we attempt to offer solutions to jaguar depredation questions, especially as they relate to areas near protected areas. We also address two questions: what actions can be taken to reduce jaguar-livestock conflict, and how can these actions be facilitated by protected area managers?

METHODS

This paper is a summary of depredation solutions observed by the authors on more than 120 ranch sites, ongoing research on 30 ranches (in Belize, Costa Rica, Colombia and Brazil), and supporting data from additional publications (Rosas-Rosas et al., 2008; Salom

-Perez, unpublished; Foster, 2008; Hoogesteijn & Hoogesteijn, 2014[2]). Geographic variation was not considered to be an important influence in the assessment of solution effectiveness in the depredation solution observations; however, for the current assessment of the ongoing research on 30 pilot ranches, data on rainfall, vegetation composition, and additional physical and biological characteristics are recorded.

Data were compiled through two approaches. First, observations were made on ranches with and without jaguar depredation issues; some ranches were visited due to depredation activity; other ranches were visited because they were in important jaguar areas. Second, ranches with depredation histories were selected for application of livestock management modifications. Depredation activity after these modifications was monitored. In nearly all cases specific information on ranch operations were collected (e.g. number of livestock, water sources, forested area, fencing design, etc.) and this information was related to depredation incidents and observations of the area. Prior to 2008, a large amount of the data collected was collected opportunistically. For instance, a depredation increase or decrease was associated with some aspect of livestock husbandry; additional applications of that method produced similar results, and the method was termed successful. Since 2008, 30 ranches have been assessed and monitoring of depredation has taken place in a regular and systematic fashion. At the 30 ranches experimental applications include: electrical fencing on 12 ranches, night enclosures on 22 ranches, eight separate new-born enclosures, two ranches with creole cattle and two with water buffalo. Camera traps are deployed to detect the presence of jaguars and other predators.

RESULTS

To compile observations of depredation solutions, the findings of more than 120 ranch visits over a period of nearly twenty years were combined with monitoring data from the 30 ranches. From this compilation more than a dozen ranch modifications were tested and found effective in reducing jaguar depredation or were highly correlated with reduced jaguar depredation (see discussion). Preliminary results are supported of previous works of the authors (e.g. Hoogesteijn & Hoogesteijn, 2014) and others (Rosas-Rosas et al., 2008). Although data are still being collected, the 15 farms in Costa Rica, with electric fencing and night pens, experienced no depredation during the first two years of monitoring; six farms in Belize experienced no depredation over 15 months of monitoring, with guard animals and improved fencing; night pens in 14 Brazil farms took depredation from six events to one over a period of 18 months; and four farms using water buffalo or creole breeds (Costa Rica, Colombia, and Brazil) experienced no predation from herds monitored from six months to four years. All of the above farms had experience some level of jaguar attacks prior to the application of depredation remedies.

DISCUSSION

Results from currently monitored farms display high potential for reducing jaguar depredation. Although the list of activities that help reduce depredation is an extensive one, and the list is expected to become more extensive and more detailed, below a reduced set of activities that have been found to be particularly successful is presented. These individual activities still require further testing in a variety of conditions. What works in one environment, might not work in another (for instance, in our research, guard donkeys were inexpensive and very effective in preventing jaguar depredation in Belize, but in Costa Rica they were prohibitively expensive even for testing). However, the following were tested and found effective not only in the current research, but in previous work (e.g. Salom-Perez, unpublished; Foster, 2008; Hoogesteijn & Hoogesteijn, 2014).

- **Electric fences**

One of the most important and effective tools available to prevent predation by wild felids on cattle, sheep, pigs, goats and fowl, is the use of electric fencing specifically designed to repel predator attacks; we are currently monitoring seven farms that have had no depredation over two years; all of these farms had experienced depredation losses prior to the implementation of electric fencing. The specific designs of electric fencing applications appear to effect results. Scognamillo et al. (2002) used three strands at 30, 60 and 90 cm high charged with 3,000 volts as being less effective than when the system was charged with 4,500 to 5,000 volts; eight attacks occurred in the former design and no attacks occurred in the latter design.

