Chapter 16
Use of Electric Fencing and Associated Measures as Deterrents to Jaguar Predation on Cattle in the Pantanal of Brazil

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Introduction

As top predators, jaguars, *Panthera onca*, constitute an important component of the megafauna of the Neotropics. Like other large carnivores, they require vast areas of relatively wild habitat and a stable prey base. Therefore, their populations are often restricted to protected areas or inhospitable, remote areas where human densities remain low. The Pantanal, a seasonally inundated plain of over 140,000 km^2 in the centre of South America is one such place, harbouring abundant wildlife and being considered of high importance for the long-term persistence of jaguars (Sanderson et al. 2002). Nevertheless, cattle ranching has been a traditional activity for over 200 years in the Pantanal, and the region harbours the largest beef cattle herd of Brazil (IBGE 2009). As in other areas of the world where large carnivores coexist with domestic animals (Fritts et al. 1992; Mizutani 1993; Srivastav 1997), this proximity between cattle and jaguars results in conflict with ranchers that makes it one of the greatest causes of mortality for the species, throughout its range (Sanderson et al. 2002).

Under certain conditions, jaguars will kill livestock (Schaller and Crawshaw 1980; Schaller 1983; Crawshaw and Quigley 2002; Crawshaw 2003; Azevedo and Murray 2007; Cavalcanti and Gese 2010). Therefore, despite other cultural factors (Amâncio et al. 2007; Cavalcanti et al. 2010), jaguar predation on livestock may pose a real economic predicament to ranching operations and significantly contribute to the conflict with ranchers and ranch hands, leading to retaliatory killing

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(Cavalcanti and Gese 2010). For this reason, livestock depredation is an important issue to be resolved in jaguar conservation.

Throughout the world, there has been an increased interest in the use of non-lethal methods of depredation control (Shivik 2000; Shivik et al. 2003). These methods range from the traditional management practices, use of guard animals and exclusion methods to the more recent use of chemical repellents and aversive agents, to the rapidly growing technology of visual and acoustical stimuli (Koehler et al. 1990; Andelt and Hopper 2000; Shivik 2006). Examples of these later methods include devices with movement detection sensors, strobe lights, sirens, bells, recorded distress calls, scarecrows, loud music or noise from radios, propane exploders, fladry and electronic training collars (Koehler et al. 1990; Linnell et al. 1996; Shivik 2006). Such practices are viewed as humane, practical and with a potential to minimise problems without necessarily removing the predator. Despite these new advances in the field of predation management, information regarding the use of such devices in Brazil is scarce and to protect their livestock, ranchers still resort to the use of tools they have used for many generations.

The use of electric fences to deter terrestrial predators was first reported by McAtee (1939). Their use has been tested as deterrents for several species of predators such as coyotes (*Canis latrans*), wolves (*Canis lupus*), bears (*Ursus arctos*), and lynx (*Lynx rufus*; Acorn and Dorrance 1994; Levin 2002; Mertens et al. 2002). In general terms, fencing may be more viable for protecting smaller herds (or flocks) of livestock in smaller pastures, as opposed to large open ranges, particularly arid ranges, where they typically spread out in search of food and water. However, it would be desirable if fences provided a reliable, economical way to decrease predation on cattle in field conditions in the Pantanal. In this chapter, we describe the use of an electric fence in a large cattle ranch in the Pantanal as a method to deter predation from jaguar. In addition, we describe the trials we conducted to assess the use of electric fences as a deterrent for jaguars and pumas, *Puma concolor,* in captive situations.

Study Area

Evaluation of Electric Fences as Jaguar Deterrent in Field Conditions

The use of electric fences in field conditions was implemented in the Santa Tereza ranch (18° 18′ 38″ S; 57° 30′ 10″ W), located in the municipality of Corumbá, on the westernmost region of the Pantanal, Mato Grosso do Sul state, Brazil. The ranch, 63,000 ha in size, encompassed a high diversity of habitats, from the open water of the Baía Vermelha on the border with Bolivia, to cerrado (open shrublands) and flooded areas, to mountain tops at about 900 m, on the southern extension of the Serra do Amolar mountain range (Fig. 16.1).