Until now, the use of electric fencing has not been widely used as a predator deterrent in Latin America. More often, it has been used to keep domestic animals in rather than keeping wild animals out. It is very important to note that electric fences for livestock control, with one or two strands of electrified wire, prevents cattle from moving from one pasture to another, but is not effective in preventing predator attacks. Fences must be specifically designed to prevent the entry of jaguars. They

Electric fencing, even in very rudimentary forms, can be an effective deterrent to jaguar predation on livestock © Hoogesteijn & Corrales, Panthera

are therefore particularly useful when used in smaller areas, such as corrals used as night enclosures, or smaller pastures such as those used for late-stage pregnant cows or newborn calves and their dams. Electric fences have also been used to surround all the pastures of a farm, especially when small, or around areas known to be at high predation risk.

In the Venezuelan Llanos, Scognamillo et al. (2002) initially tested a design with three strands of electric wire. An 18 ha calving paddock with a 1,697 m perimeter was surrounded with strands arranged at 30, 60 and 90 cm from the ground. Strands were charged with 2,500 to 3,000 volts. Felines were however not deterred by this design. Subsequently, an additional negative strand was

added at 85 cm from the ground, and voltage was increased to 4,500-5,000 volts. With these modifications the attacks ceased.

Another trial was conducted in the Brazilian Pantanal (Cavalcanti et al., 2011). The fence consisted of two electrified wires at 25 and 50 cm in height with a 5,000 to 7,000 volts charge. The perimeter was approximately 14 km, enclosing several pastures. The fence was regularly checked to prevent leakages of energy or faulty wiring. Additionally, the fence and sleeping areas of the herds were monitored during the night by a ranch employee equipped with a powerful spotlight and explosive deterrents. This system was shown to be effective and decreased predation losses over several years. However, the results suggested that enclosing smaller pastures might have been even more effective.

- **Night enclosures**

A very effective action in areas with intense predation is to enclose domestic animals in corrals, pens or small pastures near human habitation during night time. If the night enclosure has lights or is located near human habitation with dogs, it is even more effective. These night enclosures can also be provided with electric fencing. The animals (whether cattle, pigs, sheep or goats) are easily habituated to enter the corrals. The action reduces predation impacts significantly but necessitates a slight increase in farm labour and operating costs. This action can also enhance animal nutrition because concentrated feed and supplements can be supplied within the enclosure.

These night enclosures have been tried in different sized farms and various ecological settings. For example, in Costa Rica, in the Nairi Awari Indigenous Reservation on the Talamanca Mountains, jaguars and pumas (*Puma concolor*) attacked and consumed domestic pigs that freely foraged in the forests. When enclosed at night, there was initially a significant decrease in attacks (from several in previous years plus a jaguar killed in retaliation), to zero attacks in the final year of the project (Salom-Pérez, unpublished data). Along with the pens bio-digesters were built to produce biogas from the faeces of the animals locked-in at night. The use of biogas eliminated the need to collect firewood, thus minimizing 'wood collection time' in exchange for 'pig collection time' and can reduce forest destruction in and around protected areas. Additionally this practice had the positive side effect of reducing harmful smoke exposure from the wood stoves (Salom-Pérez, unpublished data).

- **Control of breeding and protection of young**

One critical element that can be integrated with all of the solutions presented here is the control of breeding within livestock herds. The control of breeding is an essential starting point in the reduction of jaguar depredation. Despite the fact that jaguars can kill prey much larger than themselves (including adult cattle) smaller, younger individuals are particularly vulnerable. Controlling the time in which these individuals are present in the landscape helps managers improve their safety. Conversely, if breeding takes place year round, farmers are constantly attempting to secure and care for newly-born young. With the young, vulnerable individuals presenting themselves during one particular period of the year farmers can provide more easily for their safety in a more efficient and focused manner.

The most effective management strategy is to keep calves, calves and mothers and late-pregnancy livestock in special holding pens. Holding pens should not be pastures containing forested areas or be adjacent to forested areas (Cavalcanti et al., 2011). Cows should be placed in open pasture areas, and preferably close to human dwellings. This countermeasure is easily applied in small and medium-sized ranches, especially those that are well organized and have a 3-4 months breeding season, which limits the calving season to 4-5 months in the year. Added protection can be afforded through the use of electric fencing.

In Costa Rica, a combination of night enclosures and electric fences for birthing areas eliminated predation on young calves. This work was performed in twelve small experimental farms located at the Barbilla-Destierro Biological Sub-corridor and the San Juan–La Selva Biological Corridor (D. Corrales and Panthera Costa Rica Team, unpublished data).

- **Guard animals**

Guard animals can take several forms. They can be older animals within a herd, or they can be other species that are placed in the herd to prevent attack. Preliminary data from field experiments indicates that experienced older animals (bulls, steers or older cows with horns) will often confront predators, as evidenced by marks from injuries on these animals, sustained by felids. Therefore, a certain percentage of these animals should be retained in the herd. These animals teach defensive grouping behaviour to the younger animals thus reducing predation. Tortato et al., (in press) documented this on a ranch in the Brazilian Pantanal. The ranch had high frequency jaguar and puma predation. A larger proportion of older animals in the herds diminished losses. Between January 2006 and September 2010, 73 per cent of the deaths

A young boy leads goats into an enclosure for the night. These enclosures, if used properly, can reduce jaguar predation on a wide variety of domestic livestock © Hoogesteijn & Payan, Panthera

caused by jaguars and pumas happened when the proportion of adults in the herd was lower than 60 per cent. The authors (Tortato et al., in press) point out that this is a less aggressive alternative to predator removal or relocation that produces economic benefits in herd production.

Additional protection can be provided with guard animals. Guard donkeys (*Equus asinus*), grazing with herds of cattle, have been effective in reducing jaguar predation in Belize (S. Juan, pers. comm.) due to their aggressive braying and their tendency to confront threats. This experience is being tested experimentally, with promising preliminary results in Belize (R. Foster & Panthera Belize Team, unpublished data).

- **Creole cattle**

The majority of cattle in tropical America are zebu (*Bos indicus*) pure- or cross-bred with varying admixtures of European breeds (*B. taurus*) introduced into the Americas by Europeans in the 17th Century. Although high proportions of adults, especially males, in a herd of zebu can reduce predation (see above; due to size, awareness and defensiveness), the original European breeds (e.g. Nelore breed) retained a stronger, innate defensive response to threats. For example, cows have highly defensive reactions against predators and protect their newborn from attacks while zebu breeds stampede in the presence of a predator, leaving small calves alone, disoriented and prone to attack.

Several hardy breeds of *B. taurus* are however notable for their adaptation to New World wildlife, plants, parasites, etc. and in particular to the harsh conditions of the flooded savannahs of the Neotropics. Two of these are the Creole/Criollo Llanero and the Pantaneiro breeds, in the Colombian and Venezuelan Llanos and the Brazilian Pantanal, respectively. Most of these breeds have an inherent ability to defend themselves from predator attacks (Calzadilla Valdés, 2007), and demonstrate a gregarious herd behaviour similar to the one exhibited by the Asian water buffalo (described below). Most of these breeds however do not have the good carcass conformation for meat production demanded by modern markets. Consequently, they almost disappeared.

Experimental use of these breeds is currently underway to scientifically document their predation-deterring capabilities, along with their rescue and recovery for potential use in areas of high jaguar predation. Preliminary results indicate the Creole breed effectively reduced jaguar predation in herds totally made up of Creole cattle (San Martiniero breed, Colombia; no predation over a two-year period), in herds with only a percentage of Creole cattle (San Mariniero breed mixed herds, Colombia, no predation over two-year period; Pantaneiro breed mixed herds, Brazil, no predation over one-year period), and potentially in herds of first generation crosses (F1 offspring) of Creole cattle with

zebu cattle, thus enhancing carcass and meat quality and conserving the defensive traits. This latter experiment is still underway, attempting to produce increased meat production while observing if anti-predation behaviours are retained. First-generation offspring are displaying defensive behaviours when approached; depredation on these individuals, in paired comparisons with zebu breeds, will measure differences in field conditions.