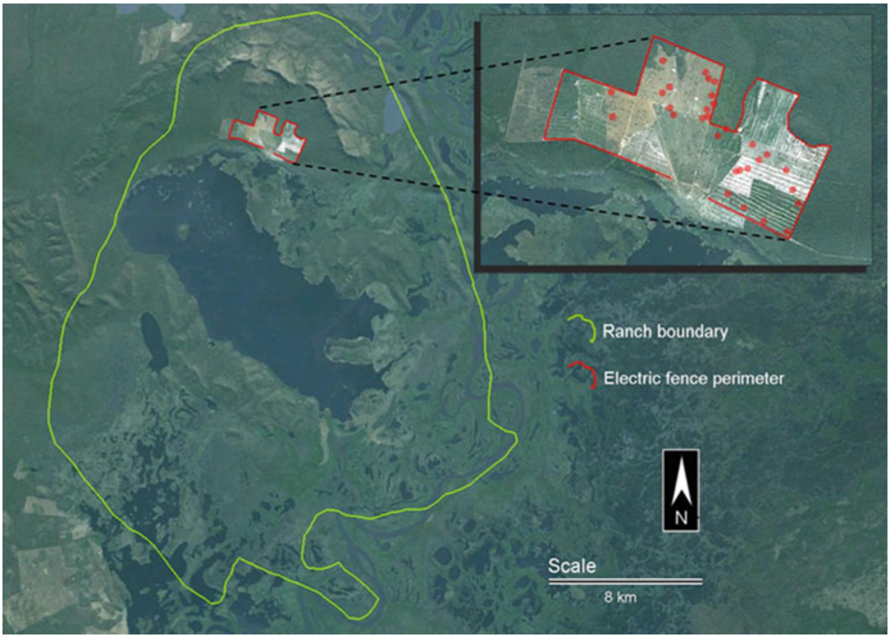

Fig. 16.1 Santa Teresa ranch, Corumbá, MS, Brazil. Most of the area is characterised by open range, with the big Baía Vermelha (lake) in the central portion and the Serra do Amolar mountain chain encircling the area from the west to the northeast. The area in the detail is 900 ha of introduced grasses and surrounded by electric fence. The red dots are locations of jaguar kills within the enclosed area

The ranch was purchased by the current owners in early 2006 and included a herd of 1,300 cattle in a semi-feral state, which grazed the open range for most of the year and spent the wet period in the shrublands above flood level. During the first year, the owners rebuilt/restored fences and recuperated about 900 ha of pasture land that had been opened and planted by the original owner but was kept without the regular grazing of cattle in recent years (R. Jank, pers. comm.). These 900 ha of overgrown pasture mostly comprise brachiaria grass, *Brachiaria humidicola,* and islands of colonião grass, *Panicum maximum*. Characterised by dry ground above flood level, this area was divided into 12 pastures of approximately 75 ha each, to manage the different age/classes of a cattle herd of 2,000 head (Fig. 16.1).

The cattle business was characterised by a beef cattle fattening operation, with the vast majority of the herd comprising heifers of up to 350 kg (78%). Cattle management was divided into two distinct phases according to the drought and flooding cycles, characteristic of the Pantanal. During the floods (mid-February through August), the cattle herd was confined in these 900 ha of high ground pastures. In the drought period (September to mid-February), about 80% of the herd was released into the lower areas of the ranch, where they found large extensions of native grasses.

After an initial bout of recurrent predation, where nice head of cattle were killed in 11 days in February 2007, the owners of the ranch contacted the authors to request assistance with the problem. In contrast with the predominant attitude among ranchers in general, they expressed concern regarding jaguar conservation and sought to reduce the conflict and economic losses to an acceptable level.

Responses of Jaguars and Pumas to Electric Fences in Captivity

As a complement to the field data presented in this chapter, we conducted trials to assess the efficacy of electric fencing as a deterrent for jaguars and pumas, in two zoological parks in the state of São Paulo. The zoos were the Parque Zoológico Quinzinho de Barros (23°30′23.28″ S, 47°26′11.68″ O), in Sorocaba, where we assessed the behaviour of two jaguars (one male and one female) and three pumas (one male and two females), and the Parque Zoológico de Guarulhos (23°26′33.77″ S, 46°33′11.90″ O), in Guarulhos, where we assessed the behaviour of two jaguars (one male and one female) and one puma (male). In the Sorocaba Zoo, animals were kept in a circular enclosure divided into four segments, which encompassed an area of approximately 156 m^2 each (front: 23.85 m, back: 7.95 m, sides: 10.60 m each, and height: 2 m.). In the Guarulhos Zoo, enclosures measured 13.7×4.7×4 m, encompassing an area of approximately 65 m^2. In both zoos, with the exception of the male puma in the Guarulhos zoo, all the other study animals lived together with conspecifics within the enclosures and were fed once a day.