- **Water buffalo**

The Asian water buffalo (*Bubalus bubalis*) originates from Southeast Asia and was domesticated nearly 5,000 years ago. Having evolved in the presence of a large predator, the tiger (*P. tigris*), they exhibit gregarious behaviour. When under a perceived threat, females form a circle around their calves, while the bulls walk around this circle, actively looking for predators. Buffaloes tend to graze in closed groups never straying far away from each other and aiding any member of the herd that calls in distress.

A study conducted in four Venezuelan ranches which held cattle and buffaloes together (Hoogesteijn & Hoogesteijn, 2008) compared predation mortality between the two species held in equal conditions. The results found that the likelihood of cattle being preyed upon by jaguars or pumas was 25 times higher than for buffaloes. Buffalo had the same protective reaction toward predator attacks, regardless of circumstances or management systems in which the herds were kept.

The use of water buffalo is expanding in the Llanos of Colombia and Venezuela. It is a more efficient and profitable species than cattle in flooded savannahs, or very moist environments, containing poor quality forage. Buffalo are highly desired for their gentleness when properly managed, plus their productivity, disease resistance, and defensive behaviour are all qualities which make them desirable over cattle. Their growth curve, fertility and longevity are also better than those of cattle under similar conditions. Although some management requirements of the species must be strictly adhered to (e.g. managing at or below pasture carrying capacity, providing regular contact so as to maintain docile temperament, etc.), dramatic reductions in jaguar predation can be obtained with both full and mixed herds of water buffalo. In Costa Rica, a group of six water buffalo were introduced to a ranch that had recently suffered attacks on livestock. In six months, no attacks have occurred in the mixed group of cattle and buffalo, while there have been two attacks in neighbouring ranches (D. Corrales, unpublished data).

- **Hunting management**

Human hunting of both jaguars and their prey can influence jaguar depredation. First, the indiscriminate and opportunistic hunting of jaguars can produce crippled individuals that are not able to hunt their natural prey, and thus they turn to the killing of livestock (Rabinowitz, 1986). Second, and more importantly, studies in several different environments have found a positive correlation between the overhunting of game species by humans and elevated levels of jaguar depredation (see Polisar et al., 2003). In areas where hunting is legal, strict enforcement of sustainable harvest is essential. Especially in areas of South America in which subsistence harvesting of wildlife is present, it might be necessary to prohibit hunting if the enforcement of harvesting quotas is not effective. Most importantly for jaguars, these restrictions should also be in place for such species as spectacled caiman (*Caiman crocodilus*), capybaras (*Hydrochoerus hydrochaeris),* peccaries (*Tayassu tajacu* and *T. peccary*) and pacas (*Agouti paca*).

CONCLUSIONS

The seven actions suggested above are those we (the authors) felt are most easily applied and most effective in reducing jaguar depredation, supported by the literature and on-going data collection. However, given the loss of jaguars due to retaliatory killing, and the effects of that killing on the integrity of protected areas, additional resources must be brought to bear to enhance known solutions, and new solutions. One critical element that integrates with all of the above is the control of breeding within the livestock herds, and is thus an essential starting point in the reduction of jaguar depredation. Despite the fact that jaguars can kill prey much larger than themselves, including adult cattle, smaller, young individuals are particularly vulnerable. Lastly, the application of the above findings will require outreach and education in the communities surrounding protected areas if human wildlife conflict related to jaguars is to be reduced and the acceptance of protected areas by communities enhanced (see Wells & Brandon, 1992). In all jaguar range countries, governments have the legal oversight of wildlife and natural resources, including jaguars. Likewise, the establishment and oversight of protected areas is also directed by government. Commonly, these two government responsibilities are under one government agency or institution. In addition, in most jaguar range countries, agricultural ministries oversee the health and production of livestock, especially herds that are supplying livestock products (e.g. meat, milk, etc.) to the general public. Involving all these government entities, and integrating their policies in anti

Asian water buffalo are an important alternative to domestic cattle in some areas of Latin America due to their ability to use marginal and wetland pastures, their productivity of meat and young, and their anti-predator defence behaviours that make them less vulnerable to jaguar predation than cattle © Hoogesteijn, Panthera