Methods

Evaluation of Electric Fences as Jaguar Deterrent in Field Conditions

In February 2008, existing conventional livestock fences on the perimeter of the pasture area (13,745 m) were retrofitted with two electrified wires at heights of 25 and 50 cm from the ground. These additional wires, powered by solar panels (Duboi, Campo Grande, MS, Brazil) installed near one of the extremities of the fence, were external to the conventional fences, which had five non-barbed wires at heights of 25, 50, 75, 100 and 125 cm. The electrified wires did not complete the entire perimeter of the external fence. About 630 m of the fence, near the ranch headquarters were not electrified (Fig. 16.1). The voltage used in the fence ranged from 5,000 to 7,000 V. The fence was checked by the ranch foreman on a weekly basis. Whenever the voltage was detected to be low, the entire perimeter of the fence was verified to identify and clean branches or other material that could be isolating the system.

The use of electric fences was accompanied by additional preventive measures. Night-time surveillance of the different pastures was achieved through the use of a tractor and a strong light beam. A ranch hand visited different cattle bed sites throughout their surveillance period, and whenever a group of cattle was observed to be uneasy (i.e. the presence of a cat nearby was suspected), fire crackers were lit up and fired in the direction of the closest forest fragment.

We accompanied ranch hands in their daily activities on horseback, searching for carcasses of cattle killed by jaguars or killed by other causes, monitoring jaguars through sightings and other indirect methods (i.e. tracks and scats). Coordinates of these events were recorded using a global positioning system (GPS; Garmin 12 XL, Garmin International, Inc., Olathe, KS). Sightings of mammalian native species were also noted, with date, time and coordinates recorded.

In addition to accompanying the ranch hands in their daily activities, additional daytime surveillance of the cattle was achieved with the use of a motorcycle. During these outings, we opportunistically recorded jaguar tracks, carcasses of their native and domestic prey and wildlife sightings with the use of GPS.

Responses of Jaguars and Pumas to Electric Fences in Captivity

Electric fences were built with five electrified non-barbed wires at heights of 20, 40, 60, 80 and 110 cm from the ground, cutting off a section of the enclosure where food (raw meat, poultry and beef chunks) was placed. In addition to the food, to increase motivation, the fence cut off a section of the enclosure that included a favourite rest area, or access to it, where animals chose to spend most of their time (Fig. 16.2). The number of posts depended on the design required to close off the selected section of the enclosure. In the Sorocaba zoo, we used a configuration with five posts, for both enclosures (jaguar and puma). In Guarulhos, we used four posts in the jaguar enclosure, and three posts in the puma's. The voltage used in the fences ranged from 7,800 to 9,900 V. There was little variation between the voltage attained in the different wire strands of the fence. All equipment used was provided by Farmtech S.A. Produtos Veterinários (Porto Alegre, RS, Brazil), representatives in Brazil of Speedrite® and Tru-test®, from New Zealand. In the Sorocaba zoo, construction of the fence was supervised by a technician (A. S. Balbino) provided by Farmtech S. A. In Guarulhos, we built the fence ourselves, but followed the same guidelines and general design for the fences.

In both zoos, the trials were organised as 3 daytime and one night-time in 30-min sessions for each individual of each species where we recorded behaviour in relation to the fence. The behaviour of the animals was filmed during the day and photographed at night. In addition, a description of their behaviour was recorded with a digital voice-recorder.

As an additional motivation, study animals were not fed for the duration of the trials. In Sorocaba, the first trial with the jaguars started on a Friday, and the second only continued on the following Monday. Although the animals had been fed the morning of the first trial, they were kept without food, from their habitual feeding Friday morning to the end of the trials on the following Wednesday.

Fig. 16.2 Electric fence set up at the jaguar enclosure at Sorocaba Zoological Park, Brazil, blocking access to favourite resting spot

Results and Discussion

During the flood season of 2007, the cattle herd was brought to the higher ground fenced pastures but it was not until the following year that the electric fences were installed. Data on cattle mortality from 2006 to 2007 were reported by ranch hands and were not verified by research personnel because there was nobody stationed fulltime at the ranch to do so. According to their records, in 2006 jaguars were responsible for 24% of all losses ($n=11$ of 46 total losses). During 2007, the percentage of losses attributed to jaguar kills escalated to 86% ($n=24$ of 28 total losses). In 2008, when we had a researcher spending 20 days/month in the field to monitor jaguars and cattle depredation, total cattle losses attributed to jaguar predation represented 10% of the total losses ($n=50$ of 504 total losses). In that year, total cattle loss escalated to over 500 head, but the vast majority of them were recorded as missing cattle (82%, $n=413$). There was a difference observed in the percentage of losses attributed to jaguars as recorded by research personnel and by ranch hands (10 and 13%, respectively), although this difference was not as high as the ones observed in other studies (Crawshaw and Quigley 1984, 2002; Cavalcanti 2006, 2009).

Jaguars killed mostly heifers (73% of all kills), followed by steers and adult cows (10% each) and calves (7%). Given that heifers comprised 78% of the herd, jaguars did not seem to select for any specific age/class category but rather selected the prey according to their availability.

When we were first contacted by the ranch owners, we recommended that they install electric fences in relatively small enclosures where better control of conditions could be exerted. Electric fences can be effective in decreasing predation losses, particularly in areas where predation is moderate to severe, and particularly if used to enclose the most vulnerable age classes and/or used during the most critical periods. In Venezuela, Scognamillo et al. (2002) tested an initial design with three electrified wire strands (30, 60 and 90 cm) with voltage ranging between 2,500 and 3,000 V, which encompassed an enclosure of 18 ha (with a perimeter of 1,697 m). However, the authors recorded eight attacks by two jaguars and one puma in the first 3 weeks of the experiment. They later modified the existing fence to include an additional wire (20, 40, 60 and 85 cm) and increased the voltage to 4,500–5,000, after which the attacks ceased.

In our study area, we found that the use of the electric fence, as implemented, had limited effect in reducing the probability of livestock depredation by jaguar. Although losses attributed to jaguars in 2008 decreased considerably in relation to the previous year, they can still be considered high. The design adopted by the ranch, to fence only the perimeter of a 900-ha management area (13,745 m), left too many opportunities for jaguars to enter the area and take cattle. Potential for predator entry, as well as electrical malfunctions, washouts and physical damage, is likely to increase as fenced areas increase in size.

On different occasions ($n=7$), we observed sites where a jaguar appeared to have tried to enter the fence without success, as evidenced by several scrapes on the outside of the electric wires (Fig. 16.3). In addition, we followed the tracks of jaguars walking along the fence for distances of over 400 m, until they found where the electric wires were discontinued such as at gates left for the entrance of the cattle. These gates were also subsequently equipped with electric wires to isolate the cattle management areas and thus prevent the entrance of predators. Therefore, we surmised that the predator entrance was made more difficult but not precluded.

Night-time surveillance of the different pastures was initiated in early 2007, as per our recommendation, after we were first contacted by the ranch owners. However, given that we did not have research personnel in the field during 2007, an unbiased evaluation of this measure could not be made. According to the ranch foreman, at one period when night surveillance and the use of firecrackers was conducted by one well-prepared, conscientious employee, it achieved the proposed objectives, and had a marked effect on reducing attacks (F. Machado, pers. comm.). However, the change in personnel and insufficient time schedules through the night left open opportunities that resulted in increased predation. Employees often used firecrackers at will with no relation to the presence or threat of cats to demonstrate that the person was "working". This may likely have hampered the positive effect of the method, making the cats habituated to the explosions, not linked with their proximity to the cattle.