-predation activities is an important – if not essential – part of the long-term reduction of jaguar depredation in and near protected areas. Governments are becoming more aware of the pervasiveness of the jaguar-livestock conflict issue. At the same time, they are also becoming aware that the problem is not solved by the constant killing of depredating individuals. In addition, the growing ecotourism industry in Latin America (Wallace, 1993; Stonza & Durham, 2008) provides added economic incentives for maintaining complete assemblages of native vertebrates, including large predators. Foster (2008) analyzed the survival potential of jaguars in a Belizean landscape and found that the current two protected areas had the potential of supporting isolated jaguar populations, but the probability of all populations persisting for 100 years was approximately 50 per cent unless dispersers from the core protected areas exceeded 12 percent per year. Thus, these landscapes and the jaguar populations they support are dependent on the interactions between protected areas and the more human dominated landscape around them.

FOOTNOTES

[1] http://maps.iucnredlist.org/map.html?id=15953
[2] http://www.panthera.org/species/jaguar

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RESUMEN

Debido en gran parte a su éxito en áreas no perturbadas, la conservación de los grandes carnívoros está ligada a las áreas protegidas. Sin embargo, debido a su necesidad de superficies extensas, los grandes carnívoros –y su conservación– siempre estarán vinculados a zonas fuera de las áreas protegidas. La matanza en represalia de jaguares cerca de las reservas y en los corredores entre reservas amenaza con disminuir severamente las poblaciones de jaguares en las áreas protegidas y en sus corredores, con la consiguiente reducción de la viabilidad ecológica de las áreas protegidas para la especie. La resolución de este conflicto permitirá a los jaguares utilizar el paisaje dominado por humanos, deparará oportunidades para la conservación de los corredores, y mejorará la eficacia de las áreas protegidas. Examinamos los métodos para reducir la depredación de ganado y evitar el control letal de jaguares. Entre los enfoques para mitigar los conflictos cabe señalar los planes de seguros, la gestión de presas silvestres, y –sobre todo– la mejora de la cría y la gestión ganadera. Las mejoras que se recomiendan para problemas específicos en granjas agrícolas y ganaderas pueden incluir cercas eléctricas, recintos nocturnos, diseños de corrales para recién nacidos, el uso de animales de guardia, y la sumersión parcial de razas criollas de ganado o búfalos de agua. Describimos múltiples escenarios de prueba y los resultados de toda América Latina para reducir la depredación de ganado en áreas protegidas y paisajes agrícolas.

RÉSUMÉ

Due en grande partie aux succès remportés dans les zones non perturbées, la conservation de grands carnivores est associée aux aires protégées. Toutefois, en raison de leurs exigences de matière d'espace, la conservation de grands carnivores sera toujours liée aux régions à l'extérieur des aires protégées. L'abattage de jaguars, en tant que mesure de représailles, se passe à proximité des réserves et dans les couloirs entre les réserves et constitue une grave menace pour les populations de jaguar dans les aires protégées et leurs couloirs, diminuant ainsi la viabilité écologique des aires protégées pour l'espèce. Seule une résolution de ce conflit permettra aux jaguars de se déplacer à travers les territoires dominés par l'homme, ouvrira la possibilité de mesures de conservation dans les couloirs et renforcera l'efficacité des aires protégées. Nous examinons les méthodes permettant de réduire la déprédation du bétail et empêcher le contrôle létal de jaguars. Les conflits humains-faune peuvent être gérés grâce à des approches variées tels des systèmes d'assurance, la gestion des proies sauvages et surtout l'amélioration des techniques d'élevage. Certaines améliorations recommandées pour les fermes et les ranches sont, par exemple, des clôtures électriques, des enclos de nuit, des enclos d'hébergement pour nouveau-nés, la présence d'animaux de garde, et l'incorporation partielle du bétail créole ou des buffles d'eau à l'intérieur de troupeaux. Nous présentons les résultats de plusieurs tests en situation réelle à travers l'Amérique Latine destinés à réduire la déprédation du bétail dans les aires protégées et les terrains agricoles.