Night-time surveillance is best conducted by an employee specifically appointed and trained for this function. In this case, overload of duties during the day made it difficult to complete the required number of hours during the night. Attempted night-shifts starting at 24:00 h and finishing at 05:00 h or from 21:00 to 03:00 h were shown

Fig. 16.3 Photograph showing where a jaguar tried to enter the fenced enclosure and was impeded by the electric fence (photo F. Tortato)

not to cover the crepuscular hours when jaguars have been shown to be usually active (Crawshaw and Quigley 1991; Cavalcanti and Gese 2009). In four instances, jaguars were seen close to the herd between 18:00 and 21:00 h. Therefore, optimum surveillance timing would include from dusk to dawn, or 18:00–06:00 h, requiring one full-time employee or two employees to divide the task.

We also recommended the maintenance of the pasture and other vegetation at short heights in the cattle management modules, but this was not implemented. However, it was shown to be important, since 51% of all predation events happened at clumps of tall grass or very close to them (within 50 m). Jaguars do not pursue their prey for long distances and usually rely on ambush and a short distance chase. Therefore, they depend on cover to launch their attacks. With the elimination of these patches within the fenced management modules, the opportunities for these attacks would likely decrease.

Cultural factors play an important role in the conservation of jaguars in cattle ranches in the Pantanal and make the interface between ranch personnel and researchers a difficult issue. From our experience in this and other projects, it is clear that most ranch hands do not believe in the efficacy of anti-predation measures and think that jaguar conservation is actually incompatible with cattle operations (Crawshaw & Cavalcanti, pers. obs.). Several studies have shown that most ranches over-estimate the amount of jaguar predation (Schaller and Crawshaw 1980; Crawshaw and Quigley 1984; Azevedo and Murray 2007; Cavalcanti 2009). Ranch hands often perceive that if jaguars are protected, their numbers will rise exponentially and predation will increase accordingly. It is difficult for them to accept that factors other than just the availability of cattle control their population size, such as social behaviour, and that jaguars still rely on native prey, such as peccaries and caiman (Cavalcanti and Gese 2010). It is important to educate ranch employees and their families regarding jaguar ecology to build an understanding of the integral part large cats play in healthy ecosystems. This may allow them to recognise the importance of jaguar conservation and therefore, motivate them to fulfil their important mission in reducing the conflict and achieving coexistence.

During our evaluations in captivity, we observed that each one of the jaguars sustained at least one shock from the fence. Mean interval between first introduction to the fence and first shock was 1 min. The male jaguar in Sorocaba took two shocks in the first session, with the second shock 2 min after the first one (Fig. 16.4). The female also immediately approached the fence, sustaining a shock 1 min after being released into the enclosure. In the next 2 daytime sessions, she spent most of the time at the front of the enclosure, apparently indifferent to the fence. However, during the night session, she appeared to be bolder, approaching the fence at least 5 times, and receiving another shock (Fig. 16.4).

The male and the female jaguar in the Guarulhos zoo also received one shock each in the first session. The male received two shocks in the second session; the first, 7 min after entering the enclosure, and the second, 11 min later. In this setting, a narrow corridor of approximately 1 m was left between one of the sides of the enclosure and the electric fence. In two occasions, the male rushed through this corridor, pressing himself close to the outside wall and as away from the electric fence as possible. During the third session, the male approached the fence twice, with the obvious intention of getting to the meat, but was deterred, most likely due to the previous experience with the shocks. Most of the time during the trials, both the male and female retreated to the shady, covered section of the enclosure.

Results for the pumas were all similar, considering all individuals in both zoos. Each of the animals received a total of two shocks, one each in the first session and one in the night session. The only difference was regarding the greater time interval for the male puma in the Guarulhos zoo, with the shock sustained 13 min after being introduced in the enclosure (Fig. 16.4).

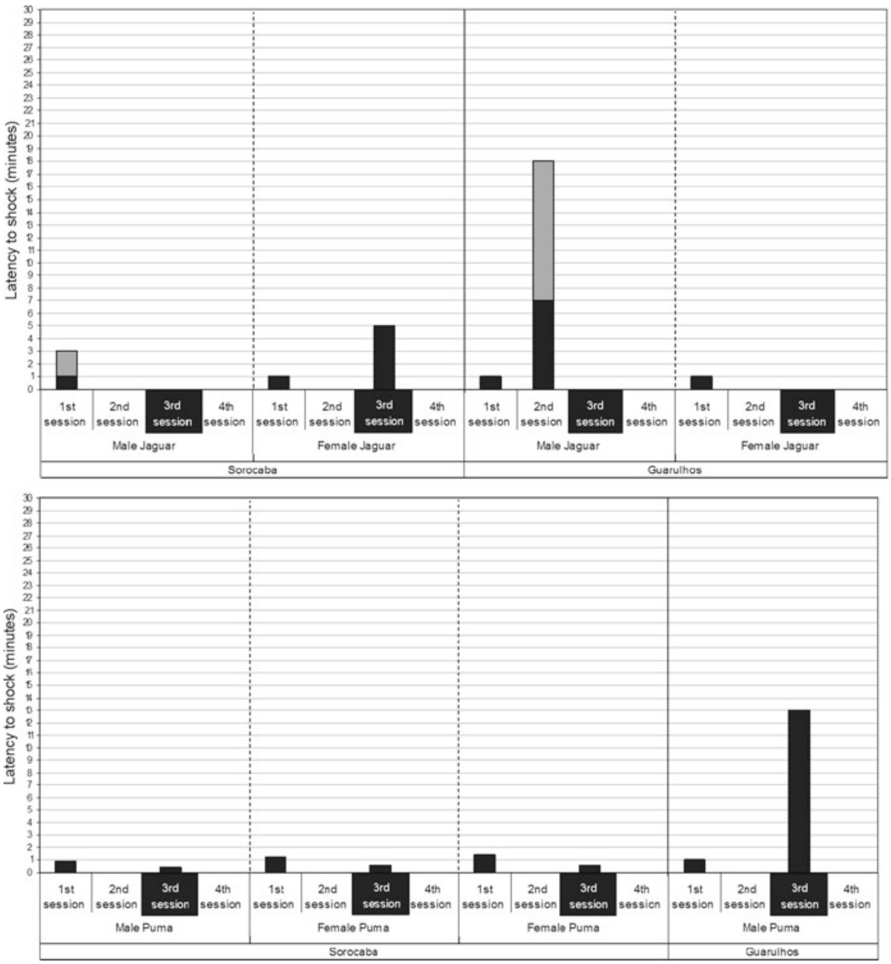

Fig. 16.4 Latency to shock sustained by four jaguars and four pumas, recorded in Sorocaba and Guarulhos zoological parks in the state of São Paulo, Brazil. The *black bar* is the first shock and the *grey bar* is the second shock sustained by individual animals. The third session, in *black*, was conducted at night

The pumas in the Sorocaba zoo seemed to be extremely sensitive to disturbances to their surroundings. After the first session, their behaviour, from openly exploratory, went to extremely wary, looking very alert and skittish. In the last session, the male showed patches of bare skin, which according to the zoo vets (A.V. Nunes, pers. comm.), was due to stress. Even though the male at Guarulhos did not show any physical signs of distress, his behaviour became very reserved in that he spent most of the time after the shocks, lying on a platform at one of the corners of the enclosure. This was the most evident difference in the behaviour of the two species, regarding the electric fence. While pumas became skittish and alert, jaguars reacted as if mostly aloof, most of the time disregarding the fence.

Fig. 16.5 Female puma upon receiving a discharge from the electric fence at the Sorocaba Zoological Park, Sorocaba, SP, Brazil

For the two species, the first contact with the electric fence was determined mainly by exploratory behaviour when animals were investigating novel stimuli in their surroundings. The first shock for all animals was within one and a half min after releasing the animals back into the enclosures. Although our samples do not allow for statistical analyses, they do demonstrate that after one or two shocks, the animals learned to avoid the fence, spending most of the time away from it. However, we noted an apparent increase in exploratory behaviour in the night sessions, especially for the pumas, in that both males and females received shocks in the night sessions (Fig. 16.5), even though they were apparently avoiding the fence during the day. The same was the case for the female jaguar in the Sorocaba zoo.

The effect of the fence was evident also by the contrast in the behaviour exhibited by all animals, of both species, as soon as the fence was removed: immediately, animals proceeded to eagerly explore all that was previously fenced out. On several occasions, jaguars of both zoos displayed marking behaviour, at specific points of the enclosure. However, since we have no information on previous marking rates, we cannot link observed markings to the presence of the fence.

On several occasions, animals approached the fence cautiously and appeared to sense the electricity with the long whiskers (vibrissae), which function as tactile sensors (Kitchener 1991), backing away before receiving a shock.

After the initial shocks, all animals remained as distant as possible from the fence, most of the time apparently indifferent to it. The male and female jaguars from Sorocaba also exhibited what could be interpreted as displacement activities

(Ewer 1968; Kitchener 1991). On a few occasions, after intently looking in the direction of the fence (and/or the food), they would go directly to the tree trunk and sharpen their claws for several minutes. In another instance, they rolled on their backs, playfully.

Conclusion

Total exclusion of predators may be not practical because a predators' response to an electric fence is influenced by various factors, such as the animal's motivation and previous experience with fences. In our study area, cattle grazed spread out in the open range for quite some time before being confined into a smaller pasture area, which considerably increased their density. Optimal foraging theory predicts that predators should choose the most profitable prey (MacArthur and Pianka 1966). However, profitability may be influenced by a combination of search time, encounter rates and energetic costs of capture. During the wet season, when herbaceous fields and drainage vegetation habitats become extremely dense and difficult to move through, high search time and low encounter rates may make hunting in these habitats less profitable for jaguars. The option of a readily available prey item confined into areas of more profitable hunting grounds may be a strong enough motivation for jaguars to overcome the electric fence.

In our observations within the captive settings, we did not record a scraping behaviour (shown by wild jaguars) on the outside of the electric fence at points where the animal was apparently kept from entering the enclosure (Fig. 16.3). It is possible that conditions in captivity, especially easy food availability, mask (or dampen) what could be interpreted as motivation to overcome the fence. However, it is probably safe to surmise that the ease, with which animals in captivity learn to avoid electric fences after one or two electrical discharges, is also applicable to wild individuals. What is likely to differ, from our captive observations, is the drive to overcome the fence. This possibility underscores the need to consider the adaptive capabilities of the predators when planning the use of electric fencing.

According to the owners of the ranch (R. Jank, pers. comm.), the measures decreased in efficacy in the following order: (1) predation was reduced significantly when the herds were moved to open, short native grasses during the drought season, which provided ample visibility preventing the undetected approach of predators. With the flooding season and the cattle being confined in taller vegetation, predation increased considerably; (2) night patrolling with a tractor in a central corridor in between the fenced pastures holding the cattle at night was also effective in reducing predation; (3) the electric fence, as used by the ranch, encompassing a very long perimeter, likely deterred some individuals, but others managed to overcome the fences and succeeded in preying on the cattle; and (4) fireworks and lighting (as employed by the ranch), after habituation by the jaguars, were the least effective measures.

The opinion of the ranch owners, as the results of our study, highlights some of the problems associated with inadequate use of electric fences and other management alternatives in decreasing livestock depredation by large cats in the Pantanal. Nonetheless, we believe that the combined information from the wild and captive conditions is useful in developing solutions to human-jaguar conflict as it relates to livestock depredation.

Despite the costs incurred in fencing for conservation (Hayward and Kerley 2009), we view the use of electric fencing as a possible aid to reduce the conflict between large cats and ranchers. However, it is important to understand that there is seldom a single "right" preventive or control measure that will resolve the issue of livestock depredation. The efficacy of any method will depend on a combination of factors that range from the biology of the predator and its motivation, to the environmental characteristics of the area, to the size and species of the herd to be protected, to cultural factors of the local community, and to the motivation of the ranch owner and his/her willingness to deal with the problem. Thus, it is important that both researchers and ranch personnel work together to test the new methods that should comprise their toolbox of prevention and control methods.

In the Pantanal, for example, the inherent characteristics of the area make it difficult to effectively control the access of predators to cattle, and as long as this is an issue, it is likely that predation will occur, to a certain extent. Ranchers should focus on increasing their production potential, curtailing losses due to rudimentary herd management and poor husbandry practices, which can be more significant than jaguar depredation in many cases (Hoogesteijn et al. 1993). In addition, Cavalcanti and Gese (2010) illustrated the possible role native prey abundance could have on jaguar predation of cattle. Maintaining native prey populations in the Pantanal may not only help alleviate losses incurred from depredation, but may contribute in the efforts to conserve jaguars in the long term.

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